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Cover Crop Effects on Infiltration, Aggregate Stability, and Water Retention on Loessial and Alluvial Soils of the Lower Mississippi River Valley

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Cover Crop Effects on Infiltration, Aggregate Stability, and Water Retention on Loessial and Alluvial Soils of the Lower Mississippi River Valley

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by

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Abstract

Cover crops are a widely considered practice to improve soil health in the form of erosion control, organic matter additions, and improving water-holding capacity. Despite the well-documented benefits, little is known about the effect of cover crops on soils in the Lower Mississippi River Valley (LMRV), an area historically dominated by intensive cultivated agriculture, with soils prone to erosion, and unsustainable aquifer withdrawals for irrigation. The main objective of this study was to evaluate the effects of cover crops [with cover crops (CC) and without cover crops (NCC)] on near-surface soil physical/chemical- and infiltration-related properties, aggregate stability, and water retention. The secondary objective of this study was to evaluate the effects of sample/measurement placement [in the bed (B) and in the wheel-track (WT) and non-wheel-track (NWT) furrow] in adjacent CC and NCC treatments on the same soil under wide-row cotton (*Gossypium hirsutum* L.) production. Soil samples were collected and in-situ measurements were conducted between May 2018 and May 2019 across four locations within the LMRV portion of eastern Arkansas. Using a falling-head, double-ring infiltrometer method for 20 minutes, overall- and steady-state infiltration rates were unaffected ($P > 0.05$) by cover-crop treatment. Across all locations, extractable soil Na content in the top 10 cm was greater ($P \leq 0.05$) with NCC (31.6 kg ha^{-1}) compared with CC (21.6 kg ha^{-1}). Soil pH, electrical conductivity (EC), total C (TC), soil organic matter (SOM), and bulk density (BD) in the top 10 cm were also unaffected ($P > 0.05$) by cover-crop treatment. However, EC and BD were numerically greater with NCC compared to CC, while TC and SOM were numerically greater with CC compared to NCC. Based on a wet-sieving approach for five minutes, averaged across cover treatment and soil depth (0- to 5- and 5- to 10-cm), water-stable aggregate (WSA) concentration differed ($P \leq 0.05$) by aggregate size class. Averaged across treatment and soil

depth (0-to 5- and 5- to 10-cm), WSA concentration in the 0.25- to 0.5- (0.101 g g^{-1}) was 1.5 times greater than that in the 1.0- to 2.0-mm size class (0.068 g g^{-1}) and was at least 1.2 times greater than that in the 0.5- to 1.0- (0.079 g g^{-1}) and 2.0- to 4.0-mm (0.084 g g^{-1}) size classes, which were intermediate. Averaged across treatment and soil depth, WSA concentration in the > 4.0- (0.097 g g^{-1}) was at least 1.2 times greater than that in the 0.5- to 1.0- and 1.0- to 2.0-mm size classes, which did not differ, while WSA concentration in the 2.0- to 4.0- was 1.2 times greater than that in the 1.0- to 2.0-mm size class. Extractable soil Na content was greater (P = 0.03) in NCC-WT (26.8 kg ha^{-1}) and CC-WT (26.7 kg ha^{-1}), which did not differ, than NCC-B (19.8 kg ha^{-1}) and NCC-NWT (17.5 kg ha^{-1}), which did not differ. Soil BD in WT was 1.1 times greater than the other two placements, while SOM content was greater in CC-WT (30.7 Mg ha^{-1}) than in all other treatment-placement combinations, except for CC-NWT, which did not differ. Similarly, WSA concentration was 2.3 and 1.6 times greater in the CC-NWT and CC-WT combinations, respectively, which did not differ, compared to their corresponding placements under NCC. Though many soil properties did not significantly differ between CC treatments due to the collective variations in background management practices, CC and cash crop species grown, and CC duration, which ranged from less than one year to greater than 19 years, results of this study clearly demonstrated that CC positively affect physical, chemical, and hydraulic properties across a large area. With continued management using CC, soil property differences that were only numeric will likely continue to deviate from one another into the future, at which time the fuller benefits of long-term CC use may be realized.

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Chapter 2

Introduction

Cover crops (CC) are grasses, forbs, or legumes typically grown between cropping seasons after a cash crop has been harvested. In Arkansas, most CC are planted in the fall after cash crop harvest, grown in the winter and terminated sometime in the spring at or before planting summer cash crops. Cover crops can also be grown in the summer when fields would typically be left fallow or in tandem with cash crops (Roberts et al., 2018). Leaving the soil fallow can exacerbate erosion and crusting that lead to soil loss, nutrient loss, decreased infiltration, diminished aggregate stability, and lower soil water content (Blanco and Lal, 2008). The benefits CC impart on soil and hydraulic properties are well known and have been widely studied in certain areas of the United States (Dabney et al., 2001; NRCS-USDA, 2016; NRCS-USDA, 2018; Blanco-Canqui and Ruis, 2020). However, due to the dynamic nature of soil processes and the relatively greater, inherent variability of soil hydraulic processes, the magnitude of, and length of time before, soil enhancements are realized can be region-specific.

Cover crops benefit soil properties in many ways, including through nutrient retention and soil organic matter (SOM) additions. By utilizing excess nutrients not taken up by the preceding cash crop, CC keep nutrients in place (Dabney et al., 2001), while leguminous CC can fix extra nitrogen (N) into soil, lowering fertilizer demands (McVay et al., 1989; Roberts et al., 2018). Additionally, decomposing above- and belowground biomass act as natural organic soil amendments (Blanco and Lal, 2008). Aboveground plant biomass and residues provide soil cover that protects topsoil from the erosive forces of water and wind (Blanco and Lal, 2008; Blanco-Canqui et al., 2013; Marzen et al., 2016). Furthermore, belowground roots (i.e., living and decomposing roots) provide increased pathways for infiltrating water and access to the deeper soil profile to increase water storage capacity. Plant root additions from CC also promote greater soil microbial diversity and abundance and mycorrhizal fungi excretions (Locke et al., 2012). When SOM (Six et al., 2000) and fungi excretions in the soil increase, soil aggregation is enhanced. Soil aggregation promotes water infiltration by maintaining conductive pore space at the surface for water to enter rather than remaining at the surface to potentially run off. Aggregation is especially important for loessial and alluvial soils located in the Lower Mississippi River Valley (LMRV) of eastern Arkansas that are particularly prone to erosion due to the dominantly fine particle-size distributions.

According to the United States Department of Agriculture's (USDA) Census of Agriculture, land in farms in Arkansas for 2017 totaled > 5 million ha, of which harvested cropland was almost 3 million ha, and irrigated harvested cropland was almost 2 million ha (NASS-USDA, 2017). Arkansas' portion of the LMRV constitutes 42% of state agricultural sales, with 78% of that coming from crops (NASS-USDA, 2017). Intensive cultivation of crops, commonly soybeans (*Glycine max sp.*), cotton (*Gossypium hirsutum* L.), corn (*Zea mays*), and rice (*Oryza sativa*), on highly erodible lands imposes challenges on the LMRV soil and water resources. Much of the land in the LMRV is prone to water erosion due to the cultivated agriculture land use, repetitive use of heavy farm machinery causing soil compaction, and proximity to the Mississippi River (Hassan et al., 2017). Some of the soils in this area are loessial, thus are also prone to wind erosion (Blanco-Canqui et al., 2013; Marzen et al., 2016).

Despite well-documented benefits, CC use in the LMRV region of eastern Arkansas remains low and under-studied (Kroger et al., 2012), with only approximately 5% of farmland under CC (NASS-USDA, 2017). The LMRV is an area historically dominated by intensive cultivated agriculture, with soils prone to erosion, and where the need for irrigation has led to unsustainable aquifer withdrawals (Reba et al., 2017). Given that CC impacts can be site-specific

(Blanco-Canqui and Ruis, 2020), it is important to document CC benefits to soil health and crop production within specific regions.

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Chapter 1

Literature Review

Literature Review

Cover Crops

Cover crops (CC) are grasses, forbs, or legumes typically grown between cropping seasons after a cash crop has been harvested. In Arkansas, most CC are planted in the fall after cash crop harvest, grown in the winter and terminated sometime in the spring at or before planting summer cash crops. Cover crops can also be grown in the summer when fields would typically be left fallow or in tandem with cash crops (Roberts et al., 2018). Winter cereals, such as wheat (*Triticum aestivum*), cereal rye (*Secale cereale* L.), and barley (*Hordeum vulgare*), and winter legumes, such as clover (*Trifolium spp.*) and hairy vetch (*Vicia villosa* Roth), are common CC used to improve soil quality (Blanco and Lal, 2008). Oftentimes, after crops are harvested, cultivated soils are left fallow and bare through winter or summer months. While leaving the soil fallow can allow weeds to germinate and grow, acting as a naturally occurring but shallow-rooted CC, erosion and crusting that lead to soil loss, nutrient loss, decreased infiltration, diminished aggregate stability, and lower soil water content can occur (Blanco and Lal, 2008). The benefits CC impart on soil and hydraulic properties are well known and have been widely studied in certain areas of the United States (Dabney et al., 2001; NRCS-USDA, 2016; NRCS-USDA, 2018; Blanco-Canqui and Ruis, 2020). However, due to the dynamic nature of soil processes and the inherent variability of soil hydraulic processes, the magnitude of, and length of time before, soil enhancements are realized can be region-specific.

Cover Crop Effects on Soil Properties

Cover crops benefit soil properties in many ways, including through nutrient retention and soil organic matter (SOM) additions. Cover crops utilize excess nutrients not taken up by preceding crops, keeping nutrients in place (Dabney et al., 2001). Leguminous CC fix extra nitrogen (N) into soil as ammonium (NH_4^+), a plant available form, for immediate uptake by succeeding cash crops, resulting in lower fertilizer demands (McVay et al., 1989; Roberts et al., 2018). Additionally, CC act as a natural organic soil amendment at all plant residue decomposition stages (i.e., undecomposed to fully decomposed; Blanco and Lal, 2008; Blanco-Canqui and Ruis, 2020). Undecomposed plant residue provides a mulch layer that protects surface soil horizons erosion, while CC plant residue can provide additional, important post-harvest soil cover for low-residue crops (Blanco and Lal, 2008). Unharvested CC are green manures (Blanco and Lal, 2008) that decompose in place, cycling nutrients back into cultivated agriculture soil systems. If the aboveground CC biomass is harvested, CC roots remain to contribute organic matter (OM) to the soil (Moore et al., 2013; Locke et al., 2012). Additional OM in the soil can decrease soil bulk density (BD), which can, over time, offset soil compaction caused by repetitive use of farm implements and machinery (Blanco-Canqui and Ruis, 2020). Furthermore, belowground roots (i.e., living and decomposing roots) provide increased pathways for infiltrating water and access to the deeper soil profile to increase water storage capacity. Soil microbial diversity is limited in monoculture cropping systems. Adding CC diversifies the soil biome and improves soil health by promoting greater soil microbial diversity and abundance and mycorrhizal fungi excretions (Locke et al., 2012).

A long-term study of cotton (*Gossypium hirsutum* L.) production in the Lower Mississippi River Valley (LMRV) region showed greater microbial diversity in the upper 2 cm of soil in CC systems versus no cover crop (NCC; Locke et al., 2012). A greater abundance of microbial activity occurred in cotton roots under CC treatments. Additionally, a symbiotic relationship between plant roots and mycorrhizal fungi promoted soil aggregate formation (Locke et al., 2012).

As SOM (Six et al., 2000) and fungi excretions in the soil increase, soil aggregation is enhanced. The fungi excretions act as a glue to hold the soil together. Boswell et al. (1998) determined correlations between corn (*Zea mays* L. cv. 'Bodacious') yield and mycorrhizal fungi increases from CC treatments. The number of ears per plant increased 20% in CC versus NCC, with 1.5 and 1.3 ears, respectively, contributing to a 104% increase in grain dry weight per plant for CC versus NCC (18.4 g and 9.0 g, respectively; Boswell et al., 1998). Cover crops left in place crowd out weeds, preventing establishment (DeVore et al., 2013). Some CC suppress weed development, although the suppression can be plant-specific (Creamer et al., 1996).

Vegetation functions as a barrier between rainfall events and soil, protecting soil aggregates from erosive impacts of water (Blanco-Canqui et al., 2013). Coverage also reduces wind erosion (Blanco-Canqui et al., 2013) and, most erosive, wind-driven rain erosion (Marzen et al., 2016), acting as a buffer for highly erodible loess and alluvial soil. Soil aggregation promotes water infiltration by maintaining conductive pore space at the surface for water to enter rather than remaining at the surface to potentially run off. Aggregation is especially important for loessial and alluvial soils that are particularly prone to erosion due to the dominantly fine particle-size distributions.

Infiltration

Infiltration is an important hydraulic property responsible for the amount of water that enters the soil surface. Water infiltration into the soil is controlled by gravitational and soil matric forces. A soil's ability to allow water to infiltrate affects the amount of water immediately available for plant growth, nutrient transport to plant roots, and, paired with pore space, the amount of water stored in the soil (Blanco and Lal, 2008; Kirkham, 2014). Increasing soil infiltration makes water and water-soluble nutrients available for plant uptake and has the potential to promote aquifer recharge (NRCS-USDA, 2016), especially in groundwater-irrigated agroecosystems. In a review of CC and soil physical properties, Blanco-Canqui and Ruis (2020) noted either improved infiltration or improved cumulative infiltration under CC in 14 of the 17 infiltration studies reviewed. Similarly, another literature review on the effects of soil health management practices on soil hydraulic properties stated that, overall, CC generally improve infiltration due to benefits from increased aboveground canopy cover, soil aggregation improvement, and an increase in macropores from the belowground root systems (NRCS-USDA, 2016).

While many studies have shown a significant increase in infiltration under CC compared to NCC treatment (Meek et al., 1992; Kaspar et al., 2001; Steele et al., 2012; Nouri et al., 2019), the Blanco-Canqui and Ruis (2020) review notes that the extent of infiltration is widely variable likely due to variation in site-specific management. Infiltration is linked to other properties; therefore, infiltration improvements may not occur until other soil properties (i.e., BD, aggregate stability, and porosity) improve (Blanco-Canqui and Ruis, 2020). This is supported by an infiltration study on the effects of traffic, tillage, and plant roots on a sandy-loam soil with a 3-yr CC treatment (Meek et al., 1992), where infiltration decreased across treatments with increased BD from wheel compaction.

One study also noted that additional root channels from CC may not improve infiltration until live roots decompose leaving root channels vacant (Gish and Jury, 1983). The live roots block root channels and/or, while growing, rearrange pore-size distribution indicating some time must pass before CC roots decompose and benefit soil hydraulic properties (Gish and Jury, 1983). Across soil physical properties (i.e., BD, penetration resistance, dry aggregate stability, wet aggregate stability, macroporosity, infiltration, saturated hydraulic conductivity, field capacity water content, and available water content) evaluated in 98 peer-reviewed publications, CC species and duration were noted as having the greatest impact on infiltration and saturated hydraulic conductivity, with greater infiltration in >10-yr CC duration and CC grasses or CC mixes (Blanco-Canqui and Ruis, 2020).

Aggregate Stability

Soil structure consists of the size and arrangement of soil particles and the distribution of soil pore space. Soil aggregates form through interactions between various soil components (i.e., clay particles, SOM, plant roots, and plant root and soil fauna exudates; Oades, 1984). Soil OM additions enhance soil aggregation that, in turn, increases aggregate size by binding smaller, microaggregates together into larger macroaggregates (Puget et al., 2000; Six et al., 2000). Soil aggregates and soil structure can also be destroyed through tillage, repetitive wheel traffic, and low OM inputs that result in greater organic acid inputs, which lead to more soluble OM, loss of water-stable aggregates (WSA), and clay dispersion (Oades, 1984).

Soil WSA are an indicator of near-surface soil structure, which can change rapidly in response to cultivated agricultural management (Blanco-Canqui and Ruis, 2020). In a review on CC impacts on soil properties, CC increased WSA by 0.5 to 22% in 15 of 29 study locations (Blanco-Canqui and Ruis, 2020). Similarly, soil WSA increased by 20 to 35% during the first year and by 37 to 41% the second year in silt-loam soils under CC in humid, temperate Coastal Plain and Piedmont regions of Maryland (Steele et al., 2012). Blanco-Canqui et al. (2013) also reported increased dry and wet aggregate diameter in CC treatments compared to fallow treatments up to a 7.5-cm depth in a silt-loam soil in Garden City, KS.

McVay et al. (1989) reported greater WSA concentrations of 37.9% and 36.7% by weight in CC treatments compared to 28.9% by weight in fallow in a sandy-clay-loam soil in the Coastal Plain regions of Georgia. Research by Villamil et al. (2013) and Rachman et al. (2003) correlated increases in aggregate stability with CC treatments. Villamil et al. (2006) studied a corn/soybean (*Glycine max sp.*) no-tillage system in Illinois on silt-loam soils with 100 to 150 cm loess over loamy glacial till. Winter fallowing was utilized as the control, with various CC combinations used in crop rotations. The study reported greater WSA in CC treatments (41, 43, and 44 g g^{-1}) compared to corn-fallow/soybean-fallow (38 g g^{-1}; Villamil et al., 2006). Additionally, in a cropping system and soil erodibility study on a silt-loam soil in north-central Missouri, Rachman et al. (2003) reported significant increases in aggregate stability in cropping systems that converted from continuous wheat or corn to corn-wheat rotations that included CC. A 34-year study on cultivated cotton using CC and NCC on a silt-loam soil in western Tennessee resulted in greater macroaggregate (> 2 mm) fractions in CC than NCC (Nouri et al., 2019). Cover crops yielded 55.1% and 56.5% macroaggregate abundance in the 0- to 15-cm depth and 49.3% and 44.8% in the 15- to 30-cm depth, while NCC yielded macroaggregate (> 2 mm) fractions of 43.7% and 37.8% in the 0- to 15- and 15- to 30-cm depth, respectively (Nouri et al., 2019).

