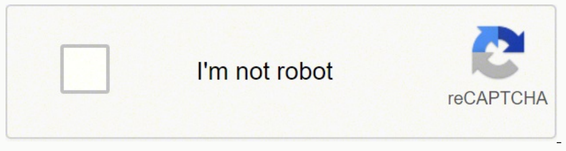

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Causes and Effect of Soil Erosion and its Preventive Measures

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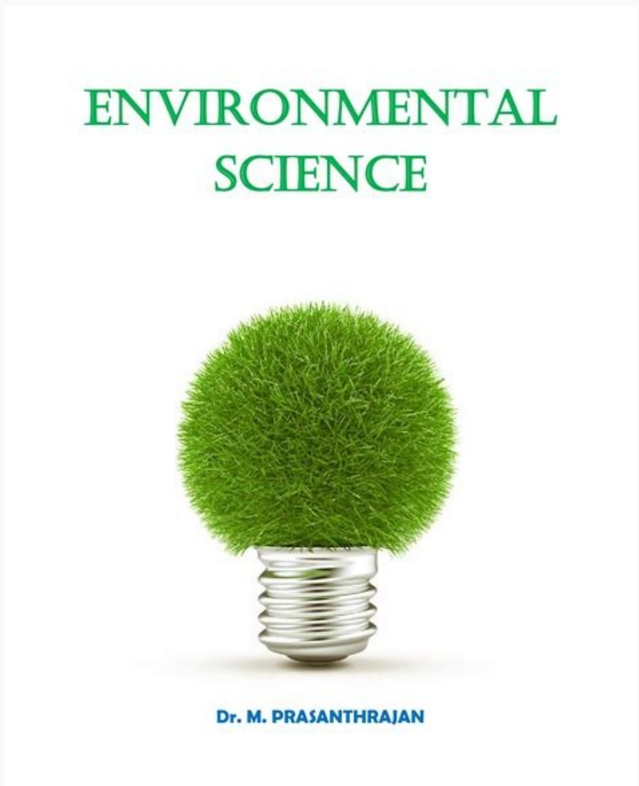
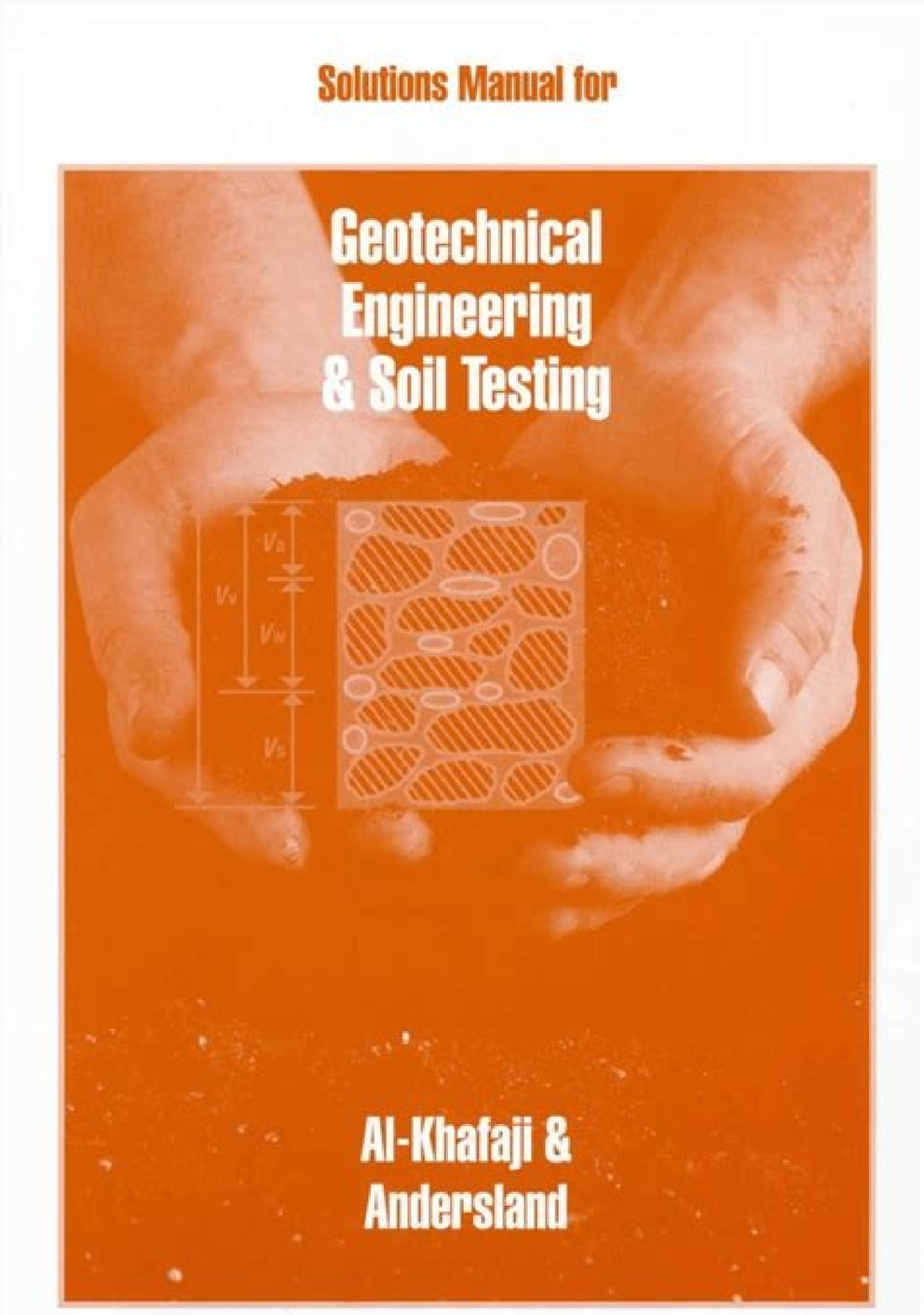
Abstract: Soil formation and soil erosion are two natural but important processes. Numerous regular, undisturbed soils have a pace of development that is adjusted by a pace of disintegration. Under these conditions, the soil seems to stay in a steady state as the scene advances. By and large, the paces of soil disintegration are low except if the soil surface is presented straightforwardly to the wind and water. It is a worldwide common problem which additionally prompts ecological harm through sedimentation, contamination and expanded flooding. The expenses related with the development and statements of landscape in the scene as often as possible out-gauge those emerging from the erosion loss of soil in dissolving fields. By and large, the paces of soil disintegration are low except if the soil surface is presented straightforwardly to the wind and water. The disintegration issue emerges when the characteristic vegetative spread is expelled and rate of soil erosion are incredibly quickened. At that point, the rate of soil erosion extraordinarily surpasses the pace of soil arrangement and there is a requirement for erosion control practices that will lessen the disintegration rate and keep up soil efficiency. Erosion is a three-step process: detachment followed by transport and deposition. The energy for erosion is derived from falling rain and the subsequent movement of runoff water or the wind. In this part we will concentrate on basic erosion forms, demonstrating of these procedures, model applications, and erosion control. Wind erosion will be examined first, trailed by water erosion.