A residue and water management study on a silt-loam soil under long-term soybean-wheat rotations in the LMRV region of east-central Arkansas reported that WSA concentration in the 0- to 10-cm depth interval decreased with increasing aggregate-size class (Smith et al., 2014). After 10 complete soybean-wheat cropping cycles, total WSA (TWSA) in the top 10 cm were greater under low fertility/residue compared to high fertility/residue treatment, where lower mineral-N additions allowed for slower microbial decomposition while belowground roots remained in the soil after aboveground biomass was burned to provide additional OM to the soil (Smith et al., 2014).

Water Retention

Water content is a measure of the amount of water in a soil that is held by matric forces, controlling the amount of water within the soil available for plant uptake (Kirkham, 2014). Cover crops potentially can change the amount of water a soil can store by extending the soil water profile deeper with vacated root channels from deep-rooting crops. Additionally, water retention potentially increases when crop residues are left on the soil surface, creating surface roughness to slow water and increase infiltration (Unger and Vigil, 1998). Timing of CC termination in humid regions correlates to increased water storage, where residues are left on the surface to shade and protect the soil from runoff and erosion, but the living CC is no longer taking up soil water, making that soil water available to the cash crop that follows (Unger and Vigil, 1998; NRCS-USDA, 2018).

Surface CC residues and living CC can lower near-surface soil temperatures in the spring and summer and increase soil temperature in the winter (Blanco and Lal, 2008; Blanco-Canqui and Ruis, 2020). Lower soil surface temperature is important in regions with hot summer temperatures, as lowering the near-surface soil temperature can decrease evaporation and slow SOM decomposition, which can potentially increase soil water retention, while insulating the soil surface in the winter to raise near-surface soil temperatures can aid seed germination in the spring and continued biological processes throughout the winter (Dabney et al., 2001; Blanco-Canqui and Ruis, 2020). Overall, CC have a larger impact on daytime temperatures than nighttime temperatures (Blanco-Canqui and Ruis, 2020) likely due to shade provided by canopy cover and/or a mulching effect by residue cover.

Several studies have noted the effectiveness of CC on water retention through plant-available water (PAW). A study on long-term CC use for soil water improvements in a loam soil managed as a corn-soybean rotation with 13 years of rye CC and a NCC treatment in central Iowa reported greater PAW in the upper 15 cm under CC compared to NCC (Basche et al., 2016). In the study, CC increased PAW by at least 21% (Basche et al., 2016). Similarly, a CC study on soil physical properties in a loamy-sand soil in Georgia documented an effect of measurement placement over a 3-yr sampling period, with PAW greater in the raised bed compared to in the wheel-track furrow (WT; Hubbard et al., 2013). Villamil et al. (2006) also reported similar results in the 3- to 10-cm soil depth interval in a silt-loam soil in east-central Illinois. The study examined a corn-soybean rotation with two years of rye and vetch CC and reported less water was retained at lower tensions under NCC than all CC treatments and lower PAW under NCC than under all CC treatments (Villamil et al., 2006). A treatment-depth effect was observed by Keisling et al. (1994) on a silt-loam soil in the LMRV region of south-west Tennessee. The study with 17 years of rye, hairy vetch, and white lupine (*Lupinus albus* L.) CC with cotton reported significantly greater PAW in the rye-vetch treatment in the 0- to 10-cm soil depth compared to NCC in the same depth, noting that the increased water retention in the CC treatment translated to greater PAW for the cotton cash crop (Keisling et al., 1994). In general, CC provide an opportunity for better soil management and the production of resilient soils that retain water in dry years and moderate soil temperature fluctuations.

Lower Mississippi River Valley (LMRV)

The LMRV occupies eastern Arkansas, western Mississippi, and eastern Louisiana. The area lies along the Mississippi River and topographically is composed of stream terraces and floodplains within broad alluvial valleys (West et al., 2017). The LMRV region is characterized by fertile, highly erodible loessial and alluvial soils that contribute to sedimentation of the Mississippi River (Kroger et al., 2012). Dominant soil orders are Entisols, Inceptisols, Alfisols, and Vertisols, with most soils trending toward somewhat poorly to poorly drained, with some natural levees and terraces being moderately well- and well-drained (West et al., 2017). The regional climate is hot and humid (i.e., temperate to subtropical classification) with long, hot summers and short, mild winters and precipitation distributed throughout the year and generally ranging from 1100 to 1600 mm (West et al., 2017). Historically, the LMRV is an area dominated by intensive cultivated agriculture, with soils prone to erosion, and where the need for irrigation has led to unsustainable aquifer withdrawals (Reba et al., 2017).

According to the United States Department of Agriculture's (USDA) Census of Agriculture, land in farms in Arkansas for 2017 totaled > 5 million ha, of which harvested cropland was almost 3 million ha, and irrigated harvested cropland was almost 2 million ha (NASS-USDA, 2017). Arkansas' portion of the LMRV constitutes 42% of state agricultural sales, with 78% of that coming from crops (NASS-USDA, 2017). Intensive cultivation of crops, commonly soybeans, cotton, corn, and rice (*Oryza sativa*), on highly erodible lands imposes challenges on the LMRV soil and water resources. This land is prone to water erosion due to the cultivated agriculture land use, repetitive use of heavy farm machinery causing soil compaction, and the proximity to the Mississippi River (Hassan et al., 2017). Some of the soils in this area are loessial, thus are also prone to wind erosion (Blanco-Canqui et al., 2013; Marzen et al., 2016).

Due to periods of drought, irrigation is supplemented with groundwater from the relatively shallow, unconfined Mississippi River Alluvial Aquifer (MRAA). Precipitation is the primary means of groundwater recharge. Although positive average recharge in reports at 1-, 5-, and 10-yr intervals (2019-, 2015-, and 2010-2020, respectively) groundwater levels continue to decline, especially in areas with the greatest use for both the MRAA and an underlying aquifer (i.e., Sparta Aquifer; NRD-ADA, 2020). Of about 50,000 wells registered [i.e., produce > 189,000 L d^{-1} (≥ 50,000 gal d^{-1})] in Arkansas with the AR Department of Agriculture's Natural Resources Division, > 97% are agricultural wells for irrigation in eastern Arkansas (NRD-ADA, 2020). In 2018, almost 29,000 ML d^{-1} (7,500 Mgal d^{-1}) of groundwater were used for irrigation, when the estimated sustainable yield of the MRAA is approximately 12,800 ML d^{-1} (3,300 Mgal d^{-1}; NRD-ADA, 2020). With water-intensive crop cultivation increasing, aquifer recharge has become a challenge (Reba et al., 2017; NRD-ADA, 2020). Despite well-documented benefits, CC use in the LMRV region of eastern Arkansas remains low and under-studied (Kroger et al., 2012), with only approximately 5% of farmland under CC (NASS-USDA, 2017).

Justification

Given that CC impacts can be site-specific (Blanco-Canqui and Ruis, 2020), it is important to document CC benefits to soil health and crop production within specific regions. Site-specific research into CC on historically intensively cultivated agricultural soils will provide quantifiable evidence reflecting the site-specific benefits CC can provide in the under-studied LMRV region where loessial and alluvial soils are prone to erosion and unsustainable groundwater withdrawals. In an area susceptible to water and wind erosion, nutrient loss, and aquifer depletion, CC may be a tangible solution that conserves soil and water resources that promote aggregate stability and infiltration.

Objectives and Hypotheses

The main objective of this study was to evaluate the effects of CC, with and without a cover crop, on near-surface soil properties, infiltration, water-stable aggregation, and water retention in loessial and alluvial soils under cultivated agriculture in the LMRV in eastern Arkansas. Due to the vegetative cover in agroecosystems with CC, OM is added to the soil through the decomposition of CC residue and/or their roots. The CC roots break up sub-soil, creating preferential pathways for water flow, promoting infiltration. Plant roots also promote soil aggregate formation and improved soil structure. Organic matter additions increase soil water-holding capacity, where larger amounts of water can be held in smaller amounts of soil. Therefore, SOM and total C (TC) were hypothesized to be greater in CC compared to NCC treatment. Soil BD was hypothesized to be greater, while overall infiltration rates (OIR) would be lowest, under the NCC compared to the CC treatment. Total WSA and water retention capacity were hypothesized to be greater under the CC than under the NCC treatment.

The secondary objective of this study was to evaluate the effects of CC and sample/measurement placement [top of bed (B), non-wheel-track (NWT) furrow, and wheel-track (WT) furrow] on near-surface soil properties, infiltration, WSA, and water retention using a subset of data from two agroecosystems within one field at a single location in an alluvial soil in the LMRV. Repetitive use of farm implements and machinery can compact soils over time, destroying soil structure, and forming sub-soil hard pans. Therefore, the SOM and TC were hypothesized to be greater in the bed compared to in the furrows between beds. Soil BD was hypothesized to be greater and infiltration to be lower in WT furrows compared to in the bed and NWT furrows. Water-stable aggregates and water-retention capacity were hypothesized to be lower in WT furrows compared to in the bed and NWT furrows.

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Chapter 2

Cover Crop Effects on Infiltration, Aggregate Stability, and Water Retention on Loessial and Alluvial Soils of the Lower Mississippi River Valley

Abstract

Cover crops are widely considered to improve soil health in the form of erosion control, organic matter additions, and improving water-holding capacity. Despite the well-documented benefits, cover crops remain under-studied in the Lower Mississippi River Valley (LMRV), an area historically dominated by intensive cultivated agriculture, with soils prone to erosion, and where the need for irrigation has led to unsustainable aquifer withdrawals. The main objective of this study was to evaluate the effects of cover crops [with cover crops (CC) and without cover crops (NCC)] on near-surface soil physical/chemical- and infiltration-related properties, aggregate stability, and water retention. The secondary objective of this study was to evaluate the effects of sample/measurement placement [in the bed (B) and in the wheel-track (WT) and non-wheel-track (NWT) furrow] in adjacent CC and NCC treatments on the same soil under wide-row cotton (*Gossypium hirsutum* L.) production. Soil samples were collected and in-situ measurements were conducted between May 2018 and May 2019 across four locations within the LMRV portion of eastern Arkansas. Using a falling-head, double-ring infiltrometer method for 20 minutes, overall- and steady-state infiltration rates were unaffected ($P > 0.05$) by cover-crop treatment. Across all locations, extractable soil Na content in the top 10 cm was greater ($P \leq 0.05$) with NCC (31.6 kg ha^{-1}) compared with CC (21.6 kg ha^{-1}). Soil pH, electrical conductivity (EC), total C (TC), soil organic matter (SOM), and bulk density (BD) in the top 10 cm were also unaffected ($P > 0.05$) by cover-crop treatment. However, EC and BD were numerically greater with NCC compared to CC, while TC and SOM were numerically greater with CC compared to NCC. Based on a wet-sieving approach for five minutes, averaged across cover treatment and soil depth (0- to 5- and 5- to 10-cm), water-stable aggregate (WSA) concentration differed ($P \leq 0.05$) by aggregate size class. Averaged across treatment and soil depth (0- to 5- and 5- to 10-

cm), WSA concentration in the 0.25- to 0.5- (0.101 g g^{-1}) was 1.5 times greater than that in the 1.0- to 2.0-mm size class (0.068 g g^{-1}) and was at least 1.2 times greater than that in the 0.5- to 1.0- (0.079 g g^{-1}) and 2.0- to 4.0-mm (0.084 g g^{-1}) size classes, which were intermediate. Averaged across treatment and soil depth, WSA concentration in the > 4.0- (0.097 g g^{-1}) was at least 1.2 times greater than that in the 0.5- to 1.0- and 1.0- to 2.0-mm size classes, which did not differ, while WSA concentration in the 2.0- to 4.0- was 1.2 times greater than that in the 1.0- to 2.0-mm size class. Extractable soil Na content was greater ($P = 0.03$) in NCC-WT (26.8 kg ha^{-1}) and CC-WT (26.7 kg ha^{-1}), which did not differ, than NCC-B (19.8 kg ha^{-1}) and NCC-NWT (17.5 kg ha^{-1}), which did not differ. Soil BD in WT was 1.1 times greater than the other two placements, while SOM content was greater in CC-WT (30.7 Mg ha^{-1}) than in all other treatment-placement combinations, except for CC-NWT, which did not differ. Similarly, WSA concentration was 2.3 and 1.6 times greater in the CC-NWT and CC-WT combinations, respectively, which did not differ, compared to their corresponding placements under NCC. Though many soil properties did not significantly differ between CC treatments due to the collective variations in background management practices, CC and cash crop species grown, and CC duration, which ranged from less than one year to greater than 19 years, results of this study clearly demonstrated that CC positively affect physical, chemical, and hydraulic properties across a large area. With continued management using CC, soil property differences that were only numeric will likely continue to deviate from one another into the future, at which time the fuller benefits of long-term CC use may be realized.

Introduction

Cover crops (CC) are a living, vegetative cover that protect and may improve soil functions for plant growth by promoting greater nutrient cycling, infiltration, water movement and storage, and increased biodiversity in microbiology. Cover crops can be grasses, forbs, or legumes that are typically grown between cropping seasons when fields are left fallow in the summer and/or during winter. Additionally, CC may grow in tandem with cash crops (Roberts et al., 2018). When soil is left bare, potential erosion and crusting may lead to soil and nutrient loss, decreased infiltration, diminished aggregate stability, and lower soil water content. The benefits CC impart on soil and hydraulic properties are well known and have been widely studied in certain areas of the United States (Dabney et al., 2001; NRCS-USDA, 2016; NRCS-USDA, 2018; Blanco-Canqui and Ruis, 2020). However, due to the dynamic nature of soil processes and the inherent variability of soil hydraulic processes, the magnitude of, and length of time before, soil enhancements are realized can be region-specific.

Cover crops benefit soil properties in many ways, including through nutrient retention and soil organic matter (SOM) additions. By utilizing excess nutrients not taken up by the preceding cash crop, CC keep nutrients in place (Dabney et al., 2001), while leguminous CC can fix extra nitrogen (N) into soil, lowering fertilizer demands (McVay et al., 1989; Roberts et al., 2018). Additionally, decomposing above- and belowground biomass act as natural organic soil amendments (Blanco and Lal, 2008). Aboveground plant biomass and residues provide soil cover that protects top soil from the erosive forces of water and wind (Blanco and Lal, 2008; Blanco-Canqui et al., 2013; Marzen et al., 2016). Furthermore, belowground roots (i.e., living and decomposing roots) provide increased pathways for infiltrating water and access to the deeper soil profile to increase water storage capacity. Plant root additions from CC also promote greater soil microbial diversity and abundance and mycorrhizal fungi excretions (Locke et al., 2012). When SOM (Six et al., 2000) and fungi excretions in the soil increase, soil aggregation is enhanced. Soil aggregation promotes water infiltration by maintaining conductive pore space at the surface for water to enter rather than remaining at the surface to potentially run off. Aggregation is especially important for loessial and alluvial soils that are particularly prone to erosion due to the dominantly fine particle-size distributions.

Despite well-documented benefits, CC use in the Lower Mississippi River Valley (LMRV) region of eastern Arkansas remains low and under-studied (Kroger et al., 2012), with only approximately 5% of farmland under CC (NASS-USDA, 2017). The LMRV is an area historically dominated by intensive cultivated agriculture, with soils prone to erosion, and that is suffering from unsustainable aquifer withdrawals (Reba et al., 2017). Given that CC impacts can be site-specific (Blanco-Canqui and Ruis, 2020), it is important to document CC benefits to soil health and crop production within specific regions. Consequently, this study was conducted to fill a research gap within the LMRV region of eastern Arkansas. Furthermore, due to the amount of intensive cultivated agriculture in the LMRV region of eastern Arkansas and the repetitive use of heavy farm machinery, soil compaction is a potential issue that could be mitigated by CC use. Soil compaction destroys soil structure and forms sub-soil hard pans that can result in yield and monetary losses for producers (Daigh et al., 2020). The main objective of this study was to evaluate the effects of CC treatment (i.e., with and without a CC) on near-surface soil properties, infiltration, water-stable aggregation (WSA), and water retention in loessial and alluvial soils under cultivated agriculture in the LMRV in eastern Arkansas. It was hypothesized that SOM and total C (TC) would be greater under CC compared to under no cover crop (NCC). It was also hypothesized that soil bulk density (BD) would be greater, while overall infiltration rate (OIR) would be lower, under NCC compared to CC. Additionally, it was hypothesized that total WSA (TWSA) and water retention capacity would be greater under CC than NCC.

The secondary objective of this study was to evaluate the effects of CC and sample/measurement placement [i.e., top of bed (B), non-wheel-track (NWT) furrow, and wheel-track (WT) furrow] on near-surface soil properties, infiltration, WSA, and water retention in an alluvial soil in the LMRV. It was hypothesized that SOM and TC would be greater in the bed compared to in the furrows between beds. It was also hypothesized that soil BD would be greater and infiltration would be lower in WT furrows compared to in the bed and NWT furrows. Additionally, it was hypothesized that WSA and water retention capacity would be lower in WT furrows compared to in the bed and NWT furrows.

Materials and Methods

Site Descriptions

Research was conducted between May 2018 and May 2019 across four LMRV locations that possessed varying crop-CC and crop-NCC combinations (Table 1). Sampling locations were in Cotton Plant, Marianna, Helena, and Dumas in eastern Arkansas (Figure 1). Three locations were privately-owned land (i.e., Cotton Plant, Dumas, and Helena), while one location had two separate research studies at an agricultural research station (i.e., Marianna).

Research was conducted at the Chappell location (Figure 2), near Cotton Plant, AR ($35^o0'52.61''$ N, $91^o13'30.01''$ W) in late May 2018 on a Mississippi River terrace on a Teksob loam soil (Fine-loamy, mixed, active, thermic Typic Hapludalf; SSS-NRCS-USDA, 2019) in three adjacent fields. In two fields, the agroecosystems consisted of drill-seeded, dryland soybeans (*Glycine max*) with 19-cm row spacing under no-tillage management with one field in switchgrass (*Panicum virgatum*) as the CC and the second without a CC. Both fields were in corn (*Zea mays*) the previous year. The third field consisted of a cultivated, twin-row, furrow-irrigated soybean agroecosystem with 76-cm-row-spaced, raised beds, where tillage occurred in Fall 2017, in year one of cereal rye (*Secale cereale*) as the CC.

Research was conducted at the Taylor location (Figure 3), near Helena, AR in late May 2018 in four fields in the Mississippi River floodplain. One area (34^{o}29’52.40” N, 90^{o}37’42.49” W) consisted of two adjacent fields on a Henry silt loam (Coarse-silty, mixed, active, thermic Typic Fragiaqualf; SSS-NRCS-USDA, 2013b). One field consisted of non-land-leveled, non-bedded, conventionally tilled, and irrigated soybeans with 76-cm row spacing with NCC, while the adjacent field was non-land-leveled, bedded, conventionally tilled, furrow-irrigated soybeans with 76-cm row spacing with cereal rye planted annually since the mid-1990s. Both fields had soybeans the previous year. The third and fourth areas were on opposite ends of the same field (34^{o}28’58.24” N, 90^{o}37’58.78” W) on a Commerce silt loam (Fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquept; SSS-NRCS-USDA, 2013a) cropped to a furrow-irrigated, conventionally tilled, corn-soybean rotation, with corn planted on raised beds with 76-cm row spacing in 2018, with cereal rye and turnip (*Brassica rapa*) as the CC mix.

Research was conducted at the University of Arkansas, Division of Agriculture's Lon Mann Cotton Research Station (LMCRS; Figure 4), near Marianna, AR in late November 2018 in two fields. One field (34^{o}43’46.72” N, 90^{o}44’39.58” W), on a Memphis silt loam (Fine-silty, mixed, active, thermic Typic Hapludalf; SSS-NRCS-USDA, 2018b), contained a multi-year, small-plot, furrow-irrigated soybean research study (LMCRS-1) with multiple CC treatments, including hairy vetch (*Vicia sp.*) and canola (*Brassica napus* cv. ‘Coahoma’) since 2015, cereal rye since Fall 2017, and a NCC fallow treatment, which was lightly disked each spring prior to soybean planting (Dr. John Rupe, personal communication, July 18, 2020). The study area was conventionally tilled prior to raised bed and CC establishment in 2015, with soybeans and CC drill-seeded without tillage annually thereafter with 96.5-cm bed spacing (Dr. John Rupe, personal communication, July 18, 2020). The second field (34°43’37.43” N, 90°45’28.46” W), on a Calloway silt loam (Fine-silty, mixed, active, thermic Aquic Fraglossudalf; SSS-NRCS-USDA, 2018a), contained another research study (LMCRS-2), but with cotton (*Gossypium spp.*) (Smartt et al., 2020) on raised beds with 96.5-cm row spacing, with and without cereal rye as a CC treatment (Slaton et al., 2018). Conventionally tilled, furrow-irrigated corn was cropped to the second field during the previous year (Slaton et al., 2018).

Research was conducted at the Stevens location (Figure 5), near Dumas, AR in late May 2019 in three fields on a Hebert silt loam (Fine-silty, mixed, active, thermic Aeric Epiaqualf; SSS-NRCS-USDA, 2002). One field (33°49’15.77” N, 91°20’28.16” W) was cropped to wide-row, furrow-irrigated cotton on raised beds, with 97.3-cm row spacing and 60-cm furrow widths, with one area with a cereal rye CC for the previous five years and cotton planted as no-tillage and an adjacent area without a CC treatment and cotton planted after minimum tillage. A second field (33°49’24.87” N, 91°19’56.08” W) was cropped with minimally tilled, furrow-irrigated cotton on narrow-spaced (96.5-cm row spacing with 60-cm furrow widths), raised beds with one area with two years of a cereal rye CC and an adjacent area without a CC treatment. Additional details regarding management practices of these two fields are described in Daniels et al. (2019). The third field (33°48’56.89” N, 91°18’58.24” W) consisted of non-tilled, drill-seeded, twin-row, dryland soybean, with 76.2-cm furrow widths, with two years of cereal rye as the CC. Across all locations where CC were present, the CC were chemically terminated prior to planting the summer cash crop, with the exception of the LMCRS multi-year soybean study with multiple CC treatments where the CC were incorporated by disking several weeks prior to planting (Dr. John Rupe, personal communication, July 18, 2020).

A total of 18 agroecosystems, 12 with CC and 6 without CC, were sampled from four locations. Among all agroecosystems, a total of 33 individual measurement and soil sample locations existed with a history of cover cropping with a variety of species and for various durations, while a total of 21 individual locations existed without CC.

Across the four locations included in this field study, the regional, 30-year mean annual air temperature (1981 to 2010) ranged from 16.1^{o}C to 17.3^{o}C (Table 2; NOAA, 2010). The 30-year mean annual precipitation throughout the region ranged from 123 to 129.4 cm (Table 2; NOAA, 2010). The 30-day precipitation totals prior to each sampling date, across the four locations, ranged from 5.9 to 17.2 cm, with Stevens having the greatest and Chappell having the least 30-day precipitation totals (Table 2; NCEI, 2021). Additionally, the 15-day precipitation totals prior to each sampling date ranged from 3.0 to 9.2 cm, with Taylor having the greatest and LMCRS-1 and -2 having the least precipitation, while 7-day precipitation totals prior to each sampling date ranged from 0 to 9.2 cm, with Taylor having the greatest and Stevens having the least precipitation (Table 2; NCEI, 2021). Daily precipitation observation stations were within 6 km of three locations, except Chappell, where the observation station was within 24 km.

Infiltration Measurements

Similar to procedures used recently by Desrochers et al. (2019a) and Anderson et al. (2020), infiltration measurements were conducted at the four locations on five dates between late May 2018 and late May 2019 (Table 1). The same procedures were used at each location, with random sampling points chosen within each agroecosystem. A falling-head, double-ring infiltrometer (model IN7-W, Turf-Tec International, Tallahassee, FL), with a 15-cm inner-ring diameter, was inserted to a depth of approximately 2 cm into the soil surface. If raised beds were present, the infiltrometer was inserted on top of the raised bed. To prevent water leakage from both rings and lateral flow from the inner ring, soil was pressed against the outside around the perimeter of the outer and inner rings. Prior to infiltration measurements, three volumetric soil-water-content measurements from the top 6 cm were recorded for antecedent-soil-water content (ASWC) from within the outer ring of the infiltrometer using a Theta Probe (model TH 300, Dynamax Inc., Houston, TX) and a hand-held readout unit (HH2 Moisture Meter, Delta-T Devices Ltd., Cambridge, UK).

After completing ASWC measurements, a ruler was mounted to the inside of the infiltrometer’s inner ring with the 0-mm mark at the soil surface. The outer ring was then filled, and kept filled, with tap water to within 2 cm of the top of the outer ring. The inner ring was then filled with water to within 2 cm of the top, a timer was started, and an immediate measurement of the water height within the inner ring was recorded as Time 0. Subsequent water-height measurements were recorded at 1, 2, 3, 4, 5, 8, 10, 12, 15, 18, and 20 minutes. If water in the inner ring completely infiltrated before reaching 20 minutes, the time of complete infiltration was recorded. Infiltration measurements were conducted in triplicate for each agroecosystem.

At the Stevens location, additional infiltration measurements were made in triplicate in NWT and WT areas under CC and NCC treatment in one field. The extra measurements constituted a sub-study to evaluate the effect of CC/NCC and sample/measurement placement (i.e., B, NWT, and WT) on near-surface soil properties and processes.

The OIR, the infiltration rates between each time point, and the natural logarithm (LN) of the infiltration rates between each time point were calculated for each agroecosystem replicate.

Overall infiltration rate was calculated by subtracting the final from the initial water height, then dividing by 20 minutes, or the time of complete infiltration if less than 20 minutes. The infiltration rate between each time point was calculated in a similar manner as the OIR, then the LN of the infiltration rate between each time point was linearly regressed against the mid-point of time (i.e., 0.5, 1.5, 2.5, 3.5, 4.5, 6.5, 9, 11, 13.5, 16.5, and 19 minutes) using Excel (Office 365 Pro Plus, Microsoft, Redmond, WA). If the infiltration rate between each time point was equal to 0, the LN could not be calculated; thus, that data point was not included in the data set for the linear regression. The slope, intercept, and coefficient of determination (R^2) from each individual linear regression were recorded. The steady-state infiltration rate (SSIR) was approximated as the average of the final two infiltration rates between each time point (i.e., 15 to 18 and 18 to 20 minutes) for each individual infiltration measurement.

Soil Sampling, Processing, and Analyses

Following infiltration measurements, a soil sample was collected from the top 10 cm and within 1 m of each infiltration measurement using a slide hammer with a 4.8-cm-diameter, stainless steel core. At the Stevens location, additional soil samples were collected in triplicate in WT and NWT areas of the CC and NCC treatments in one field.

Soil samples were oven-dried at 70°C for 48 hours and re-weighed. Each oven-dried soil sample mass was divided by the soil sample volume to calculate soil BD. Oven-dried soil was pulverized and passed through a 2-mm sieve for particle-size analysis using a modified, 12-hr hydrometer method (Gee and Or, 2002) and for chemical analyses.

Soil pH and electrical conductivity (EC) were determined potentiometrically with an electrode in a 1:2 (m/v) soil-to-water mixture. Total C and total N (TN) concentrations were determined by high-temperature combustion (Elementar VarioMAX Total C and N Analyzer, Elementar Americans Inc., Mt. Laurel, NJ). Soil organic matter concentrations were determined by weight-loss-on-ignition, combusting soil in a muffle furnace for 2 h at 360^{o}C. All measured soil C was assumed to be organic C, as no soil effervesced when treated with dilute hydrochloric acid. Soil C:N, TN:SOM, and TC:SOM ratios were calculated using the measured TC, TN, and SOM concentrations. Soil was extracted with Mehlich-3 extractant solution in a 1:10 (m/v) soil-to-solution ratio (Tucker, 1992) followed by analysis for extractable nutrient concentrations (i.e., P, K, Ca, Mg, S, Na, Fe, Mn, Zn, and Cu) using inductively coupled plasma-atomic emission spectrometry (ICP-AES; CIROS CCD model; Spectro Analytical Instruments, MA; SERA-IEG-6, 2014). Measured soil concentrations were converted to contents (kg or Mg ha^{-1}) using the measured BD and 10-cm sample depth.

Aggregate Stability

Similar to procedures used by Smith et al. (2014) and Desrochers et al. (2019b), a second soil sample was collected with a 7.4-cm-diameter, stainless steel soil core tip, without an inner sleeve, and slide hammer from the top 10 cm. Samples were collected following and within 1 m of each infiltration measurement, on top of the raised bed if present. At the Stevens location, additional soil samples for aggregate stability were collected in triplicate in NWT and WT areas of the CC and NCC treatments in one field.

The intact core was carefully, manually pushed out of the chamber onto a plastic tray, trimmed to the desired 10-cm length, then cut into the 0- to 5- and 5- to 10-cm depth intervals for aggregate-stability determination. Each soil sample core was gently, manually separated into large chunks, then manually pushed through a 6-mm screen field moist. Sieved samples were left to air dry for approximately 7 days.

Water-stable aggregates were measured using a wet-sieving approach (Yoder, 1936). Air-dried soil from each sample (0- to 5- and 5- to 10-cm depths) was weighed to 150 g (+/- 0.1 g), then processed in a mechanical wet-sieve apparatus at 30 oscillations per minute for 5 minutes. The apparatus contained five, stacked, progressively finer-sized sieves (4.0-, 2.0-, 1.0-, 0.50-, and 0.25-mm). After sieving, the material retained on each sieve was quantitatively transferred to a small, aluminum tray and oven-dried at 70ºC for 24 hours. Coarse fragments were removed from the > 4.0- and 2- to 4-mm samples with a 2-mm sieve or manually with tweezers, then weighed. After coarse fragment removal, each processed, oven-dried sample was weighed and the coarse fragment masses subtracted from their respective > 4.0- and 2- to 4-mm sample masses. Individual WSA fractions (mass/mass) were calculated using the oven-dried soil mass from each aggregate fraction divided by the initial soil mass, which had an estimated gravimetric water content of 2%. The sum of each sample's aggregate-fraction masses was also calculated and divided by the initial soil mass to determine the TWSA fraction per sample.

Water Retention

The impact of CC on water retention was determined using a wetting-curve approach (Brye, 2003; Norman et al., 2015). After processing samples for aggregate stability analyses, a portion of all air-dried soil samples were pulverized and processed through a 2-mm sieve. From each sieved soil sample, 10, 5-g (+/- 0.01g) masses of air-dried soil were weighed into 10 pre-weighed sample cups, to which varying amounts of distilled water (i.e., 1, 2, 4, 6, 10, 12, 15, 20, 30, and 40 drops) were added. Each sample of varied wetness was stirred until uniformly wet, transferred to a pre-weighed, shallow, 1.2-cm-tall plastic cup, lightly tamped to a uniform level of no more than half the cup height, and covered with a lid. After equilibrating overnight, each soil sample's water potential was measured in a WP4 Dewpoint Potentiameter (Decagon Devices, Inc., Pullman, WA), for which the calibration was checked daily with a potassium chloride (KCl) standard. The samples were then weighed, oven-dried at 70^{o}C overnight, and re-weighed.

The LN of the absolute value of the measured water potential was linearly regressed against the gravimetric water content using Excel. The slope, intercept, and coefficient of determination (R^2) from each individual linear regression were recorded.

Statistical Analyses

Based on a completely random experimental design and aggregating data across all sampled locations (all-locations data set), a one-factor analysis of variance (ANOVA) was conducted using the GLIMMIX procedure in SAS (version 9.4, SAS Institute, Inc., Cary, NC) to evaluate the effect of cover-crop treatment (CC and NCC) on near-surface physical and chemical soil properties, ASWC, OIR, the slope and intercept parameters from the linear relationship between the LN of the infiltration rate and the mid-point of time (Anderson et al., 2020), and the estimated SSIR (n = 54 for soil samples and infiltration-related measurements). A gaussian data distribution was used for the slope, intercept, C:N, TC:SOM, TN:SOM, and SSIR parameters, while the gamma distribution was used for all other parameters. A separate two-factor ANOVA was conducted in SAS to evaluate the effects of cover-crop treatment, soil depth (0- to 5- and 5- to 10-cm), and their interaction on TWSA (Smith et al., 2014) and the slope and intercept that characterized the linear relationship between the LN of the measured soil water potential and gravimetric water content (Brye, 2003). A gaussian data distribution was used for the TWSA, slope, and intercept parameters. Additionally, a separate three-factor ANOVA was conducted in SAS to evaluate the effects of cover-crop treatment, soil depth, aggregate-size class (0.25- to 0.5-, 0.5- to 1.0-, 1.0- to 2.0-, 2.0- to 4.0-, and > 4.0-mm), and their interactions on WSA (Smith et al., 2014). A gaussian data distribution was used for the WSA parameter. Significance was judged at $P \leq 0.05$. When appropriate, means were separated by least significant difference at the 0.05 level.

Based on a completely random experimental design and aggregating data across two agroecosystems within one field at the Stevens location (Stevens-only data set; referenced on Table 1), a two-factor ANOVA was conducted in SAS to evaluate the effects of cover-crop treatment, sample placement (B, NWT, and WT), and their interaction on near-surface physical and chemical soil properties, ASWC, OIR, the slope and intercept parameters from the relationship between the LN of the infiltration rate and the mid-point of time (Anderson et al., 2020), and the estimated SSIR. A gaussian data distribution was used for the slope, intercept, C:N, TC:SOM, TN:SOM, and SSIR parameters, while the gamma distribution was used for all other parameters. A separate three-factor ANOVA was conducted in SAS to evaluate the effects of cover-crop treatment, sample placement, soil depth, and their interaction on TWSA (Smith et al., 2014) and the slope and intercept from the linear relationship between the LN of the measured soil water potential and gravimetric water content (Brye, 2003). A gaussian data distribution was used for the TWSA, slope, and intercept parameters. In addition, a separate four-factor ANOVA was conducted in SAS to evaluate the effects of cover-crop treatment, sample placement, soil depth, aggregate-size class, and their interaction on WSA (Smith et al., 2014). A gaussian data distribution was used for the WSA parameter. Due to the small sample size of the data subset (n = 18 for soil samples and infiltration-related measurements), significance was judged at $P \leq 0.10$. When appropriate, means were separated by least significant difference at the 0.10 level.

Results and Discussion

All-locations Data Set

Across the 18 agroecosystems (12 with CC and 6 with NCC treatments), soil physical properties varied as expected, with sand, silt, and clay ranging from 0.10 to 0.62, 0.32 to 0.84, and 0.06 to 0.24 g g^{-1}, respectively and SOM concentrations and contents ranging from 9.5 to 34.1 g kg^{-1} and 12.3 to 44.7 Mg ha^{-1}, respectively, in the top 10 cm. Chemical properties also varied as expected, with soil pH and EC ranging from 5.32 to 7.77 and 0.081 to 0.284 dS m^{-1}, respectively, in the top 10 cm.