Keywords: Soil erosion, conservation, erosion control





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CABI

All data denotes inclusions of full and partial accounting data [71].Sainju [71] observed that the relationships between net GWP, net GHGI, and N rate were further improved when the duration of the experiment and soil and climatic conditions were taken into account in the multiple linear regressions. In: Proceedings of the Advances in Terrestrial Ecosystem and Carbon Inventory, Measurement, and Monitoring; 3–5 October 2000; Washington, DC. [70] reported that net GWP and GHGI calculated from soil respiration and soil C sequestration methods were lower with 80 than 0 kg N ha−1 (Table 8). 57-6860. 125-1377. 1998;27:75-8559. Beltsville. Because spring wheat was grown once in 2 years in spring wheat-fallow rotation where N fertilizer was applied only to spring wheat, soil pH was less declined in this treatment than continuous spring wheat where N fertilizer was applied every year. Ghimire et al. Journal of Environmental Quality. 2005;69:413-42238. Potential soil carbon sequestration and CO2 offset by dedicated energy crops in the USA. Combined effects of nitrogen fertilization and biochar on the net global warming potential, greenhouse gas intensity, and net ecosystem budget in intensive vegetable agriculture in southeastern China. Carbon accumulation in cotton, sorghum, and underlying soil as influenced by tillage, cover crops, and nitrogen fertilization. Liang BC, McKenzie AF. 2001;93:157-16320. Weston DT, Horsley RD, Schwarz PB, Goos RJ. Guo JH, Liu XJ, Zhang Y, Shen JL, Han WX, Zhang WF. Negative values indicate GHG sink.hColumn (L) = Column (I)/Column (J) [61]. At 90–180 kg N ha−1, soil total N was lower with disc plow than other tillage practices. Mahler RL, Harder RW. Effect of nitrogen on the growth, yield, and grain protein content of barley. Crop yields have declined in places where soil acidification is high due to unavailability of major nutrients and basic cations and toxic effect of acidic cations. 2006;35:1584-159862. Nitrogen-use efficiency for crops, however, can be lower at high N fertilization rates [5]. Nitrogen fertilizers also indirectly emit N2O through NH3 volatilization and NO3-N leaching [68].N fertilizationCO2 fluxN2O fluxCH4 fluxkg N ha−1Mg C ha−1g N ha−1g C ha−101.15b†308a−314a801.23a329a−291aEffect of N fertilization on total soil surface greenhouse gas fluxes (from March to November) averaged across years from 2008 to 2011 under rainfed malt barley in eastern Montana, USA [65].†Numbers followed by different letters within a column are significantly different at P ≤ 0.05 by the least square means test.Increased N fertilization rate can enhance net GWP and GHGI due to increased N2O and CO2 emissions associated with the manufacture, transport, and application of N fertilizers, regardless of cropping systems and calculation methods [61, 70]. Seasonal changes in smooth bromegrass top and root growth and fate of fertilizer nitrogen. Bronson KF, Mosier AR. Sainju UM, Allen BL, Lenssen AW, Ghimire RP. For example, N leaching is greater in sandy than clayey soils due to the presence of a large number of macropores and leaching is higher in the humid than arid and semiarid regions due to differences in annual precipitation [56, 58]. Effect of no-till and conventional tillage systems on the chemical composition of soils solid phase and soil solution of Brazilian Savanna soils. Yadav SN. As a result, N fertilizer is usually applied in large quantity to increase crop production throughout the world. Fujinuma R, Venterea RT, Rosen C. It is not unusual to achieve higher crop yield with increased N fertilization rate due to increased soil N availability [11]. Residual soil nitrogen as affected by continuous cropping, two-year, and four-year crop rotations. [29] observed that soil total N at 10–20 cm increased with increased N rates after 70 years of N fertilization to winter wheat, but the trend varied with different tillage practices at higher N rates in eastern Oregon, USA (Figure 8). Nitrogen fertilizers are usually placed at the soil surface, and N rates are usually higher in NT due to the accumulation of surface residue that partly immobilizes N than CT where fertilizers are incorporated into the soil due to tillage [33]. The net GWP for a crop production system is expressed as kg CO2 eq. Overview and introduction. Nitrogen application more than crop’s need can also result in reduced yield [3]. USA: USDA-ARS; 200044. Varvel GE, Peterson TA. They suggested that longer than 5 years is needed to observe the effect of N fertilization on soil total C under perennial grasses.Soil total C at 30–60 and 60–90 cm depths as affected by 5 years of N fertilization rates to perennial grasses in eastern Montana, USA. A study reported a need of 27 kg of total soil and fertilizer N to produce 1 Mg of malt barley grain in irrigated no-till field in Colorado, USA [11].Annualized grain and biomass yields of barley and pea and C content as affected by N fertilization rate in eastern Montana, USA [9].Effects of cropping sequence and N fertilization rate on malt barley grain yield, N uptake, and N-use efficiency in eastern Montana, USA. 2002;94:413-42022. Agronomy Jpornal. Springerplus. 2013;78:248-26171. In-season nitrogen uptake by grain sorghum following legume green manures in conservation tillage systems. At 60–90 cm, the trend reversed with grasses. Managing Nitrogen for Groundwater Quality and Farm Profitability. Greenhouse gases in intensive agriculture: Contribution of individual gases to the radiative forcing of the atmosphere. Formulation and estimation of nitrate-nitrogen leaching from corn cultivation. 