The all-locations data set served as a survey of agricultural sites utilizing CC in the LMRV with locations intentionally chosen to result in large variability. Therefore, if significant differences occur, those differences represent widespread implications despite large, inherent, soil property variability.

Soil properties

Across all agroecosystems in the LMRV, with the exception of extractable soil Na content, all other measured soil properties in the top 10 cm were unaffected ($P > 0.05$) by cover-crop treatment (Table 3 and 4). However, extractable soil Na content was 1.5 times greater under NCC than under CC (Table 3). Similarly, the soil EC was numerically, though not significantly, greater under NCC (0.173 dS m^{-1}) than CC (0.146 dS m^{-1}; Table 3). The bare soil of the NCC treatment lacks the canopy shade and/or residues provided by vegetative cover. The greater exposure of a bare soil surface increases evaporation and decreases the effectiveness of rainfall and/or irrigation water to leach soluble salts away from the upper soil profile and root zone, which can increase surface and near-surface salt accumulation (Rodriguez-Navarro and Doehne, 1999; Dai et al., 2016). Uptake and storage in CC biomass could have been responsible for the lower soil extractable Na content in the CC treatment, where the Na is tied up in the CC residue and has yet to cycle back into the soil. Table 3 summarizes the overall means for soil pH, EC, extractable nutrient concentrations (P, K, Ca, Mg, S, Na, Fe, Mn, Zn, and Cu) and contents (P, K, Ca, Mg, S, Fe, Mn, Zn, and Cu). Across all sites within this study, soluble salt concentrations produced an EC range of 0.081 to 0.284 dS m^{-1}, thus the EC range fell below the soluble salt concentration that can interfere with plant growth (EC range of ~ 2 to > 4 dS m^{-1}; Weil and Brady, 2016). However, this study’s EC range fell outside the maximum EC range of 0.06 to 0.11 dS m^{-1} across various landuses (i.e., native prairie, deciduous forest, coniferous forest, Conservation Reserve Program grassland, conventionally tilled agriculture, and non-tilled agriculture) within the LMRV of eastern Arkansas (Anderson et al., 2020). Table 4 summarizes the overall means for measured soil physical properties (i.e., BD, TC, TN, and SOM concentrations and contents, and C:N, TC:SOM, and TN:SOM ratios). In general, silt-loam soils with a BD < 1.40 g cm^{-3} are ideal for plant growth, with BD of > 1.60 g cm^{-3} affecting root growth and > 1.75 g cm^{-3} restricting root growth (NRCS-USDA, 2014). Soil BD across various landuses (i.e., native prairie, deciduous forest, coniferous forest, Conservation Reserve Program grassland, conventionally tilled agriculture, and non-tilled agriculture) within the LMRV of eastern Arkansas ranged from 1.24 to 1.41 g cm^{-3} (Anderson et al., 2020). Therefore, across all sites within this study, the soil BD range of 1.15 to 1.42 g cm^{-3} fell outside the minimum range for LMRV loessial and alluvial soils in eastern Arkansas, but not above the threshold where BD would affect or interfere with root growth (NRCS-USDA, 2014).

Similar to the BD results of the current study, on a silt-loam soil in western Tennessee with 30 years of vetch, winter wheat, and NCC treatments in cotton production, Nouri et al. (2019) reported no difference in BD in the top 15 cm across all CC treatments. Similarly, Kaspar et al. (2001) reported no difference in BD between CC and NCC treatments in a 3-yr field study on a loam soil in central Iowa. However, the BD results of the current study differ from other studies, where BD was greater under NCC than CC (Villamil et al., 2006; Steele et al., 2012).

The large number of soil properties that did not differ between CC treatments was likely due to the variation in background management practices, the variation in CC species and cash crop species, and the variation in CC duration, which ranged from less than one year to greater than 19 years. Despite expecting TC and SOM to be greater under CC than NCC and expecting BD to be lower under CC than NCC, TC and SOM did not differ between CC treatments and BD was not lower under CC than NCC. However, TC concentration and content and SOM concentration were numerically greater under CC than NCC. Similarly, though not significantly different, soil pH and soil P and K concentration and content were numerically greater under CC than NCC and soil EC was numerically lower under CC than NCC. With continued management under CC, the soil properties in the top 10 cm measured in the current study may continue to deviate between CC treatments so that significant differences may be identified at some time in the future.

Infiltration

For the all-locations data set, r^2 values for the linear relationship between the LN of the infiltration rate between each time point and the mid-point of time ranged from < 0.01 to 1.0 across all infiltration measurements. Approximately 42% of the regression equations (53 equations for 54 total measurements) had r^2 values greater than 0.6. One infiltration measurement had insufficient data for a regression equation and r^2 value to be determined due to no measurable infiltration over the 20-min time period. Based on these results, it was concluded that the linear trendline was reasonable to systematically apply to all infiltration measurements to characterize and evaluate the relationship between the LN of the infiltration rate between each time point and the mid-point of time among CC treatments.

Across all agroecosystems, measured hydraulic properties, OIR, SSIR, and the slope and intercept characterizing the linear relationship between the LN of the infiltration rate between each time point and the mid-point of time, except for ASWC, were unaffected ($P > 0.05$) by cover-crop treatment (Table 4). However, ASWC in the top 6 cm, assessed prior to conducting infiltration measurements, differed ($P = 0.04$) between cover-crop treatments, where ASWC under CC was twice that under NCC because of greater evaporation without the vegetative canopy provided by CC (Table 4). Conversely, Kaspar et al. (2001) reported the mean infiltration rate was 1.1 times greater under CC than NCC in a 3-yr field study on a loam soil in central Iowa, whereas, in a long-term study, Nouri et al. (2019) reported nearly 2-fold greater infiltration in vetch and wheat CC compared to NCC, which was also reported by Steele et al. (2012).

Table 4 summarizes the overall mean for all infiltration-related properties. The OIR across various landuses (i.e., native prairie, deciduous forest, coniferous forest, Conservation Reserve Program grassland, conventionally tilled agriculture, and non-tilled agriculture) within the LMRV of eastern Arkansas ranged from 0.004 to 0.117 cm min^{-1} (Anderson et al., 2020). Therefore, across all sites within this study, the OIR range of 0.0 to 0.6 cm min^{-1} falls outside the maximum of the expected range for LMRV loessial and alluvial soils in eastern Arkansas.

Though infiltration-related properties were expected to differ between CC treatments, the process of infiltration and other hydraulic properties are known to be inherently variable. Furthermore, the variation in management practices, CC and cash crop species, and CC duration contributed to the lack of an ability to identify significant differences in infiltration-related properties. Given more time, significant differences in infiltration-related properties will likely result.

Aggregate stability

Across all agroecosystems, WSA concentration differed ($P < 0.01$) by size class, but was unaffected by treatment or soil depth ($P \geq 0.05$; Table 5). Averaged across treatment and soil depth, WSA concentration in the 0.25- to 0.5- (0.101 g g^{-1}) was 1.5 times greater than WSA in the 1.0- to 2.0-mm size class (0.068 g g^{-1}) and was at least 1.2 times greater than WSA in the 0.5- to 1.0- (0.079 g g^{-1}) and 2.0- to 4.0-mm (0.084 g g^{-1}) size classes, which were intermediate. In addition, averaged across treatment and soil depth, WSA concentration in the > 4.0- (0.097 g g^{-1}) was at least 1.2 times greater than that in the 0.5- to 1.0- and 1.0- to 2.0-mm size classes, which did not differ, while WSA concentration in the 2.0- to 4.0- was 1.2 times greater than that in the 1.0- to 2.0-mm size class. Similarly, Nouri et al. (2019) reported no difference in WSA by CC treatment. Conversely, in long-term CC study on a silt-loam soil in Maryland with a corn cash crop and 13-year rye and NCC treatment, Steele et al. (2012) reported greater WSA in the 0.5- to 2-mm and 2- to 6-mm fractions under CC compared to NCC. Villamil et al. (2006) also reported greater WSA in the 1- to 2-mm size-class under CC than NCC and that CC in three crops rotations (i.e., corn-rye/soybean-rye, corn-rye/soybean-vetch, corn-rye/soybean-vetch and rye) had greater WSA than NCC. Smith et al. (2014) reported that the WSA concentration in the 0- to 10-cm depth interval decreased with increasing aggregate-size class in a silt-loam loessial soil after more than 12 years of consistent management in long-term wheat-soybean rotation in the LMRV region of eastern Arkansas.

Similar to WSA, TWSA, which was summed across the five size classes, was also unaffected ($P > 0.05$) by treatment and soil depth (Table 6) and averaged 0.494 g g^{-1} in the top 10 cm across all treatment-soil depth combinations. Though not significantly, TWSA was numerically greater under CC than under NCC and, with more time under consistent management, differences would be expected to increase in the future. Smith et al (2014) reported that, after 10 complete wheat-soybean cropping cycles, TWSA in the top 10 cm was greater under the low-fertility/residue treatment compared to the high-fertility/residue treatment. In the low-fertility/residue treatment, lower mineral-N additions likely resulted in slower microbial decomposition, while belowground roots remained in the soil after aboveground biomass was burned to provide additional OM to the soil (Smith et al., 2014).

Water retention

For the all-locations data set, r^2 values for the linear relationship between the LN of the soil water potential and gravimetric water content ranged from 0.36 to 0.92 across all water-retention measurements. Approximately 67% of the regression equations (106 equations for 108 total measurements) had r^2 values greater than 0.6. The lack of sufficient soil mass data allowed for only one replicate, instead of three, for one of the agroecosystems at one soil depth. Based on these results, it was concluded that the linear trendline was reasonable to systematically apply to all water-retention measurements to characterize and evaluate the relationship between the LN of the soil water potential and gravimetric water content among CC treatments.

Across all agroecosystems, the slope characterizing the linear relationship between the LN of the measured soil water potential and gravimetric water content was unaffected ($P > 0.05$) by treatment and soil depth, while the intercept was greater ($P = 0.05$) for NCC (3.4) than for CC (3.1) (Table 6). The lack of an effect on the slope likely suggests not enough time has passed under CC to characteristically alter the wetting-curve version of the soil moisture characterization curve. However, the lower intercept indicates that soil under CC has greater water storage than NCC when the soil is dry.

In a study on a silt-loam soil with a corn-soybean rotation and two years of rye and vetch CC in east-central Illinois, Villamil et al. (2006) reported similar results in the 3- to 10-cm soil depth interval using a pressure-plate method, where less water was retained at lower tensions under NCC than all CC treatments and lower plant available water (PAW) under NCC than under all CC treatments. Basche et al. (2016b) also reported PAW was 1.2 times greater in the upper 15 cm under CC compared to NCC in a loam soil managed as a corn-soybean rotation with 13 years of rye CC and an NCC treatment in central Iowa.

Stevens-only Data Set

This portion of the study was conducted using a subset of data collected from two agroecosystems within one field (Stevens, referenced on Table 1 and Figure 5). The one field had additional management practices that created the opportunity to evaluate the effects of sample/measurement placement (B and WT and NWT furrows) in adjacent CC and NCC treatments on the same soil under wide-row cotton production. In contrast to the all-locations data set, the Stevens-only data set was expected to have much less variability among treatment combinations, but also had a much smaller sample size ($n = 18$ for soil samples and infiltration-related measurements compared to $n = 54$ for the all-locations data set).

Soil properties

All measured soil physical and chemical properties in the top 10 cm were affected ($P \leq 0.10$) by either treatment, placement, or both (Table 7 and 8), while soil Ca and Zn concentrations, Ca, Mg, and Zn contents, sand, and TC:SOM ratio were unaffected ($P > 0.10$) by treatment or placement (Table 7 and 8). Averaged across placement, soil K concentration and content were 1.1 times greater under CC than NCC (Table 9). Conversely, soil Mg concentration and Mn concentration and content were 1.1 times greater under NCC than CC (Table 9). Similarly, soil Cu concentration and content, averaged across placement, were at least 1.2 times greater under NCC than CC (Table 9). Although soil extractable K concentration and content differed between CC and NCC treatments, differences were minor and likely would have little effect on CC and/or cash crop growth. Averaged across placement, silt was 0.03 g g^{-1} greater under NCC than CC (Table 10). Total C, TN, and SOM concentrations and TC and TN contents were at least 1.1 times greater under CC than NCC (Table 10). The CC is taking up plant available nutrients, which explains why some elements are lower under CC than under NCC, however, despite their significant differences, many of the differences were not large. The annual input of belowground residue from CC roots is contributing more C, N and SOM to the soil than under NCC.

Averaged across treatment, K concentration and content and Mg concentration in NWT and WT were similar (*P* > 0.10), but were at least 1.4, 1.3, and 1.2 times less (*P* ≤ 0.10), respectively, than in the top of the bed (Table 11). Averaged across treatment, soil BD was similar (*P* > 0.10) for the bed and NWT, while BD in WT was 1.1 times greater than the other two placements due to compaction from periodic vehicle traffic (Table 12). Due to greater total porosity within the B and NWT (0.55 cm^3 cm^{-3}) placements from less compaction compared to the WT (0.51 cm^3 cm^{-3}) placement, the B and NWT soils have the potential to hold 0.33 cm more water in the top 10 cm than the WT soil. The increased porosity at the soil surface also allows greater access to deeper soil water storage, thus reducing potential rainfall and nutrient losses as well as sediment. In addition, averaged across treatment, soil TN concentration in the bed and NWT, which did not differ, were 1.3 times greater than TN in WT (Table 12). Due to the extra compaction in WT, N inputs would be more prone to runoff losses in WT than from the bed and NWT, which were less compacted and had greater surface porosity. This explanation at least partially explains the differences in soil K and Mg among placements. Daniels et al. (2019) evaluated surface runoff in the same agroecosystems used in the current sub-study and reported greater soluble N concentrations in rainfall runoff, averaged across cover and no-cover-crop treatments, during the growing season compared to the non-growing season.

Comparatively, in a 6-yr conservation management study on a silt-loam soil in the LMRV region of Mississippi, with a cotton cash crop and Balansa clover [*Trifolium michelianum* Savi var. *balansae* (Boiss.) Azn.], Abruzzi rye (*Secale cereal* L.), and fallow treatments, Locke et al. (2012) reported that BD in the 0- to 15-cm soil depth interval was 1.1 greater in WT compared to the bed and NWT placements. Hubbard et al. (2013) observed similar BD differences on a loamy-sand soil in Georgia with a 3-yr duration of varying combinations of sun hemp (*Crotalaria juncea* L.) and crimson clover (*Trifolium incarnatum* L.) as CC and fallow NCC treatments in corn production. Soil BD in the 0- to 2.5-cm soil depth interval in the WT placement was 1.1 times greater than the NWT placement (Hubbard et al., 2013). Additionally, Kaspar et al. (2001) reported that soil BD in the 0- to 7.6-cm depth interval was 1.1 times greater in WT than NWT placement in a 3-yr oat and rye CC field study with corn and soybean cash crops on a loam soil in central Iowa. In general, silt-loam soils with a BD < 1.40 g cm^{-3} are ideal for plant growth, with BD of > 1.60 g cm^{-3} affecting root growth and > 1.75 g cm^{-3} restricting root growth (NRCS-USDA, 2014). Soil BD across various landuses (i.e., native prairie, deciduous forest, coniferous forest, Conservation Reserve Program grassland, conventionally tilled agriculture, and non-tilled agriculture) within the LMRV of eastern Arkansas ranges from 1.24 to 1.41 g cm^{-3} (Anderson et al., 2020). Therefore, across all sampled points within the Stevens-only sub-study, the soil BD range of 1.14 to 1.36 g cm^{-3} fell outside the minimum of the expected range for LMRV loessial and alluvial soils in eastern Arkansas, but not above the threshold where BD would affect or interfere with root growth (NRCS-USDA, 2014).

In contrast to the measured properties with treatment and/or placement main effects, soil pH, EC, P, S, Na, and Fe concentrations and contents, clay, SOM content, and C:N and TN:SOM ratios differed ($P \leq 0.10$) among treatment-placement combinations (Table 7 and 8). Within each placement, soil pH was at least 0.25 units greater ($P = 0.01$) under NCC than CC (Figure 6). Above- and belowground biomass release organic acid compounds into the soil upon decomposition to contribute to soil acidification. Otte et al. (2020) noted that cereal rye roots are a more significant contributor of phenolic acid compounds to soil than the shoots. Within NCC, soil pH was greater in the bed than in WT, while soil pH in NWT was intermediate (Figure 6). Within CC, soil pH was greater in the bed than in NWT and WT, which did not differ (Figure 6).

Soil EC was at least 1.2 times greater (*P* = 0.01) in the NCC-B and CC-WT combinations, which did not differ, than in all other treatment-placement combinations, which did not differ (Figure 6). There was no effect of treatment on soil EC in the NWT furrows (Figure 6). Across all sampled points within the Stevens-only sub-study, soluble salt concentrations produced an EC range of 0.135 to 0.235 dS m^{-1}, thus the measured EC range was well below the soluble salt concentrations that can interfere with plant growth (EC range of ~ 2 to > 4 dS m^{-1}; Weil and Brady, 2016). However, the sub-study's EC range fell outside the maximum EC range of 0.06 to 0.11 dS m^{-1} across various landuses (i.e., native prairie, deciduous forest, coniferous forest, Conservation Reserve Program grassland, conventionally tilled agriculture, and non-tilled agriculture) within the LMRV of eastern Arkansas (Anderson et al., 2020).

Extractable soil P concentration and content were greater ($P \leq 0.08$) in the CC-NWT (87.1 mg kg^{-1} and 106.4 kg ha^{-1}, respectively) than NCC-WT (67.8 mg kg^{-1} and 86.2 kg ha^{-1}, respectively), NCC-B (60.1 mg kg^{-1} and 73.0 kg ha^{-1}, respectively), and CC-B (48.2 mg kg^{-1} and 55.9 kg ha^{-1}, respectively) (Figure 7). Extractable soil P concentration and content were at least 1.2 times greater in the NCC-B than in the CC-B combination (Figure 7). Within CC, P concentration and content were greater in NWT (87.1 mg kg^{-1} and 106.4 kg ha^{-1}, respectively) and WT (76.6 mg kg^{-1} and 100.0 kg ha^{-1}, respectively), which did not differ, than in the bed (48.2 mg kg^{-1} and 55.9 kg ha^{-1}, respectively) (Figure 7). Within NCC, P concentration did not differ between placements, while P content in NCC-NWT (89.3 kg ha^{-1}) was greater than NCC-B (73.0 kg ha^{-1}), with NCC-WT being intermediate (Figure 7).

Extractable soil S concentration and content were greater ($P \leq 0.02$) in CC-WT (16.7 mg kg^{-1} and 21.8 kg ha^{-1}, respectively) than all other treatment-placement combinations (Figure 8). Soil S concentration and content were at least 1.4 times greater in CC-WT than NCC-WT

(Figure 8). Within CC, S concentration and content were greater in the WT placement than NWT (11.7 mg kg^{-1} and 14.4 kg ha^{-1}, respectively) and in the bed (8.99 mg kg^{-1} and 10.4 kg ha^{-1}, respectively), which also differed from one another (Figure 8). Within NCC, extractable soil S concentration did not differ between placements, while soil S content was greater in WT (14.8 kg ha^{-1}) than NWT (11.9 kg ha^{-1}), with that in the bed being intermediate (Figure 8).

Extractable soil Na concentration was greater (P = 0.02) in NCC-WT (20.8 mg kg^{-1}) and CC-WT (20.4 mg kg^{-1}), which did not differ, than NCC-NWT (14.4 mg kg^{-1}) and CC-B (10.5 mg kg^{-1}), with that in the CC-NWT and NCC-B being intermediate (Figure 9). Similarly, extractable soil Na content was greater (P = 0.03) in NCC-WT (26.8 kg ha^{-1}) and CC-WT (26.7 kg ha^{-1}), which did not differ, than NCC-B (19.8 kg ha^{-1}) and NCC-NWT (17.5 kg ha^{-1}), which did not differ, and CC-B (12.2 kg ha^{-1}), with that in CC-NWT being intermediate (Figure 9). Extractable soil Na concentration and content were 1.6 times greater in NCC-B compared to CC-B, while NCC-WT and CC-WT did not differ (Figure 9). Within CC, Na concentration and content in the bed (10.5 mg kg^{-1} and 12.2 kg ha^{-1}, respectively), were less than NWT and WT, which did not differ (Figure 9). Within NCC, soil Na concentration in NWT (14.4 mg kg^{-1}) was less than WT (20.8 mg kg^{-1}), but did not differ from the bed. Similarly, soil Na content under NCC was less in NWT (17.5 kg ha^{-1}) and B (19.8 kg ha^{-1}), which did not differ, than in WT (26.8 kg ha^{-1}) placements (Figure 9).

Soil Fe concentration in CC-NWT (486.9 mg kg^{-1}) was greater than all other treatment-placements combinations, except for CC-WT, which did not differ (Figure 10). Similarly, soil Fe content in CC-NWT (598.2 kg ha^{-1}) and CC-WT (572.9 kg ha^{-1}) were greater than all other treatment-placements combinations (Figure 10). Soil Fe concentration and content were 1.3 times greater in CC-NWT and CC-WT than NCC-NWT and NCC-WT, respectively (Figure 10).

Conversely, soil Fe content was 1.2 times greater in NCC-B than CC-B (Figure 10). Within CC, soil Fe concentration and content in CC-NWT (486.9 mg kg^{-1} and 598.2 kg ha^{-1}, respectively) and CC-WT (439.1 mg kg^{-1} and 572.9 kg ha^{-1}, respectively), which did not differ, were greater than CC-B (267.4 mg kg^{-1} and 310.0 kg ha^{-1}, respectively) (Figure 10). Within NCC, soil Fe concentration did not differ by placement, while Fe content was greater in NCC-NWT (447.7 kg ha^{-1}) than NCC-B (383.2 kg ha^{-1}), with that in NCC-WT being intermediate (Figure 10).

In general, averaged across CC treatments, extractable soil elements were numerically lower in the bed than in the furrows, which was likely due to uptake from the cash crop and partial off-site removal of plant material during harvest. Overall, extractable soil elements demonstrated few consistent trends within CC treatments across placements.

Clay concentration was greater in CC-WT (0.10 g g^{-1}) than all other treatment-placement combinations, except for CC-NWT, which did not differ (Figure 11). Clay concentration in CC-WT and CC-NWT were 1.3 times greater compared to their respective NCC-placement combination (Figure 11). Within CC, clay concentration ranged from 0.10 g g^{-1} in CC-WT to 0.07 g g^{-1} in CC-B, while clay concentration did not differ among placements within NCC (Figure 11). In general, averaged across CC treatments, clay was numerically greater in the furrows than in the bed, where clay particles would move off the bed and into the furrows as the beds slowly erode over time.

Soil organic matter content, C:N ratio and TN:SOM ratio in the top 10 cm were affected ($P \leq 0.03$) by treatment and placement (Table 8). Similar to clay concentration, SOM content was greater in CC-WT (30.7 Mg ha^{-1}) than in all other treatment-placement combinations, except for CC-NWT, which did not differ (Figure 12). The SOM content in CC-WT was 1.3 times greater than NCC-WT, while, similarly, SOM content was 1.1 times greater in CC-NWT compared to NCC-NWT (Figure 12). Within CC, SOM content for CC-B (25.3 Mg ha^{-1}) was lower than that for CC-NWT and CC-WT, which did not differ, while, within NCC, there was no difference in SOM content among placements (Figure 12). The additional above- and belowground organic matter from the CC in the bed is contributing to increasing SOM in WT and NWT placements in CC treatments, as roots are able to extend vertically as well as horizontally to explore for water and nutrients. Keisling et al. (1994) reported SOM content in the 0- to 10-cm depth interval was 1.3 times greater in CC compared to NCC treatment in a 17-yr winter CC study on a silt-loam soil under cotton production with rye-vetch and NCC treatments in the LMRV region of Tennessee.

The soil C:N ratio was numerically larger in CC-WT (11.6) than all other treatment-placement combinations, but did not differ from that in NCC-B and NCC-NWT (Figure 12). The soil C:N ratio in CC-WT was 1.2 times greater than NCC-WT, while, conversely, the soil C:N ratio in NCC-B was 1.2 times greater than in CC-B (Figure 12). Within CC, the soil C:N ratio was greater in WT (11.6) than in NWT and in the bed, which did not differ, while the soil C:N ratio under NCC did not differ among placements (Figure 12). The generally lower soil C:N ratio under CC than NCC, which would be considered desirable, was likely due to above- and belowground decomposition of residue from the CC with greater N enrichment from CC than from NCC.

Across all treatment-placement combinations, the TN:SOM ratio was greatest in the CC-B combination (0.06; Figure 12). The TN:SOM ratio was 1.5 times greater under CC than under NCC in the bed, while the TN:SOM ratio did not differ between treatments with NWT or WT placements (Figure 12). Within CC, the TN:SOM ratio in the bed (0.06) was greater than in NWT (0.05) and WT (0.04), while the TN:SOM ratio in NWT was also greater than in WT, but the TN:SOM ratio did not differ among placements under NCC (Figure 12). Across all treatment-placement combinations, overall means for soil Ca and Zn concentrations and for soil Ca, Mg, and Zn contents are summarized on Table 7, while overall means for sand and TC:SOM ratio are summarized on Table 8. The greater TN:SOM ratio under CC likely occurred because there is OM from both the CC and cash crop that are cycled back to the soil. These results are also supported by Sanchez et al. (2019) who reported SOM, N, and C concentrations in the 0- to 10-cm depth interval increased by 15, 35, and 22%, respectively, after 2 years under CC in a CC-corn rotation on a silt-loam soil in northwest Louisiana.

Infiltration

For the Stevens-only data set, r^2 values for the linear relationship between the LN of the infiltration rate between each time point and the mid-point of time ranged from < 0.01 to 0.89 across all infiltration measurements. Approximately 33% of the regression equations (18 equations for 18 total measurements) had r^2 values greater than 0.6. Based on these results, it was concluded that the linear trendline was reasonable to systematically apply to all infiltration measurements to characterize and evaluate the relationship between the LN of the infiltration rate between each time point and the mid-point of time among CC-placement treatment combinations.

All measured hydraulic properties differed ($P < 0.10$) by treatment and/or placement, except for SSIR (Table 8). Averaged across placement, ASWC in the top 6 cm was 1.2 times greater under CC than NCC (Table 10). Averaged across treatment, ASWC was 1.3 times greater in NWT than in the bed, while OIR was two times greater in the bed (0.2 cm min^{-1}) than in NWT and WT, which did not differ (0.1 cm min^{-1}; Table 12). Averaged across treatment, the slope characterizing the LN of the infiltration rate between each time point and the mid-point of time was at least two times greater in the bed than in NWT and WT, which did not differ (Table 12). Similar to the slope, averaged across treatment, the intercept characterizing the LN of the infiltration rate between each time point and the mid-point of time was 1.2 times greater in the bed than in NWT and WT, which did not differ (Table 12). Steady-state-infiltration rate was unaffected ($P > 0.10$) by treatment or placement (Table 8) and averaged 0.02 cm min^{-1} across all treatment combinations.

Similar to the results of the current study, Locke et al. (2012) reported the surface infiltration rate was 1.4 to 30 times greater in the bed compared to the WT and NWT placements in a 6-yr, CC conservation management study in the LMRV region of Mississippi. Kaspar et al. (2001) also reported the surface infiltration rate was 1.6 times greater under NWT than WT placements in a 3-yr CC field study on a loam soil in central Iowa. Furthermore, Meek et al. (1992) reported a decreased surface infiltration rate with wheel compaction that increased soil BD in a 3-yr study evaluating machinery traffic, tillage, and plant roots. The OIR across various landuses (i.e., native prairie, deciduous forest, coniferous forest, Conservation Reserve Program grassland, conventionally tilled agriculture, and non-tilled agriculture) within the LMRV of eastern Arkansas ranged from 0.004 to 0.117 cm min^{-1} (Anderson et al., 2020). Therefore, across all sampled points within the Stevens-only sub-study, the OIR range of 0.1 to 0.3 cm min^{-1} fell outside the maximum of the expected range for LMRV loessial and alluvial soils in eastern Arkansas.

Aggregate stability

Water-stable aggregate concentrations differed ($P < 0.01$) among treatment-placement combinations (Table 13). Averaged across soil depth and size class, WSA concentration under both CC treatments in the bed were similar and at least 1.2 times greater than WSA in all other treatment-placement combinations (Figure 13). Water-stable aggregate concentration was also 2.3 and 1.6 times greater in the CC-NWT and CC-WT combinations, respectively, which did not differ, compared to their corresponding placements under NCC, which were lowest among all treatment-placement combinations and did not differ (Figure 13). Similarly, in a long-term CC study in north-central Missouri on a silt-loam soil where red clover (*Trifolium pretense* L.) was grown in rotation with corn and wheat for over 100 years, Rachman et al. (2003) documented greater aggregate stability under CC compared to NCC in the 2- to 5.8- and 5.8- to 9.6-cm depths, where only the 1- to 2-mm aggregate sizes were measured.

Water-stable aggregate concentration also differed ($P < 0.01$) among placement-size-class combinations (Table 13). Averaged across treatment and soil depth, WSA concentrations in all size classes in the bed were at least 1.2 times greater than those in each respective size class in NWT and WT (Figure 13). In the bed, WSA was 1.4 times greater in the 0.25- to 0.5- than in the 0.5- to 1.0- and 1.0- to 2.0-mm size classes, which did not differ (Figure 13). In both NWT and WT, WSA generally decreased with increasing aggregate size class (Figure 13). Similarly, after more than 10 years of consistent management in a long-term wheat-soybean, double-crop production system on a silt-loam, loessial soil in the LMRV region of eastern Arkansas, WSA concentration in the top 10 cm decreased with increasing aggregate-size class (Smith et al., 2014).

Summed across all five size classes and similar to WSA, TWSA also differed ($P < 0.01$) among treatment-placement combinations (Table 14). Averaged across soil depth, TWSA concentration in the top 10 cm was greater in NCC-B (0.56 g g^{-1}) than all other treatment-placement combinations, with that in CC-B being intermediate (Figure 11). Total WSA in the CC-NWT was 2.1 times greater than in the NCC-NWT combination, while TWSA in the CC-WT was 1.8 times greater compared to in the NCC-WT combination, but TWSA did not differ between CC and NCC in the bed (Figure 11). Under both CC treatments, TWSA was at least 1.3 times greater in the bed than in WT (Figure 11). The greater TWSA in the CC-NWT and -WT treatment-placement compared to their corresponding NCC treatment-placement combinations was likely due to the additional belowground CC roots and the subsequent microbial/fungal activity that promote aggregate formation.

Water retention

For the Stevens-only data set, r^2 values for the linear relationship between the LN of the soil water potential and gravimetric water content ranged from 0.47 to 0.80 across all water-retention measurements. Approximately 69% of the regression equations (36 equations for 36 total measurements) had r^2 values greater than 0.6. Based on these results, it was concluded that the linear trendline was reasonable to systematically apply to all water-retention measurements to characterize and evaluate the relationship between the LN of the soil water potential and gravimetric water content among CC-placement treatment combinations.

Both the slope and intercept characterizing the linear relationship between the LN of the measured soil water potential and gravimetric water content were affected by treatment, placement, and/or soil depth ($P < 0.1$; Table 14). Averaged across soil depth, the slope characterizing the linear relationship between the LN of the measured soil water potential and gravimetric water content in the CC-NWT and CC-WT combinations, which did not differ, were greater (*P* = 0.01) than that in the CC-B, NCC-NWT, and NCC-WT combinations, which did not differ, while the slope for the NCC-B combination was intermediate (Figure 14A). Conversely, Hubbard et al. (2013) reported overall greater PAW in the bed compared to the WT, while noting inconsistent patterns in soil water content over the 3-yr sampling period. Additionally, in the current study and averaged across placement, the slope characterizing the linear relationship between the LN of the measured soil water potential and gravimetric water content in the CC-5-10-cm combination was greater (*P* = 0.07) than that in the other three treatment-depth combinations, which did not differ (Figure 14B). In contrast to the slope, averaged across placement, the intercept characterizing the linear relationship between the LN of the measured soil water potential and gravimetric water content in the CC-0-5-cm combination was greater (*P* = 0.10) than that in the CC-5-10-cm combination, while the intercept for the other two treatment-depth combinations were intermediate (Figure 14C). Results were similar to Keisling et al. (1994) who studied CC effects on cotton yield, with 17 years of rye, hairy vetch, and white lupine (*Lupinus albus* L.) CC on a silt loam in the LMRV region of south-west Tennessee and reported a CC treatment-soil depth effect on soil water retention, with 1.1 times greater PAW in the rye-vetch compared to NCC in the top 10 cm of soil, noting that the increased water retention in the CC treatment resulted in greater PAW for the subsequent summer cotton crop. Conversely, Nouri et al. (2019) reported no CC treatment-depth effect on water retention using the pressure-plate method on a silt-loam soil in western Tennessee.

Implications

Identifying the specific improvements that CC can impart on the near-surface soil and hydrologic properties in the LMRV will allow producers to make informed decisions about utilizing CC to contribute to overall soil health and aquifer recharge in the LMRV region of eastern Arkansas. While few parameters in this study were significantly affected by CC treatment, many parameters had numeric differences (i.e., EC, TC, SOM, and BD) that, given more time and based on previous CC study results (Keisling et al., 1994; Villamil et al., 2006; Steele et al., 2012; Sanchez et al. 2019), would be expected to continue to deviate over time to the point where differences will eventually become significant. Getting to the point of measurable significant differences will require more long-term, in-situ studies throughout the LMRV region that sample single agroecosystems multiple times throughout each year over several years to decades. Comparing single agroecosystem results to itself and comparing long-term agroecosystem data to each other will allow for improved evaluations of differences and trends imparted on soil properties in the top 10 cm by CC treatment.

With global air temperatures expected to continue to increase through at least 2050, causing increased frequency and intensity of extreme weather systems (i.e., extreme heat/drought and heavy precipitation), the LMRV region of eastern Arkansas will likely experience increased evaporation and flooding (Raymond et al., 1994; IPCC, 2019) whose effects CC have the potential to minimize (Basche et al., 2016a; Rosen and Xu, 2013). Meaningful, regional research that documents potential CC effects on soil health equips producers with real data to aid in management decisions. Producers need to know that implementing CC management is a worthwhile monetary, labor, and time investment. Management decisions made in favor of soil health can have regional benefits. Reducing soil erosion and runoff keeps more nutrients on-site and out of surface waters. The proximity of agriculture has caused increased sediment and nutrient loads into the Mississippi River (Hassan et al., 2017), which, in turn, has caused increased sediment and nutrient loads into the Gulf of Mexico, which is experiencing hypoxic conditions caused by eutrophication (Rablais et al., 2001, 2009). Additionally, increasing soil water-holding capacity, hence plant available soil water, can lead to lower irrigation needs (Dakhlalla et al., 2016). With less aquifer withdrawals for irrigation, the alluvial aquifer underlying much of the LMRV may begin to recharge again. With over 2 million ha of cropland and almost 2 million ha of irrigated farmland in the LMRV region of eastern Arkansas (NASS-USDA, 2017), adjustments made toward soil and water conservation management will extend beyond agricultural sustainability on an individual farm to environmental sustainability for the whole region and beyond.