2006;98:26-3335. [29] reported that soil pH decreased with increased N rate, as tillage intensity increased.Source of N fertilizer can also have a varying effect on soil acidity. 2004;96:510-51519. Bars with the same letter at the top are not significantly different among N rates at a depth at P ≤ 0.05 [46].Soil total N as affected by 72 years of N fertilization rates to spring wheat and tillage in eastern Oregon, USA. Cropping sequence and nitrogen fertilization impact on surface residue, soil carbon sequestration, and crop yields. 1981;10:421-42658. 2006;116:4-144. Omay AB, Rice CW, Maddux LD, Gordon WB. Several researchers [21, 22] reported that maximum switchgrass shoot biomass yield reached at 120–140 kg N ha−1 in Iowa and Nebraska, USA, which had 2.5 and 2.2 times, respectively, more annual precipitation than in eastern Montana, USA. Soil acidification from long-term use of nitrogen fertilizers on winter wheat. Smart investments in sustainable food productions: Revisiting mixed crop-livestock systems. Madison, WI: Soil Science Society of America; 1984. Conservation tillage-induced changes in organic carbon, total nitrogen, and available phosphorus in a semi-arid alkaline subtropical soil. In contrast, the land is tilled using discs in chisel tillage after N fertilizer is broadcast. They also found that additional N was required to optimize cotton yield following wheat (Triticum aestivumL.) in no-tillage and surface tillage systems without cover cropping, but no N rate was required following hairy vetch cover crop in either tillage practices. Thompson TL, Ottman MJ, Riley-Saxton E. 1989;53:119-12232. Studies show that ~1–2% of soil organic N in the 0–30 cm depth is mineralized every year [6]. Another problem is the groundwater contamination of nitrate-N (NO3-N) which can be a health hazard to human and livestock if its concentration goes above 10 mg L−1 in drinking water. Halvorson AD, Del Grosso SJ, Alluvione F. To reduce excessive N fertilization, composited soil sample to a depth of 60 cm should be conducted for NO3-N test prior to crop planting and N fertilization rate be adjusted by deducting soil NO3-N content from the desirable N rate.1. Franzluebbers AJ. Accumulation of soil NO3-N increases with depth and is directly related to N fertilization rate [47, 48]. 1993;85:1170-117415. Venterea RT, Burger M, Spokas KA. Similarly, N fertilization rates to cotton and sorghum can be reduced or eliminated by using legume cover crops, such as red clover (Trifolium incarnatumL.) and hairy vetch (Vicia villosaRoth), regardless of tillage practices [18]. Net GWP is also expressed as net greenhouse gas intensity (GHGI) or yield-scaled GWP, which is calculated by dividing net GWP by crop yield [61]. Sainju UM, Lenssen AW, Allen BL, Stevens WB, Jabro JD. 2017;107:326-33446. 2000;289:1922-192563. Grain protein and kernel plumpness are important characteristics of malt barley that need to be maintained at critical levels (grain protein ≤129 g kg−1, kernel plumpness ≥850 g kg−1) for beer production [12]. West TO, Marland G. Using partial accounting, net GWP decreased from 0 to 88 kg N ha−1 and net GHGI from 0 to ≤213 kg N ha−1 and then increased with increased N rate. Tarkalson DD, Hergert GW, Cassman KG. In this chapter, we discuss the consequences of N fertilization to crop yields and soil and environmental quality.AdvertisementNitrogen fertilization can increase crop yields and N uptake compared with no N fertilization. Long-term tillage, cover crop, and nitrogen rate effects on cotton: Yield and fiber properties. Sainju UM, Allen BL, Caesar-TonThat T, Lenssen AW. Basal stem nitrate tests for irrigating malt barley. These N rates probably corresponded to crop N demand when crops used most of the soil available N. Nitrogen fertilization of no-till corn on loess-derived soils. CW represents continuous wheat; NT, no-till; T, till; W-B/P, spring wheat-barley/pea; and W-F, spring wheat-fallow.bNumbers followed by the same lowercase letter within a column among treatments in a set are not significantly different at P ≤ 0.05.cNumbers followed by the same uppercase letter within a row among soil depths in a set are no significantly different at P ≤ 0.05.Ghimire et al. Heggenstaller AH, Moore KJ, Liebman M, Anex RP. Field Crops Research. Soil organic C at 5–10, 30–60, and 60–90 cm were greater with 40 kg N ha−1 than other N rates. Eickhout B, Bouwman AP, van Zeijts H. Liebig MA, Varvel GE, Doran JW, Wienhold BJ. Long-term application of ammonia-based N fertilizers, such as urea, has increased soil acidity which rendered to soil infertility where crops fail to respond with further application of N fertilizers. Australian Journal of Experimental Agriculture. Bars with different uppercase letters at the top are significantly different among N rates within a tillage practice at P ≤ 0.05 [29].AdvertisementSoil residual N refers to inorganic N (NH4-N + NO3-N) accumulated in the soil profile after crop harvest. Dryland winter wheat response to tillage and nitrogen within an annual cropping system. Licensee IntechOpen. Sainju UM, Wang J, Barsotti JL. In a meta-analysis of 12 experiments, Sainju [71], after accounting for all sources and sinks of CO2 emissions, reported that net GWP decreased from 0 to ≤45 kg N ha−1 and net GHGI from 0 to ≤145 kg N ha−1 and then increased with increased N fertilization rate (Figure 9). 1995;87:652-65629. Applying N fertilizer in the spring compared with autumn and using split application compared with one single application at planting can reduce N2O emissions in some cases [66]. Vertical bar with LSD (0.05) is the least significant difference between treatments at P = 0.05 [10].2000 cotton lint (kg ha−1)2000 cotton biomass (kg ha−1)2001 sorghum grain (kg ha−1)2001 sorghum biomass (kg ha−1)2002 cotton lint (kg ha−1)2002 cotton biomass (kg ha−1)TreatmentYieldN uptakeYieldN uptakeYieldN uptakeYieldN uptakeYieldN uptakeYieldN uptakeCover cropaWW699bb11b5200c124b2800bc43ab12,000ab133ab1091a16a3667a74aR879a15a6300bc138b2300c32b9400b81b940ab15a3567a77aHV660b11b8200a239a3500ab60a14,100a175a708b13a4067a98aHV/R706b12b7300ab194a4000a58a14,100a138ab711b14a4233a102aN fertilization rate (kg N ha−1)0736a12a5700b135c2800b41b11,600b108b1021a17a3700a80b60–65783a13a7000a178b3100b46b12,400ab135a980a16a3900a86b120–130689a11a7600a209a3700a57a13,300a152a587b11b4000a97aEffect of cover crop and N fertilization rate on yield and N uptake by cotton lint, sorghum grain, and their biomass (stems + leaves) from 2000 to 2002 in central Georgia, USA [16].aCover crops are HV, hairy vetch; HV/R, hairy vetch/rye; R, rye; and WW, winter weeds.bNumbers followed by the same letters within a column in a set are not significantly different at P ≤ 0.05.Increased N fertilization rate can also increase grain quality, such as protein concentration [10, 11]. Nitrogen influences biomass and nutrient partitioning by perennial warm-season grasses. 2007;99:1521-152912. Biology and Fertility of Soils. In strip tillage, only crop rows are tilled, leaving the area between rows undisturbed, and N fertilizer is applied in crop rows. 1991;55:1097-110036. This is due to differences in the amount and placement of N fertilizers in the soil and removal of basic cations through grain and biomass removal between the two tillage systems [32]. Boquet DJ, Hutchinson RL, Breitenbeck GA. The response of cotton yield to N fertilization, however, depended on climatic condition, as cotton lint and biomass yields were greater in 2000 than 2002 when the growing season precipitation was below the average. As a result, crops remove more basic cations, resulting in increased acidity with NT compared with CT [34]. Science. Buffer pH, the buffering capacity of the soil to resist changes in pH and is used to measure lime requirement, also similarly decreased with continuous N fertilization in all treatments. Howard DD, Gwathmey CO, Essington ME, Roberts RK, Mullen MD. Mosier AR, Halvorson AD, Reule CA, Liu XJ. Zibilske LM, Bradford JM, Smart JR. 2009;101:1363-137123. O’ Donovan JT, Turkington TK, Edney MJ, Clayton GW, McKenzie RH, Juskiew PE, et al. Because N2O emissions has a large effect on net GWP and GHGI, practices that can reduce N fertilization rates without influencing crop yields can substantially reduce net GHG emissions [61, 62]. 2002;91:217-23264. European Journal of Agronomy. 1984;137:52-6025. found that soil acidity from N fertilizer sources was in the order (NH4)2SO4 > NH4Cl > NH4NO3 > anhydrous NH3 > urea. DOI: 10.137/journal.pone 0148527Submitted: July 6th, 2018 Reviewed: March 25th, 2019 Published: September 6th, 2019© 2019 The Author(s). Measuring the actual amount of N mineralized is a time taking process. Bars with different letters at the top are significantly different at P ≤ 0.05 [29].No-till (NT) system can increase soil acidity more than the conventional till (CT) system [32]. Nitrogen storage with cover crops and nitrogen fertilization in tilled and non-tilled soils. Soil Science. Sainju [9] also found that C sequestration rate at 0–10 cm was 83 kg C ha−1 year−1 with 40 kg N ha−1 that was close to 94 kg C ha−1 year−1 at 0–15 cm with 45 kg N ha−1 for dryland cropping systems in Colorado [36].Soil organic C at the 0–120 cm depth as affected by 6 years of N fertilization rates to malt barley in various cropping systems in eastern Montana, USA. LSD (0.05) is least significant difference between grasses within a N rate at P = 0.05 [45].Nitrogen fertilization has less impact on soil total N than soil organic C. Cover crops for clean water. 2007;100:32-438. Soil organic carbon after twelve years of various crop rotations in an aridic boroll. 2014;106:1231-124210. In semiarid regions such as Great Plains of USA, N losses to the environment due to N leaching, volatilization, and denitrification during the winter are considered minimal due to cold weather and limited precipitation in the region.Nitrogen fertilizers are being increasingly applied to crops to enhance their yield and quality in South Asia, where land available for crop production is limited, the proportion of cultivated land to population is low, and the pressure to increase crop yields to meet the demand for growing population is high. Crop yields, however, can remain at similar level or decline with further increase in N rates after reaching the maximum yield. 1994;23:521-52549. Nitrate in groundwater in the United States. Varvel and Peterson [5] reported that N removed by corn and sorghum grain was 50% of the applied N at low N rates and at least 20–30% at high N rates.Nitrogen fertilization can also increase aboveground biomass yield of perennial grasses used for feedstock or bioenergy production. Amsterdam: Elsevier; 1989. This chapter examines the effect of N fertilization on soil and environmental quality and crop yields.crop yieldsenvironmental qualitymanagement practicesnitrogen fertilizernitrogen-use efficiencysoil qualityNitrogen (N) is a major limiting factor for sustainable and profitable crop production. Biomass yield, however, did not respond to N fertilization in 2012 when the annual precipitation was below the average. Nitrogen Management and Groundwater Protection. The influence of tillage methods, cropping sequence, and N rates on the acidification of a northern Idaho soil. In eastern Oregon, USA, application of total N fertilizer