Future Research

Results from the main and sub-study have spurred additional questions that are worth exploring through future research within the LMRV region of eastern Arkansas. The use of CC to remediate sodic soils or to counter the effects of irrigating with groundwater that contains large concentrations of soluble salts should be investigated based on the difference in soil extractable Na between the CC and NCC treatments. Further research into CC effects on water storage deeper in the soil profile (> 10 cm soil depth) to store water from rainfall events for future use by the cash crop may reduce irrigation demands. Exploring the link between CC roots/residues and biological properties would further shed light on the region-specific soil microbe benefits to soil health. More long-term studies with large data sets and with sampling repeated throughout the year, over multiple years, to approximate the length of time for specific soil property differences by treatment to develop, especially parameters that have wide-ranging benefits to other soil properties (i.e., SOM influence on BD and water retention), would create a timeline of soil health benefits under CC treatments that could serve as a guide to aid producers in making informed decisions regarding management practices.

Conclusions

All-locations Data Set

While CC benefits to soils under cultivated agriculture have been widely documented, CC benefits to soil health in the LMRV region of eastern Arkansas remain under-studied. This field study sought to fill a gap in research by evaluating the effects of CC (with and without a cover crop) on soil and hydraulic properties in the top 10 cm of cultivated, loessial and alluvial soils in the LMRV region of eastern Arkansas. Results of this study did not support the hypothesis that SOM and TC would be greater under CC compared to NCC. While TC concentration and content and SOM concentration were numerically greater under CC than NCC, SOM and TC were unaffected by CC treatment. Similarly, results did not support the hypothesis that BD would be greater, while OIR would be lowest, under NCC compared to CC, where soil BD and hydraulic properties (i.e., OIR and SSIR) were unaffected by CC treatment.

Results of this study partially supported the hypothesis that TWSA and water retention capacity would be greater under CC compared to NCC. Although TWSA was unaffected by treatment, thus not supporting the hypothesis, WSA differed by size class, with the largest and smallest size classes being greater than the two smallest intermediate size classes. Additionally, the hypothesis that water retention capacity would be greater under CC than NCC was supported, with more soil water stored in the top 10 cm when the soil was dry under CC compared to NCC.

Results provided valuable insight into the need for continued research in the LMRV region of eastern Arkansas. The all-locations data set served as a survey of agricultural sites utilizing CC in the LMRV with locations intentionally chosen to result in large variability. Therefore, if significant differences occur, those differences represent widespread implications despite large, inherent, soil property variability. The inherent variability of this study highlights a need for additional studies that analyze and compare the various parameters that go into a single field's management to better understand CC benefits in conjunction with these practices over time. Despite large, expected variability, results demonstrated that CC systematically affected select soil physical, chemical, and hydraulic properties across a large geographic area.

Stevens-only Data Set

Results generally supported hypotheses regarding near-surface soil and hydraulic properties in the top 10 cm. In general, averaged across CC treatments, extractable soil nutrients were numerically lower in the bed than in the furrows. However, extractable soil nutrients demonstrated few consistent trends within CC treatments across measurement placements. Although soil TC concentration and content and SOM concentration were greater under CC than NCC, they were unaffected by placement, thus partially rejecting the hypothesis that soil TC and SOM would be greater in the bed compared to the furrows. Although SOM content was affected by placement, results further rejected the hypothesis because SOM content was lower in the bed than in the other two placements.

Results partially supported the hypothesis that soil BD would be greater, while infiltration would be lower, in WT furrows compared to in the bed and NWT furrows. Soil BD was greater in the WT compared to the other two placements. Infiltration parameters (i.e., OIR, slope, intercept) were greater in the bed compared to WT and NWT placements, except for SSIR which was unaffected by placement, partially supporting the hypothesis because, although infiltration was lower in the WT placement compared to in the bed, OIR in the WT did not differ from the NWT placement.

Results partially supported the hypothesis that WSA and water retention capacity would be lower in WT furrows compared to in the bed and NWT furrows. Water-stable aggregate concentrations in the CC-WT placement were lower than in the other two placements within the CC treatment. However, WSA in the NCC-NWT and -WT combinations were lower than, while CC-B and NCC-B combinations were greater than, all other treatment-placement combinations. Additionally, WSA in both WT and NWT placements had generally decreasing WSA with increasing size class, while WSA in all size classes in the bed were greater than for all other placement-size class combinations. Water retention was affected by treatment within placement and by treatment between soil depths, with the CC-NWT, CC-WT, and CC-5-10-cm combinations having the largest change in water content as the matric potential changed.

The large number of soil properties that did not differ between CC treatments was likely due to the variation in background management practices, the variation in CC species and cash crop species, and the variation in CC duration, which ranged from less than one year to greater than 19 years. Despite inherent variability, results clearly demonstrated that CC positively affect physical, chemical, and hydraulic properties across a large area. The additional above- and belowground biomass provided to the soil by the CC growing in the bed affected soil physical, chemical, and hydraulic properties in the furrows in CC treatments, as roots are able to extend vertically as well as horizontally to explore for water and nutrients. With continued management under CC, soil physical, chemical, and hydraulic properties in the top 10 cm measured in the current study will likely continue to differentiate between CC treatments if CC use persists consistently, such that significant differences will likely be identified at some time in the future.

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Tables and Figures

Table 1. Summary of treatments (Trt), specific location names, sampling dates, agroecosystem descriptions for each sample location, duration (dur) of the cover crop in years, soil parent material (PM), mapped soil series with taxonomic descriptions, location elevations (Elev), and location slope.

Trt	Location name	Sample date	Agroecosystem description	CC dur	PM	Soil series (Description)	Elev (m)	Slope
CC[a]	Chappell	5-29-18	Soybean w/ switchgrass CC	3	A[d]	Teksob loam (Typic Hapludalf)	58.5	< 1%
		5-29-18	Soybean w/ cereal rye CC	1			58.5	< 1%
	Taylor	5-28-18	Soybean w/ cereal rye CC	> 19	L[e]	Henry silt loam (Typic Fragiaqualf)	55.5	< 1%
		5-28-18	Soybean-corn rotation w/ cereal rye and turnip CC	< 1	A	Commerce silt loam (Fluvaquentic Endoaquept)	56.4	< 1%
		5-28-18	Soybean-corn rotation w/ cereal rye and turnip CC	< 1			56.4	< 1%
	LMCRS[c]-1	11-28-18	Soybean w/ cereal rye CC	1	L	Memphis silt loam (Typic Hapludalf)	64.6	< 1%
		11-28-18	Soybean w/ hairy vetch CC	3			64.6	< 1%
		11-28-18	Soybean w/ canola CC	3			64.6	< 1%
	LMCRS-2	11-28-18	Cotton w/ cereal rye CC	1	L	Calloway silt loam (Aquic Fraglossudalf)	68.9	< 1%
	Stevens	5-28-19	Cotton w/ cereal rye CC*	5	A	Hebert silt loam (Aeric Epiaqualf)	47.8	< 1%
		5-29-19	Cotton w/ cereal rye CC	2			47.5	< 1%
		5-28-19	Soybean w/ cereal rye CC	2			46.9	< 1%
NCC[b]	Chappell	5-29-18	Soybean	-	A	Teksob loam (Typic Hapludalf)	57.0	< 1%
	Taylor	5-28-18	Soybean	-	L	Henry silt loam (Typic Fragiaqualf)	55.5	< 1%
	LMCRS-1	11-28-18	Soybean-fallow	-	L	Memphis silt loam (Typic Hapludalf)	64.6	< 1%
	LMCRS-2	11-28-18	Cotton	-	L	Calloway silt loam (Aquic Fraglossudalf)	68.9	< 1%
	Stevens	5-28-19	Cotton*	-	A	Hebert silt loam (Aeric Epiaqualf)	47.8	< 1%
		5-29-19	Cotton	-			47.5	< 1%

[a] CC, Cover crop; [b] NCC, No cover crop; [c] LMCRS, Lon Mann Cotton Research Station; [d] A, Alluvium; [e] L, Loess; *Measurements from agroecosystems used in Objective 2 sub-study.

Table 2. Summary of the 30-year (1981-2010) mean annual precipitation (precip), mean annual snow, mean monthly air temperature (temp), minimum and maximum air temperatures, and the 30-, 15-, and 7-day total precipitation prior to sampling at each study location (NOAA, 2010; NCEI, 2021).

	Mean					Total		
Location name	**Annual precip**	**Annual snow**	**Monthly temp**	**Min temp**	**Max temp**	**30-d precip**	**15-d precip**	**7-d precip**
	—— cm ——		——— °C ———			——— cm ———		
Chappell	123.0	8.6	16.1	10.6	21.6	5.9	4.8	0.1
Taylor	129.1	1.3	16.9	9.6	24.3	9.5	9.2	9.2
LMCRS[†]-1	128.4	6.1	16.6	11.1	22.0	11.6	3.0	1.1
LMCRS-2	128.4	6.1	16.6	11.1	22.0	11.6	3.0	1.1
Stevens	129.4	2.5	17.3	11.5	23.2	17.2	3.5	0

[†] LMCRS, Lon Mann Cotton Research Station

Table 3. Summary of the effect of treatment (cover crop and no cover crop) on mean soil pH, electrical conductivity (EC), and Mehlich-3 extractable soil nutrient (P, K, Ca, Mg, S, Na, Fe, Mn, Zn, and Cu) concentrations and contents in the top 10 cm across 18 agroecosystems in eastern Arkansas.

Soil property	***P***[‡]	**Cover crop**	**No cover crop**	**Overall mean**
pH	0.58	6.77 a[†]	6.67 a	6.72
EC (dS m^{-1})	0.12	0.146 a	0.173 a	0.159
P (mg kg^{-1})	0.47	62.5 a	50.9 a	56.7
K (mg kg^{-1})	0.89	175.1 a	171.2 a	173.2
Ca (mg kg^{-1})	0.19	1398 a	1552 a	1475
Mg (mg kg^{-1})	0.87	295.9 a	303.4 a	299.6
S (mg kg^{-1})	0.67	10.4 a	10.9 a	10.6
Na (mg kg^{-1})	0.05	17.4 a	24.6 a	21.0
Fe (mg kg^{-1})	0.85	244.1 a	239.3 a	241.7
Mn (mg kg^{-1})	0.10	171.1 a	135.5 a	153.3
Zn (mg kg^{-1})	0.15	5.5 a	2.2 a	3.9
Cu (mg kg^{-1})	0.42	1.7 a	1.5 a	1.6
P (kg ha^{-1})	0.48	79.9 a	64.8 a	72.3
K (kg ha^{-1})	0.95	221.2 a	218.9 a	220.0
Ca (kg ha^{-1})	0.10	1747 a	2000 a	1873
Mg (kg ha^{-1})	0.70	367.6 a	389.6 a	378.6
S (kg ha^{-1})	0.60	13.2 a	14.0 a	13.6
Na (kg ha^{-1})	0.03	21.6 b	31.6 a	–
Fe (kg ha^{-1})	0.89	308.4 a	303.8 a	306.1
Mn (kg ha^{-1})	0.17	217.0 a	175.6 a	196.3
Zn (kg ha^{-1})	0.15	7.2 a	2.8 a	5.0
Cu (kg ha^{-1})	0.49	2.2 a	1.9 a	2.0

[†] Different letters following means within a row are different at $P \leq 0.05$.

[‡] The test for treatment had 1 degree of freedom (df) and the denominator df was 52.

Table 4. Summary of the effect of treatment (cover crop and no cover crop) on mean soil physical properties in the top 10 cm and infiltration properties, including the slope and intercept characterizing the linear relationship between the natural logarithm of the infiltration rate between each time point and the mid-point of time, across 18 agroecosystems in eastern Arkansas.

Soil property	***P***[‡]	**Cover crop**	**No cover crop**	**Overall mean**
Sand (g g^{-1})	0.69	0.22 a[†]	0.23 a	0.22
Silt (g g^{-1})	0.31	0.68 a	0.64 a	0.66
Clay (g g^{-1})	0.13	0.10 a	0.13 a	0.11
Bulk density (g cm^{-3})	0.17	1.26 a	1.28 a	1.27
Total carbon (g kg^{-1})	0.48	9.3 a	8.5 a	8.9
Total nitrogen (g kg^{-1})	0.62	0.9 a	0.9 a	0.9
SOM[*] (g kg^{-1})	0.88	19.8 a	19.6 a	19.7
Total carbon (Mg ha^{-1})	0.61	11.7 a	10.9 a	11.3
Total nitrogen (Mg ha^{-1})	0.76	1.1 a	1.1 a	1.1
SOM (Mg ha^{-1})	0.86	24.9 a	25.2 a	25.1
Carbon:nitrogen ratio	0.18	10.2 a	9.6 a	9.9
Total carbon:SOM ratio	0.17	0.5 a	0.4 a	0.4
Total nitrogen:SOM ratio	0.60	0.05 a	0.04 a	0.04
ASWC[*] [±] (cm^3 cm^{-3})	0.04	0.2 a	0.1 b	–
OIR[*] (cm min^{-1})	0.14	0.1 a	0.1 a	0.1
SSIR[*] (cm min^{-1})	0.70	0.04 a	0.05 a	0.04
Slope	0.20	-0.1 a	-0.1 a	-0.1
Intercept	0.89	-1.7 a	-1.7 a	-1.7

[*] SOM, Soil organic matter; ASWC, Antecedent-soil-water content; OIR, Overall-infiltration rate; SSIR, Steady-state infiltration rate

[±] ASWC measured in the top 6 cm.

[†] Different letters following means within a row are different at $P \leq 0.05$.

[‡] The test for treatment had 1 df and the denominator df was 52.

Table 5. Analysis of variance summary of the effects of treatment (cover crop and no cover crop), soil depth (0-5 and 5-10 cm), aggregate-size class (0.25-0.5-, 0.5-1.0-, 1.0-2.0-, 2.0-4.0-, and > 4.0-mm), and their interactions on water-stable aggregates (WSA) across 18 agroecosystems in eastern Arkansas.

Source of variation	**Degrees of freedom**	**Denominator degrees of freedom**	**WSA**
			– *P* –
Treatment	1	1	0.56
Soil depth	1	16	0.67
Treatment x soil depth	1	16	0.30
Size class	4	488	< 0.01
Treatment x size class	4	488	0.79
Soil depth x size class	4	488	0.55
Treatment x soil depth x size class	4	488	0.98

Table 6. Analysis of variance summary of the effects of treatment (cover crop and no cover crop), soil depth (0-5 and 5-10 cm), and their interactions on total water-stable aggregates (TWSA) and the slope and intercept characterizing the linear relationship between the natural logarithm of the measured soil water potential and gravimetric water content across 18 agroecosystems in eastern Arkansas.

Source of variation	**Degrees of freedom**‡	**TWSA**	**Slope**	**Intercept**
			P	
Treatment	1	0.89	0.52	0.05
Soil depth	1	0.81	0.18	0.68
Treatment x soil depth	1	0.61	0.67	0.69

‡ The tests for treatment, depth, and treatment-depth interaction denominator df for TWSA was 104 and the denominator df for slope and intercept was 100.

Table 7. Analysis of variance summary of the effects of treatment (cover crop and no cover crop), sample placement (top of bed, no-wheel track, and wheel track), and their interactions on soil pH, electrical conductivity (EC), and Mehlich-3 extractable nutrient (P, K, Ca, Mg, S, Na, Fe, Mn, Zn, and Cu) concentrations and contents in the top 10 cm for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

	Source of variation			
Soil property	**Treatment**[†]	**Placement**[‡]	**Treatment x placement**[‡]	**Overall mean**
		P		
pH	< 0.01	< 0.01	0.01	–
EC (dS m^{-1})	0.28	0.08	0.01	–
P (mg kg^{-1})	0.75	< 0.01	0.08	–
K (mg kg^{-1})	0.04	< 0.01	0.12	–
Ca (mg kg^{-1})	0.32	0.15	0.31	1325
Mg (mg kg^{-1})	0.09	0.02	0.64	–
S (mg kg^{-1})	0.10	< 0.01	0.02	–
Na (mg kg^{-1})	0.29	< 0.01	0.02	–
Fe (mg kg^{-1})	0.05	< 0.01	0.01	–
Mn (mg kg^{-1})	0.03	0.76	0.59	–
Zn (mg kg^{-1})	0.23	0.57	0.77	1.6
Cu (mg kg^{-1})	0.07	0.36	0.42	–
P (kg ha^{-1})	0.75	< 0.01	0.01	–
K (kg ha^{-1})	0.05	< 0.01	0.20	–
Ca (kg ha^{-1})	0.41	0.89	0.20	1634
Mg (kg ha^{-1})	0.16	0.25	0.60	247.7
S (kg ha^{-1})	0.12	< 0.01	0.01	–
Na (kg ha^{-1})	0.35	< 0.01	0.03	–
Fe (kg ha^{-1})	0.02	< 0.01	< 0.01	–
Mn (kg ha^{-1})	0.04	0.82	0.70	–
Zn (kg ha^{-1})	0.27	0.19	0.89	2.0
Cu (kg ha^{-1})	0.09	0.56	0.59	–

[†] The test for treatment had 1 df and the denominator df was 12.

[‡] The tests for placement and treatment-placement interaction had 2 df and the denominator df was 12.