at 2.25 Mg N ha−1 over the 43-year period lowered soil pH by 0.60 units [31]. 2013;105:329-34011. 2005;273:219-23440. Changes of soil nitrate-nitrogen and denitrification as affected by nitrogen fertilizer on two Quebec soils. 2016;233:25-3252. Bremer E, Janzen HH, Ellert BH, McKenzie RH. Agriculture, Ecosystems and Environment. Increased soil residual N due to fallow as a result of enhanced soil N mineralization from increased soil temperature and water content resulted in a reduced response of malt barley yield and N uptake with N fertilization in no-till and conventional till malt barley-fallow rotation. Schroder JL, Zhang H, Girma H, Raun WR, Penn CJ, Payton ME. T0.050.08−0.010.010.010.01CW vs. 1997;61:1672-167839. 35-7457. They noted that, although CO2 equivalents from N fertilization and soil respiration were higher with 80 kg N ha−1, the amount of plant residue returned to the soil, soil C sequestration rate, and grain yields were greater with 80 than 0 kg N ha−1, thereby resulting in lower net GWP and GHGI with N fertilization than without, regardless of the method used for calculation.Cropping sequenceaN rateFarm operation (A)N fertilizer (B)bSoil respiration (C)N2O flux (D)CH4 flux (E)Annualized crop residue (F)cSOC (G)dGWPR (H)eGWPC (I)fAnnualized grain yield (J)GHGIR (K)gGHGIC (L)hkg N ha−1kg CO2 equivalent ha−1 year−1kg ha−1kg CO2 kg−1 grain yieldCTB-F182772722bi425a−16a3476b−114c−89a778a1408b−0.06a0.55aNTB-P124913303a469a−16a5980a554a−2005c115b1649a−1.22c0.07bNTCB1241033547a394a−15a5411a268b−1259b337b1683a−0.75b0.20b014303093b416a−16a4421b−94b−787a635a1399b−0.56a0.45a801431803288a443a−15a5487a566a−1448b185b1761a−0.82b0.11bNet global warming potential (GWPR and GWPC) and greenhouse gas intensity (GHGIR and GHGIC) based on soil respiration and organic C (SOC) methods as influenced by cropping sequence and N fertilization rate in eastern Montana, USA [70].aCropping sequences are CTB-F, conventional-till malt barley-fallow; NTB-P, no-till malt barley-pea; and NTCB, no-till continuous malt barley.bTotal CO2 equivalents from direct and indirect sources of N fertilization.cTotal above- and below-ground crop residue.dCarbon sequestration rate calculated from linear regression of change in soil organic C at the 0–10 cm depth from 2006 to 2011.eColumn (H) = Column (A) + Column (B) + Column (C) + Column (D) + Column (E) − Column (F) [61]. [29] found that soil pH at 0–10 cm after 70 years of N fertilization was 5.70 with 0 kg N ha−1 and 5.0 with 135–180 kg N ha−1 under winter wheat-fallow in eastern Oregon, USA (Figure 4). Organic Farming: Current Technology and its Role in Sustainable Agriculture (Special Publication 46). Ross SM, Izaurralde RC, Janzen HH, Robertson JA, McGill WB. Chen et al. Similarly, Sainju et al. 2010;327:1008-101031. Liebig et al. CTB-F denotes conventional-till malt barley-fallow; NTB-F, no-till malt barley-fallow; NTB-P, no-till malt barley-pea; and NTCB, no-till continuous malt barley. In no-till malt barley-fallow (NTB-F) and conventional till malt barley-fallow (CTB-F), the trend of soil organic C with N rates varied at various depths. [16] evaluated the effect of N fertilization on cotton and sorghum yields and N uptake from 2000 to 2002 in central Georgia, USA (Table 1). Differences in N fertilization methods between tillage practices probably affected soil organic C due to N fertilization rates.N rate (kg N ha−1)Soil organic C (Mg C ha−1)0–10 cm10–30 cm30–60 cm60–90 cm90–120 cmStrip-tilled soil010.1aa16.0a10.97.25.560–659.3b14.4b10.24.55.3120–13010.3a14.7ab9.87.35.8Chisel-tilled soil08.9b12.5b10.17.45.960–659.6a13.4b10.17.35.3120–1309.3ab14.8a10.67.96.1Effect of 3 years of N fertilization rate on soil organic C at the 0–120-cm depth in strip-tilled and chisel-tilled soils under cotton and sorghum in central Georgia, USA [39].aNumbers followed by the same letter within a column in a set are not significantly different at P ≤ 0.05.Sainju [9] observed different trends of soil organic C at the 0–120 cm depth with 6 years of N fertilization rates in various cropping systems in eastern Montana, USA (Figure 5). 1997;26:808-81451. Long-term effects of tillage on soil chemical properties and grain yields of a dryland winter wheat-sorghum/corn-fallow rotation in the Great Plains. Significant acidification in major Chinese croplands. An account of N inputs, outputs, and retention in the soil provides N balance and helps to identify dominant processes of N flow in the agroecosystem [4].Economically profitable crop yields could be achieved by recommended N fertilization rates [6]. 2005;34:1467-147769. [45] found increasing trend of soil total C at 30–60 cm with increased N rate under intermediate wheatgrass and smooth bromegrass and a declining trend with switchgrass after 5 years in eastern Montana (Figure 6). Santori F, Lal R, Ebinger MH, Parrish DJ. Soil Science Society of America, Madison. Ankeny, Iowa, USA: Soil and Water Conservation Society; 1991. [17] reported that cotton lint yield was lower with no-tillage than surface tillage without applied N, but at optimum N rate, yields were higher with no-tillage. Sainju UM, Singh BP, Whitehead WF, Wang S. Only after 4–12 years, N fertilization increased soil organic C at 0–90 cm by 0.5–2.4 Mg C ha−1 year−1 compared with no N fertilization under switchgrass in USA and Canada [42, 43]. Duration of experiment and annual precipitation had positive effects, but air temperature and soil texture had negative effects on net GWP when all sources and sinks of CO2 emissions were accounted for. The role of nitrogen in world food production and environmental sustainability. Pang XP, Gupta SC, Moncrief JF, Rosen CJ, Cheng HH. Plant and Soil. W-B/P−0.43*−0.110.200.150.160.14Buffer pHNTCW6.45bE7.10abD7.43C7.60B7.70AB7.73ASTCW6.38bE7.00bD7.43C7.58B7.68A7.70AFSTCW6.43bE7.05bD7.45C7.60B7.70AB7.73AFSTW-B/P6.66aD7.13abC7.44B7.58B7.69AB7.70ASTW-F6.80aE7.24aD7.44C7.59B7.66AB7.72AContrastNT vs. The nitrogen balance of three long-term agroecosystems on a boreal soil in western Canada. Sainju UM, Allen BL, Lenssen AW, Mikha M. Increased N fertilization rates increased malt barley grain yield and protein concentration, but reduced kernel plumpness in Canada [12]. Anhydrous ammonia can increase N2O emissions compared with urea [67, 68]. Halvorson AD, Reule CA. 1988;80:740-74524. Both pH and buffer pH, however, did not change below 15 cm with N fertilization. 2002;66:153-16353. These values can be affected both by net GHG emissions and crop yields. Broadcast urea reduces N2O but increases NO emissions compared with conventional and shallow applied anhydrous ammonia in a coarse-textured soil. 1990;30:237-24214. Nitrate-N is soluble in water and moves down the soil profile with percolating water [47, 57]. [44] noted C sequestration rate of 2.4 Mg C ha−1 year−1 at 0–90 cm under switchgrass after 4 years. Russell AE, Laird DA, Parkin TB, Mallarino AP. Suppression of methane oxidation in aerobic soil by nitrogen fertilizers, nitrification inhibitors, and urease inhibitors. Perennial grasses are IW, intermediate wheatgrass; SB, smooth bromegrass, and SW, switchgrass. In: Follett RF, editor. 49-5954. 2011;103:709-71613. Climate change 2014: Synthesis report. Enhancing N-use efficiency can maximize crop yield and N uptake with limited use of fertilizer N while reducing N rate and sustaining the environment [3]. Pulse crop adaptation in the northern Great Plains. Robertson GP, Paul E, Harwood R. Excessive application of N fertilizers in the last several decades, however, has resulted in undesirable consequences of soil and environmental degradations, such as soil acidification, N leaching to the groundwater, and greenhouse gas (N2O) emissions. Halvorson AD, Black AL, Krupinsky JM, Merrill SD. Timmons DR, Dylla AS. [44]. Wood CW, Westfall DG, Peterson GA, Burke IC. Since the measurement of N mineralization requires a long time, N fertilization rates to dryland crops are adjusted by deducting soil NO3 content to a depth of 60 cm after crop harvest in the previous year or at planting of the current year from recommended N rates [51]. The N fertilizer required for optimizing cotton and sorghum yields varied with the type of tillage and cover crop [16]. Heichel GH, Barnes DK. For net GHGI, the factors having negative effects were air temperature using the complete accounting of CO2 emissions and annual precipitation and soil texture using the partial accounting. This chapter is distributed under the terms of the Creative Commons Attribution 3.0 License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 2009;38:1569-157967. Dryland soil greenhouse gas emissions affected by cropping sequence and nitrogen fertilization. 2004;96:1436-144218. [43] reported that N fertilization to cool-season grasses increased C sequestration rate at 0–30 cm by 1.6 Mg C ha−1 year−1 compared with no N fertilization after 5 years in Kansas, USA. 2000;18:105-11241. Darusman L, Stone R, Whitney DA, Janssen KA, Long JH. Nitrate-N accumulation and movement in the soil profile depend on soil properties, climatic conditions, and management practices [58]. In the calculations of net GWP and GHGI, emissions of N2O and CH4 are converted into their CO2 equivalents of global warming potentials which are 310 and 28, respectively, for a time horizon of 100 years [60]. Rasmussen PE, Rhode CR. Sainju UM, Caesar-TonThat T, Lenssen AW, Barsotti JL. Nitrogen source effects on nitrous oxide emissions from irrigated no-till corn. Biomass and Bioenergy. Intergovernment Panel on Climate Change (IPCC). Nitrogen balance in response to dryland crop rotations and cultural practices. Increased cropping intensity can reduce soil profile NO3-N content due to greater N immobilization, less summer fallow, and a greater amount of N removed by crops [54]. 2002;66:153-16334. These include soil acidification, N leaching in groundwater, and emissions of nitrous oxide (N2O), a potent greenhouse gas that contributes to global warming. Applying N fertilizer at various depths can have a variable effect on N2O emissions [67]. Nitrogen leaching as influenced by nitrogen management and supplemental irrigation level. Other disadvantages of excessive N fertilization include increased cost of fertilization, reduced N-use efficiency, and negative impact on human and livestock health. View PDFVolume 166, March 2022, 108552 rights and contentPlant-soil-microbe interactions Open access peer-reviewed chapterSubmitted: July 6th, 2018 Reviewed: March 25th, 2019 Published: September 6th, 2019DOI: 10.5772/intechopen.86028Nitrogen (N) is a major limiting nutrient to sustain crop yields and quality. 2015;100:10-1945. Nitrogen fertilization, however, can have a variable effect on emissions of other GHGs, such as CO2 and CH4 [64, 65]. Application of N fertilizers has increased crop yields and resulted in achievement of self-sufficiency in food production in many developing countries. A similar decline in soil pH at 7.5–15.0 cm was observed from 6.75 at the initiation of the experiment to 6.15 in spring till continuous spring wheat (STCW). Critical Reviews in Plant Sciences. Birch CJ, Long KE. Impacts of soil management on root characteristics of switchgrass. Geneva, Switzerland: IPCC; 201461. W-F−0.68***−0.88**−0.080.010.130.04CW vs. 1-350. Soil organic C at 0–10 and 10–30 cm varied with N fertilization rates in strip-tilled soil, but increased in chisel-tilled soil due to differences in tillage intensity. 2011;40:1806-181568. PLoS One. Soil organic C at 0–5 and 5–10 cm peaked at 40 kg N ha−1 and then declined with further increase in N rates in no-till malt barley-pea (NTB-P) and continuous no-till barley (NTCB). 