Table 8. Analysis of variance summary of the effects of treatment (cover crop and no cover crop), sample placement (top of bed, no-wheel track, and wheel track), and their interactions on soil physical properties in the top 10 cm and infiltration-related properties, including the slope and intercept characterizing the linear relationship between the natural logarithm of the infiltration rate between each time point and the mid-point of time, for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

	Source of variation			
Soil property	**Treatment**[†]	**Placement**[‡]	**Treatment x placement**[‡]	**Overall mean**
		P		
Sand (g g^{-1})	0.16	0.78	0.48	0.21
Silt (g g^{-1})	0.01	0.54	0.15	–
Clay (g g^{-1})	0.02	0.03	0.05	–
Bulk density (g cm^{-3})	0.89	0.01	0.27	–
Total carbon (g kg^{-1})	0.03	0.42	0.38	–
Total nitrogen (g kg^{-1})	< 0.01	0.05	0.48	–
SOM[*] (g kg^{-1})	< 0.01	0.81	0.16	–
Total carbon (Mg ha^{-1})	0.02	0.82	0.29	–
Total nitrogen (Mg ha^{-1})	< 0.01	0.21	0.74	–
SOM (Mg ha^{-1})	< 0.01	0.42	0.01	–
Carbon:nitrogen ratio	0.32	0.31	0.03	–
Total carbon:SOM ratio	0.27	0.44	0.38	0.5
Total nitrogen:SOM ratio	0.03	0.03	0.03	–
ASWC[*] [±] (cm^3 cm^{-3})	0.04	0.04	0.14	–
OIR[*] (cm min^{-1})	0.72	< 0.01	0.15	–
SSIR[*] (cm min^{-1})	0.67	0.59	0.98	0.02
Slope	0.40	0.10	0.66	–
Intercept	0.24	0.02	0.17	–

[*] SOM, Soil organic matter; ASWC, Antecedent-soil-water content; OIR, Overall-infiltration rate; SSIR, Steady-state infiltration rate

[±] ASWC measured in the top 6 cm.

[†] The test for treatment had 1 df and the denominator df was 12.

[‡] The tests for placement and treatment-placement interaction had 2 df and the denominator df was 12.

Table 9. Summary of the effect of treatment on mean extractable soil K, Mn, and Cu concentrations and contents and Mg content in the top 10 cm for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

Soil property	Cover crop	No cover crop
K (mg kg^{-1})	159.8 a[†]	143.9 b
Mg (mg kg^{-1})	192.6 b	208.6 a
Mn (mg kg^{-1})	76.3 b	86.8 a
Cu (mg kg^{-1})	1.0 b	1.2 a
K (kg ha^{-1})	196.9 a	177.5 b
Mn (kg ha^{-1})	94.0 b	107.1 a
Cu (kg ha^{-1})	1.2 b	1.5 a

[†] Different letters following means within a row are different at $P \leq 0.10$.

Table 10. Summary of the effect of treatment on mean soil physical properties in the top 10 cm and antecedent-soil-water content prior to the infiltration measurements for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

Soil property	Cover crop	No cover crop
Silt (g g^{-1})	0.69 b[†]	0.72 a
Total carbon (g kg^{-1})	11.1 a	8.9 b
Total nitrogen (g kg^{-1})	1.1 a	0.8 b
SOM[*] (g kg^{-1})	22.7 a	19.9 b
Total carbon (Mg ha^{-1})	13.6 a	11.0 b
Total nitrogen (Mg ha^{-1})	1.4 a	1.0 b
ASWC[*] [‡] (cm^3 cm^{-3})	9.5 a	8.0 b

[*] SOM, Soil organic matter and ASWC, Antecedent-soil-water content

[‡] ASWC measured in the top 6 cm.

[†] Different letters following means within a row are different at $P \leq 0.10$.

Table 11. Summary of the effect of sample placement on mean extractable soil K concentration and content and Mg content in the top 10 cm for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

Soil property	Bed	No-wheel track	Wheel track
K (mg kg^{-1})	190.2 a[†]	138.7 b	132.3 b
Mg (mg kg^{-1})	222.0 a	192.9 b	188.0 b
K (kg ha^{-1})	226.0 a	169.2 b	170.8 b

[†] Different letters following means within a row are different at $P \leq 0.10$.

Table 12. Summary of the effect of sample placement on mean soil physical properties in the top 10 cm and infiltration properties, including the slope and intercept characterizing the linear relationship between the natural logarithm of the infiltration rate between each time point and the mid-point of time, for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

Soil property	**Bed**	**No-wheel track**	**Wheel track**
Bulk density (g cm^{-3})	1.2 b[†]	1.2 b	1.3 a
Total nitrogen (g kg^{-1})	1.1 a	1.0 a	0.8 b
ASWC[*] [‡] (cm^3 cm^{-3})	7.7 b	9.9 a	8.7 ab
OIR[*] (cm min^{-1})	0.2 a	0.1 b	0.1 b
Slope	-0.06 a	-0.13 b	-0.14 b
Intercept	-1.3 a	-1.6 b	-1.5 b

[*] ASWC, Antecedent-soil-water content and OIR, Overall-infiltration rate

[‡] ASWC measured in the top 6 cm.

[†] Different letters following means within a row are different at $P \leq 0.10$.

Table 13. Analysis of variance summary of the effects of treatment (cover crop and no cover crop), sample placement (top of bed, no-wheel track, and wheel track), soil depth (0-5 and 5-10 cm), aggregate-size class (0.25-0.5-, 0.5-1.0-, 1.0-2.0-, 2.0-4.0-, and > 4.0-mm), and their interactions on water-stable aggregates (WSA) for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

Source of variation	**Degrees of freedom**	**Denominator degrees of freedom**	**WSA**
			— *P*—
Treatment	1	120	< 0.01
Placement	2	120	< 0.01
Treatment x placement	2	120	< 0.01
Depth	1	120	0.62
Treatment x depth	1	120	0.36
Placement x depth	2	120	0.34
Treatment x placement x depth	2	120	0.42
Size	4	120	< 0.01
Treatment x size	4	120	0.45
Placement x size	8	120	< 0.01
Treatment x placement x size	8	120	0.85
Depth x size	4	120	0.46
Treatment x depth x size	4	120	0.63
Placement x depth x size	8	120	0.72
Treatment x placement x depth x size	8	120	0.99

Table 14. Analysis of variance summary of the effects of treatment (cover crop and no cover crop), sample placement (top of bed, no-wheel track, and wheel track), soil depth (0-5 and 5-10 cm), and their interactions on total water-stable aggregates (TWSA) and the slope and intercept characterizing the linear relationship between the natural logarithm of the measured soil water potential and gravimetric water content for two agroecosystems (Stevens, referenced on Table 1) in eastern Arkansas.

Source of variation	**Degrees of freedom**[‡]	**TWSA**	**Slope**	**Intercept**
			P	
Treatment	1	< 0.01	0.08	0.68
Placement	2	< 0.01	0.39	0.92
Treatment x placement	2	< 0.01	0.01	0.58
Depth	1	0.74	0.05	0.38
Treatment x depth	1	0.54	0.07	0.10
Placement x depth	2	0.62	0.60	0.28
Treatment x placement x depth	2	0.68	0.20	0.39

[‡] The tests for treatment, placement, depth, and treatment-placement, treatment-depth, placement-depth, and treatment-placement-depth interaction denominator df for TWSA was 24 and the denominator df for slope and intercept was 22.

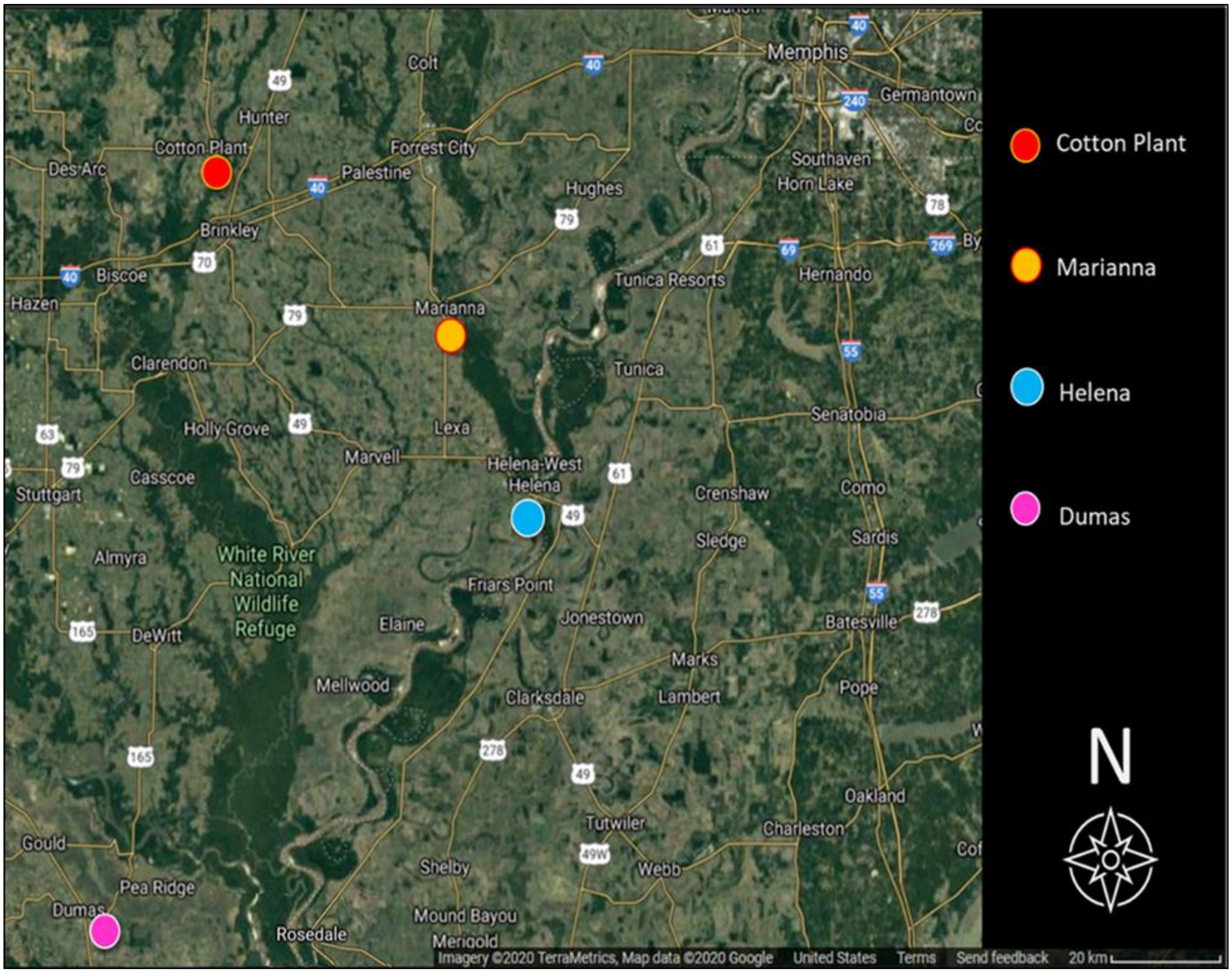

Figure 1. Locations of sample areas west of the Mississippi River in the Lower Mississippi River Valley delta region of eastern Arkansas (Google Maps, 2020).

Figure 2. Chappell location near Cotton Plant, AR where three agroecosystems, sampled in late May 2018, consisted of: 1. dryland soybeans with switchgrass CC, 2. dryland soybeans with NCC, and 3. twin-row soybeans with cereal rye CC (Image adapted from Google Earth, 2020).

Figure 3. Taylor location near Helena, AR where four agroecosystems, sampled in late May 2018, consisted of: 1. non-bedded soybeans with NCC, 2. bedded soybeans with cereal rye CC, and 3. & 4. corn-soybean rotation with cereal rye and turnip CC mix (Image adapted from Google Earth, 2020).

Figure 4. LMCRS location near Marianna, AR where six agroecosystems, sampled in late November 2018, consisted of: 1. soybeans with multiple CC treatments: hairy vetch, canola, cereal rye, and NCC and 2. cotton with cereal rye CC and cotton with NCC (Image adapted from Google Earth, 2020).

Figure 5. Stevens location near Dumas, AR where five agroecosystems, sampled in late May 2019 consisted of: 1. cotton with cereal rye CC and cotton with NCC (both CC treatments additionally sampled in WT and NWT furrows as a sub-study), 2. cotton with cereal rye CC and cotton with NCC, and 3. twin-row soybeans with cereal rye CC (Image adapted from Google Earth, 2020).

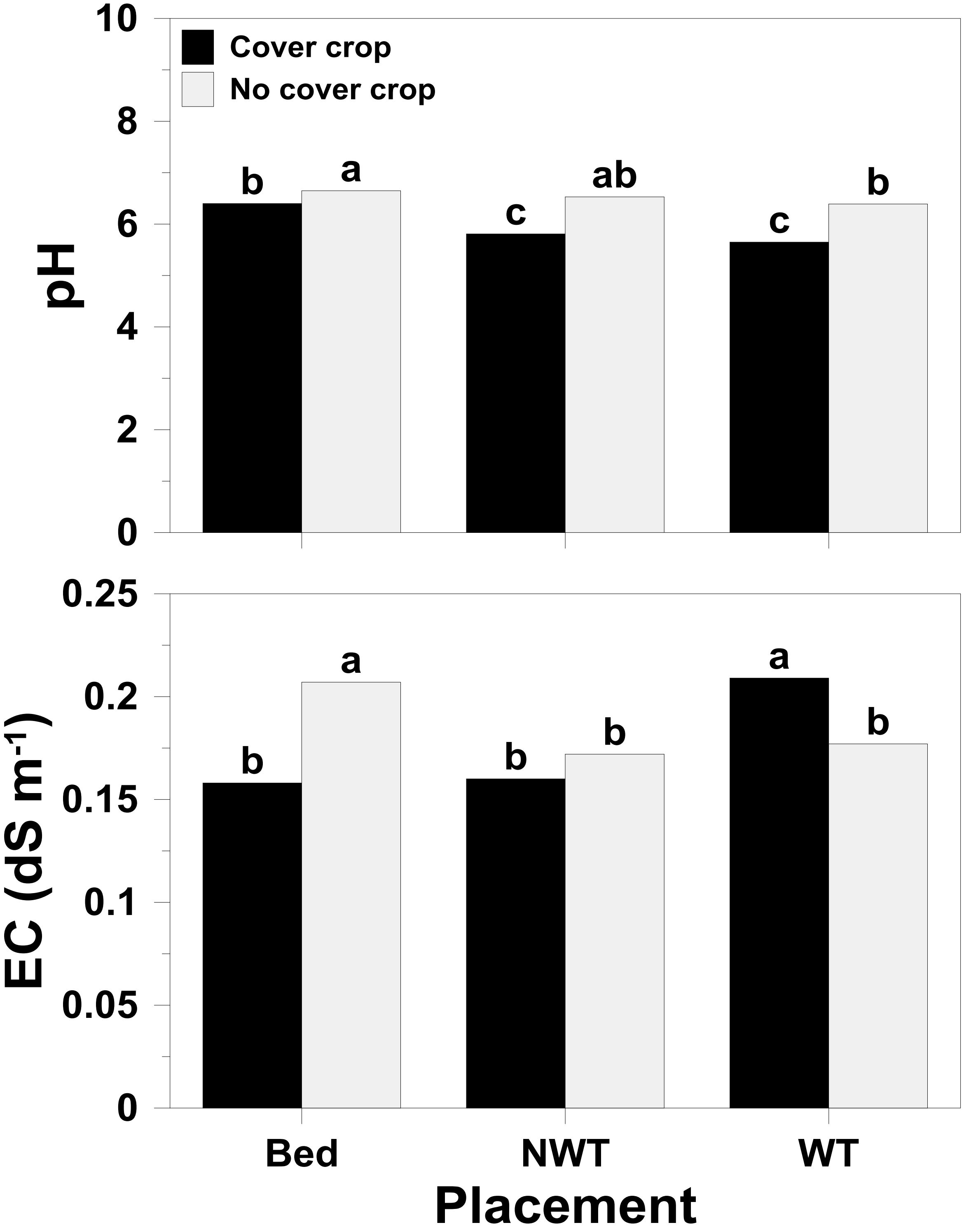

Figure 6. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) effects on soil pH and electrical conductivity (EC) in the top 10 cm. Different letters on top of bars within a panel are different at $P \leq 0.10$.