2017;210:183-19121. Nitrogen fertilization rates that exceed crop requirement can increase NO3-N accumulation in the soil profile and N leaching [50].One of the ways to reduce N fertilization rates to crops while maintaining yield goals is to account for N mineralized from soil organic matter during the crop growing season and soil residual N at crop planting [6]. [10] found that N-use efficiency by malt barley decreased curvilinearly with increased N fertilization rate (Figure 2). With partial accounting, only air temperature had a positive effect on net GWP, but other factors had negative effects. 1990;82:1115-112055. Similarly, Schroder et al. 1990;82:958-9626. Effects of cover crops on groundwater quality. Continuous application of N fertilizers to nonlegume crops and excessive application rates in some places have led to undesirable consequences, such as reduced crop yields and degraded soil and environmental quality from soil acidification, N leaching, and greenhouse gas (N2O) emissions. Crop production can be optimized and potential for N losses minimized by adjusting N fertilization rates using soil residual and potentially mineralizable N values. [16] and Sainju [9] found that both soil NH4-N and NO3-N contents increased with N rates and depths (Tables 4–6).Soil inorganic NTreatment0–10 cm10–30 cm0–30 cm(kg N ha−1)Cover cropWinter weeds19.6ba32.9b52.5cRye19.1b34.1b53.2cHairy vetch23.6a38.4a62.0aHairy vetch/rye21.6a34.8b56.4bN fertilization rate (kg N ha−1)019.6b33.5b53.1b60–6520.8b35.3ab56.1ab120–13022.5a36.4a59.9aEffect of cover crop and N fertilization rate on soil residual inorganic N (NH4-N + NO3-N) content at the 0–30 cm depth in central Georgia, USA [16].aNumbers followed by the same letter within a column in a set are not significantly different at P ≤ 0.05.N fertilization rateNH4-N content at the soil depth0–5 cm5–10 cm10–30 cm30–60 cm60–90 cm90–120 cm0–10 cm0–30 cm0–60 cm0–90 cm0–120 cmkg N ha−1kg N ha−102.4b†2.5a10.4a15.8a19.4a23.8a4.9b15.3a31.2a50.2a72.0a402.3b2.3a10.6a15.4a19.7a25.0a4.7b15.2a30.6a49.7a72.7a802.5b2.5a10.3a15.5a19.7a25.1a5.0ab15.4a30.8a49.1a72.2a1202.9a2.6a10.8a16.2a19.6a25.7a5.5a16.1a32.0a50.8a73.6aEffect of N fertilization rate on soil residual NH4-N content at the 0–120 cm depth from 2006 to 2011 in eastern Montana, USA [55].†Numbers followed by the same letters within a column are not significantly different at P ≤ 0.05.N fertilization rateNO3-N content at the soil depth0–5 cm5–10 cm10–30 cm30–60 cm60–90 cm90–120 cm0–10 cm0–30 cm0–60 cm0–90 cm0–120 cmkg N ha−1kg N ha−106.7c†3.7c13.3c15.5c13.7c16.7b10.2c23.6d39.0d52.7d68.7c408.1c4.3bc14.6c17.5bc17.1b21.4ab12.5c27.1c44.6c61.6c82.3b8010.1b5.1b16.7b19.8b17.7b21.0ab15.2b31.9b51.8b69.4b89.6b12012.2a6.2a20.0a23.4a21.7a24.7a18.3a38.2a61.7a83.3a107.0aEffect N fertilization rate on soil residual NO3-N content at the 0–120 cm depth from 2006 to 2011 in eastern Montana, USA [55].†Numbers followed by the same letters within a column are not significantly different at P ≤ 0.05.It is well known that excessive N fertilizer application can increase N leaching in the groundwater, which is a major environmental concern [50]. Madison, WI: Soil Science Society of America; 1991. On the other hand, N rates can be reduced in crop rotations containing legumes compared to monoculture nonlegume cropping systems [53]. Sainju and Singh [46] reported that soil total N at 0–15 cm under cotton and sorghum was greater with 60–65 than 0 kg N ha−1, but not at lower depths in the chisel-tilled soil in central Georgia, USA (Figure 7). USA: Wisconsin; 1991. Increased application of N fertilizer to crops during the last several decades has increased NO3-N contamination of groundwater [56]. [42] observed that N fertilization to perennial grasses increased C sequestration rate at 0–5 cm by 0.5 Mg C ha−1 year−1 compared with no N fertilization after 6–12 years. Net global warming potential and greenhouse gas intensity affected by cropping sequence and nitrogen fertilization. 2004;86:516-52416. Power JF. Improved management practices can increase N-use efficiency, enhance soil N storage, and reduce N fertilizer application which reduce N losses to the environment [4]. Changes in soil microbial and chemical properties under long-term crop rotation and fertilization. Rice et al. [27] reported that, after 30 years of tillage and cropping sequence, continuous application of N fertilizers reduced soil pH at the 0–7.5 cm depth from 6.30 at the initiation of the experiment to 5.73 in spring till spring wheat-fallow (STW-F) and to 5.02 in fall and spring till continuous spring wheat (FSTCW) under rainfed condition in eastern Montana, USA (Table 2). One option to reduce soil residual N is to increase N-use efficiency. Increased N substrate availability due to N fertilization along with tillage may have increased microbial activity and N mineralization and therefore reduced soil total N over time.Soil total N at 0–120 cm in the chisel-tilled soil as affected by 6 years of N fertilization rates to cotton and sorghum in central Georgia, USA. Agronomy Journal. Net global warming potential and greenhouse gas intensity in irrigated cropping systems in northeastern Colorado. Crop sequence and nitrogen fertilization effects on soil properties in the western Corn Belt. Sainju UM, Singh BP. A study in China, where intensive farming and high rate of N fertilizer was applied for 20 years, showed that soil pH was dropped by 0.30–0.80 units from the original level [30]. This occurs because of excessive NO3-N accumulation in the soil profile [57] due to N fertilization rates that exceed crop requirements, accompanied by poor soil and crop management practices [56]. Maryland. Lilienfein J, Wilcke W, Vilele L, Lima SD, Thomas R, Zech W. 2007;72:970-97443. Sainju et al. Producers are increasingly interested in reducing the amount of N fertilizer applied to crops because of the higher cost of N fertilization and the associated environmental degradation.Nitrogen fertilization rates to crops can be higher in the no-till than the conventional till system due to greater accumulation of surface crop residue that can enhance N immobilization [52]. Others [35], however, observed no significant differences in acidity among (NH4)2SO4, NH4NO3, anhydrous NH3, urea, and urea-NH4NO3.AdvertisementSoil organic matter refers to soil organic C and N and is a crucial component of soil health and quality [36, 37]. Nitrogen and planting effects on low-protein spring barley. 2012;76:1741-175766. Lenssen AW, Johnson GD, Carlson GR. Power [23] also observed increased shoot biomass yield with increased N rate for smooth bromegrass in North Dakota, USA.Linear and quadratic responses of shoot biomass in perennial grasses with N fertilization rates from 2011 to 2013 averaged across grass species in eastern Montana, USA [20].AdvertisementApplication of NH4-based N fertilizers can increase soil acidity due to the release of H ions during hydrolysis [24]. 2008;100:619-62747. Russell et al. From the same experiment, Aase et al. [20] observed that yields of intermediate wheatgrass (Thinopyrum intermedium[Host] Barkworth and Dewey), switchgrass (Panicum virgatumL.), and smooth bromegrass (Bromus inermisL.) increased linearly or curvilinearly with increased N fertilization rate in 2011 and 2013 (Figure 3) when the annual precipitation was near or above the average. Because of enhanced soil water conservation, crop yields are higher in NT than CT, especially in dryland cropping systems [34]. Evaluation of nitrate leaching potential on Minnesota glacial outwash soils using the CERES-maize model. Accounting for nitrogen in nonequilibrium soil-crop systems. Sainju UM, Lenssen AW, Barsotti JL. Soil nitrate-nitrogen under tomato following tillage, cover cropping, and nitrogen fertilization. 2010;327:822-8253. W-F−0.43***−0.24**−0.01−0.010.01−0.01CW vs. Therefore, appropriate N fertilization rates are required to malt barley to achieve a balance between optimum grain yield, kernel plumpness, and protein concentration [15].Sainju et al. They found that cotton lint, sorghum grain, and cotton and sorghum biomass yields and N uptake increased from 0 to 60–65 kg N ha−1 and then remained either at a similar level or slightly increased at 120–130 kg N ha−1. Cropping sequence and tillage system influence annual crop production and water use in semiarid Montana. Therefore, N fertilizers should be applied at optimum rates to reduce net GWP and GHGI while sustaining crop yields. Similar results have been reported by Li et al. Soil Science Society of America Journal. Switchgrass biomass production in the Midwest USA: Harvest and nitrogen management. Herrero M, Thorton PK, Notenbaert AM, Wood S, Masangi S, Freeman HA, et al. 1999;91:702-70737. Impact of nitrogen fertilization and cropping system on carbon sequestration in Midwestern mollisols. Similarly, chemical additives to reduce nitrification from N fertilizers, such as polymer-coated urea and nitrification inhibitors, can substantially reduce N2O emissions compared with ordinary urea and non-nitrification inhibiting fertilizers [69]. Tillage practices are DP, disk plow; MP, moldboard plow, and SW, subsurface sweep. In: Bezdicek DF, editor. Nonlegume monocropping can have higher soil residual NO3-N content than legume-based crop rotations due to increased N fertilization rate [5, 27]. In South Dakota, USA, Li et al. [65] found that the application of 80 kg N ha−1 to dryland malt barley increased CO2 emissions, but not N2O and CH4 emissions (Table 7). 1994;17:263-26865. Reduction in pH with N fertilization decreased with depth, with no significant effect below 30 cm. Soil pH, soil organic matter, and crop yields in winter wheat-summer fallow systems. 2006;25:441-47242. 2008;127:241-2505. A synthesis of carbon sequestration, carbon emissions, and net carbon flux in agriculture: Comparing tillage practices in the United States. [39] reported that 3 years of N fertilization to cotton and sorghum produced various results on soil organic C at the 0–30 cm depth in strip-tilled and chisel-tilled soils in central Georgia, USA (Table 3). pp. The third problem is emissions of N2O gas which is 300 times more powerful than carbon dioxide in terms of global warming potential. Ma Z, Wood C, Bransby DI. Soil organic carbon and nitrogen in rangeland soil under elevated carbon dioxide and land management. 2015;4:230. Meisinger JJ, Hargrove WL, Mikkelsen RI Jr, Williams JR, Benson VE. [25] reported that anhydrous NH3 produce more acidity than urea. Aase JK, Aase JK, Pikul JL Jr. Crop and soil responses to long-term tillage practices in the northern Great Plains. Soil and Tillage Research. Other factors that can influence N2O emissions are the type, placement, time, and method of application of N fertilizers. Ghimire R, Machado S, Bista P. Nitrogen fertilization can increase soil organic C and N by increasing crop biomass yield, and the amount of residue returned to the soil [38]. This has been documented for malt barley (Hordeum vulgareL.), cotton (Gossypium hirsutumL.), and sorghum (Sorghum bicolor[L.] Moench) (Figures 1 and 2, Table 1) by various researchers in Georgia and Montana, USA [9, 10, 14]. Rice CW. Deep accumulation of NO3-N in the soil profile increases the potential for N leaching to shallow water tables [49]. While some studies reported malt barley grain protein concentration of

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