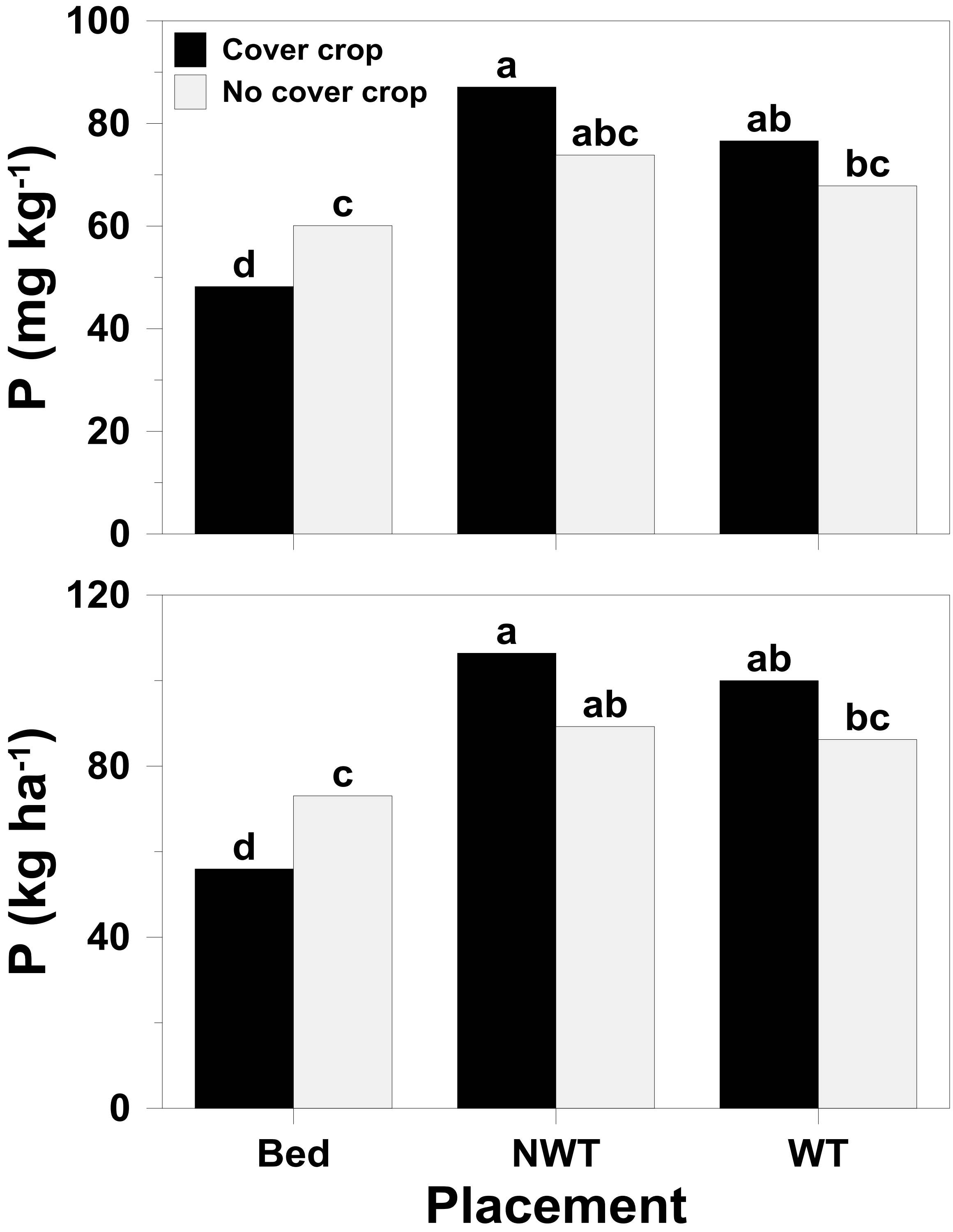

Figure 7. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) effects on soil P concentrations and contents in the top 10 cm. Different letters on top of bars within a panel are different at $P \leq 0.10$.

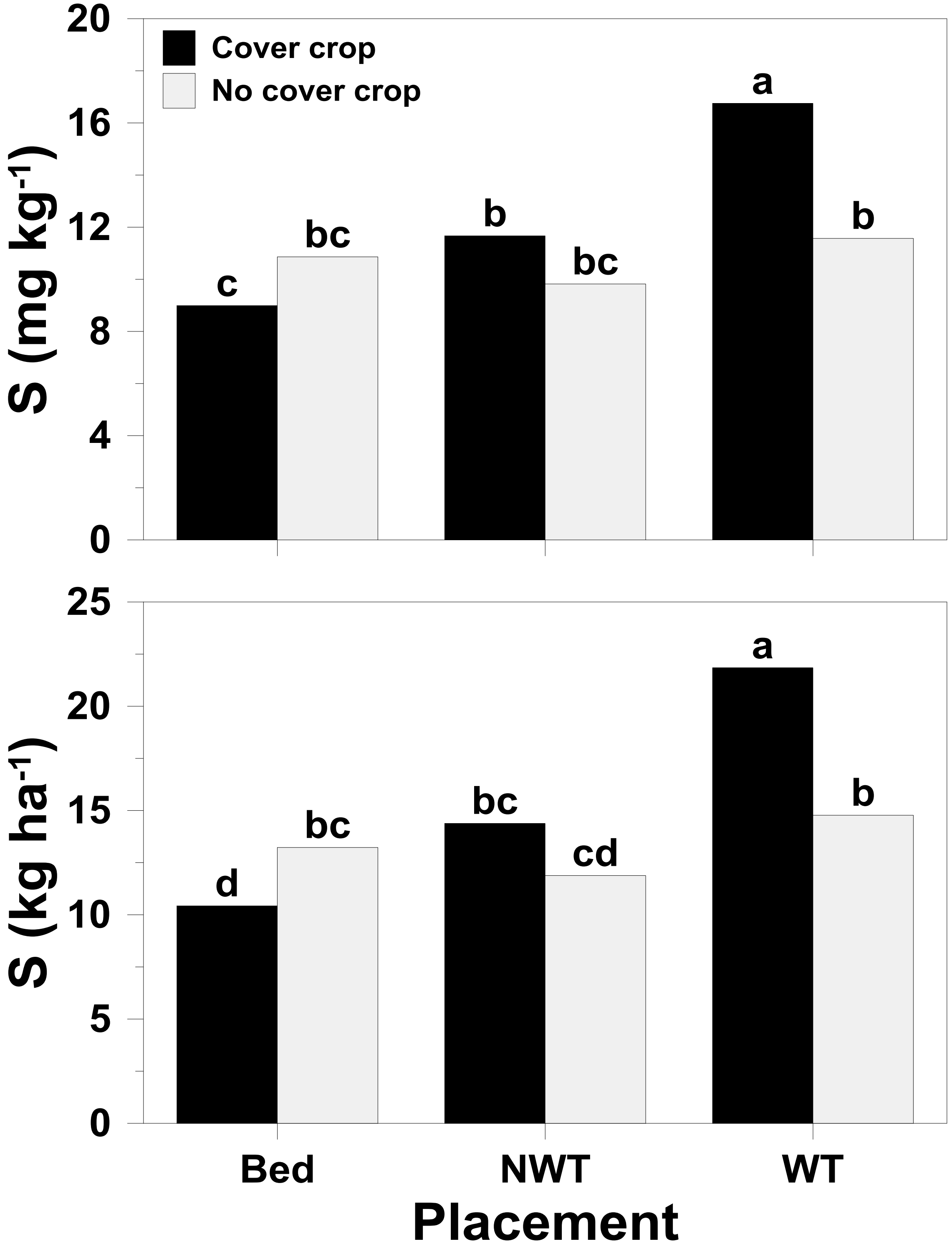

Figure 8. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) effects on soil S concentrations and contents in the top 10 cm. Different letters on top of bars within a panel are different at $P \leq 0.10$.

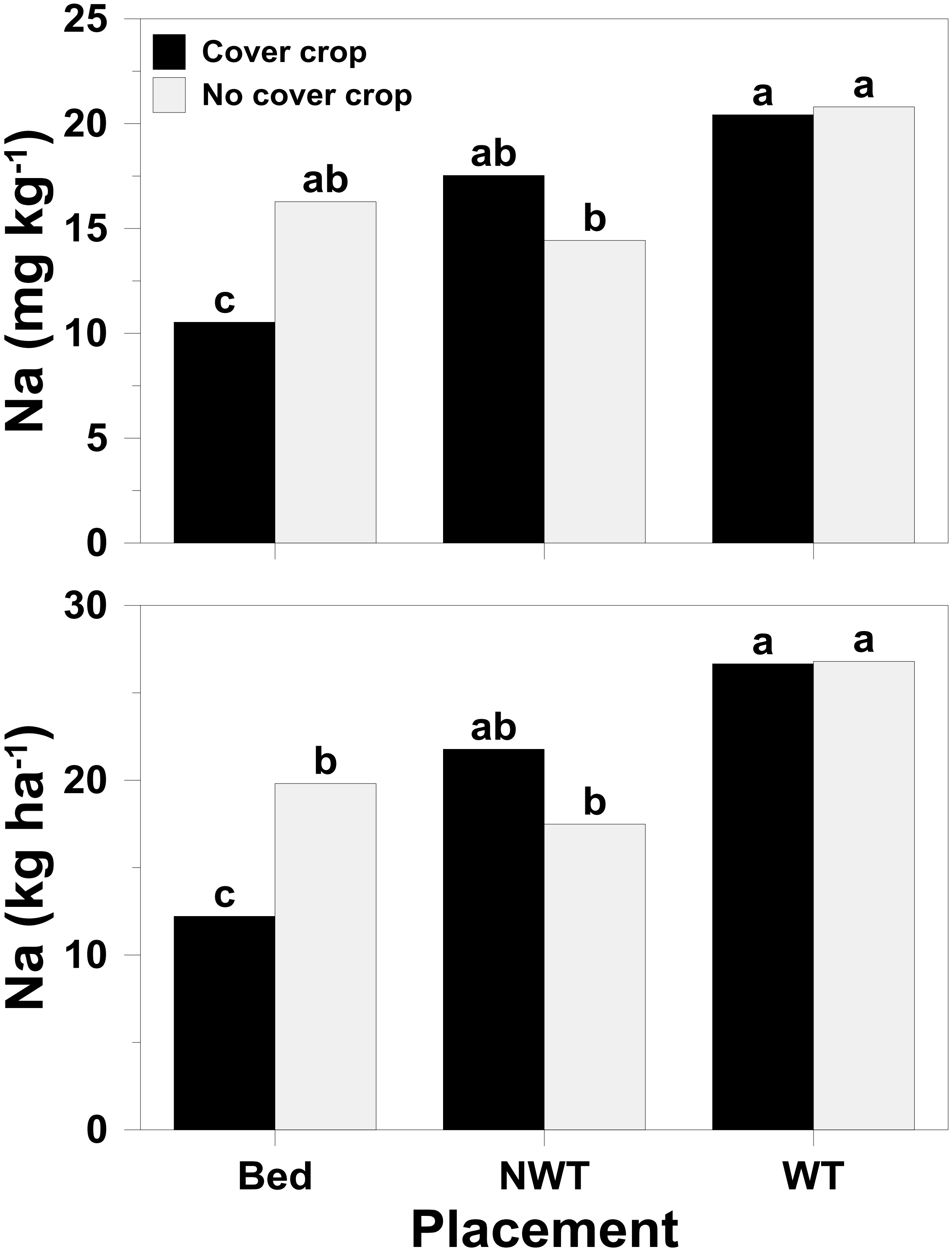

Figure 9. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) effects on soil Na concentrations and contents in the top 10 cm. Different letters on top of bars within a panel are different at *P* ≤ 0.10.

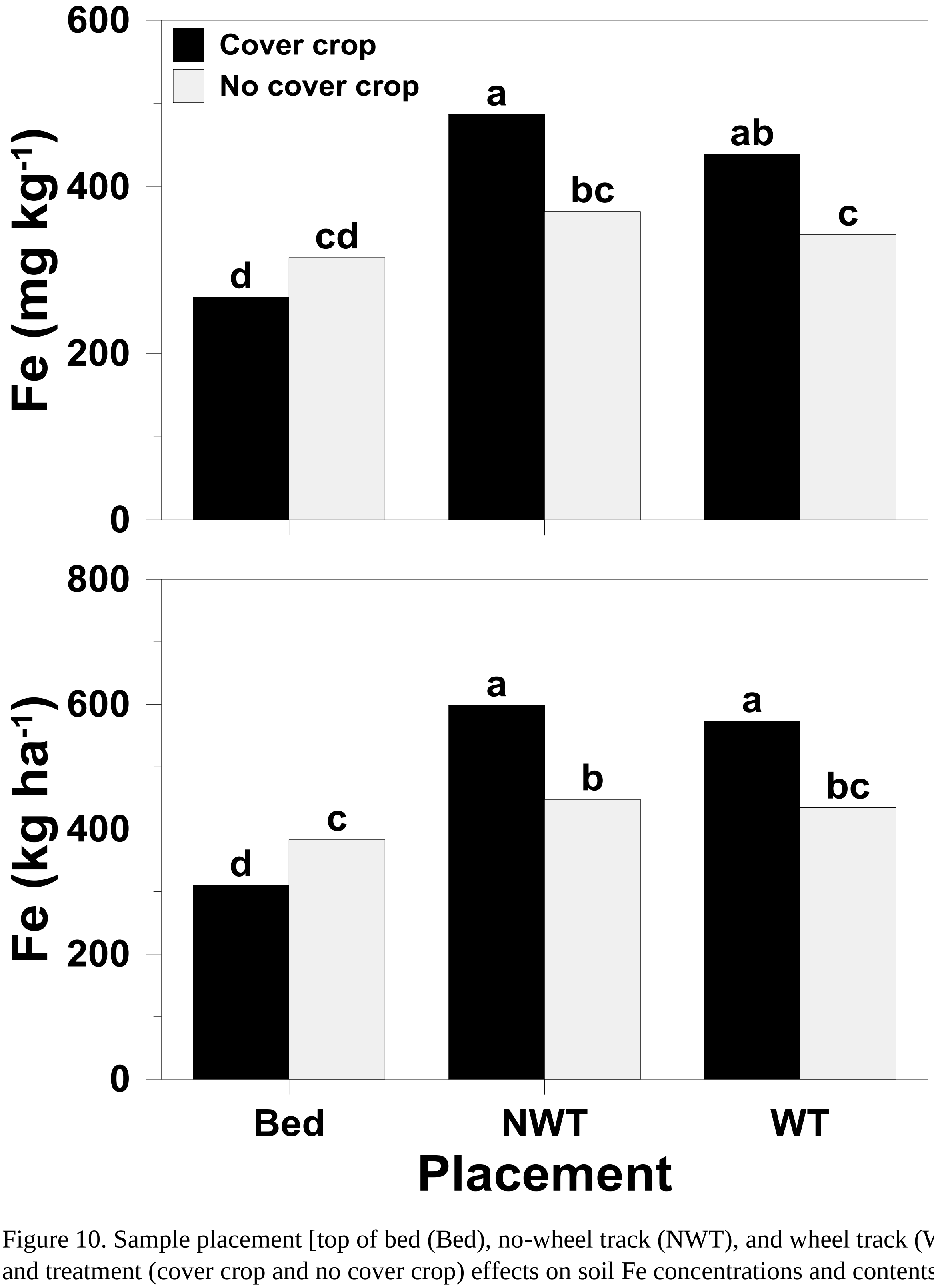

Figure 10. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) effects on soil Fe concentrations and contents in the top 10 cm. Different letters on top of bars within a panel are different at $P \leq 0.10$.

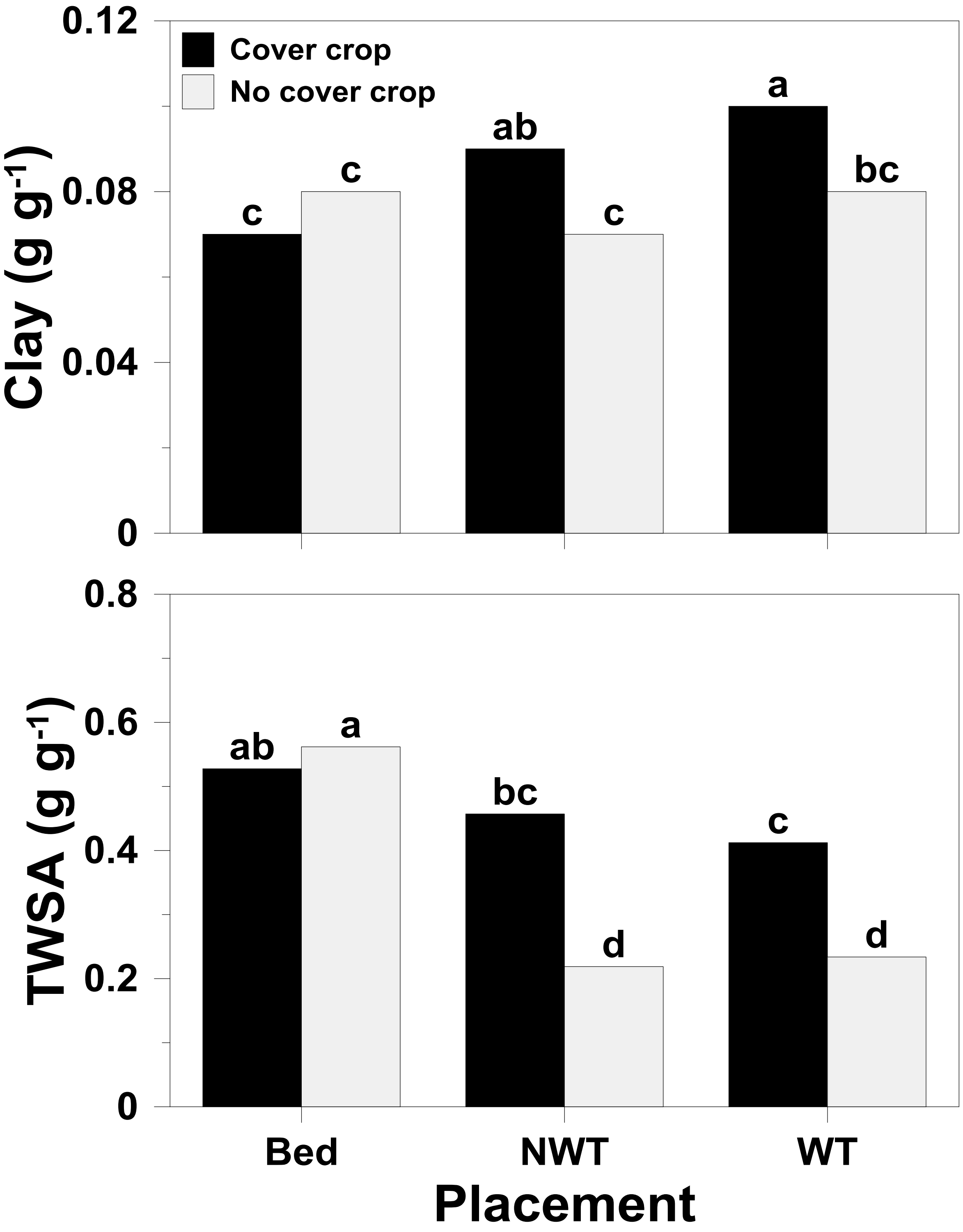

Figure 11. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) effects on clay in the top 10 cm and total water-stable aggregates (TWSA), averaged across soil depths, in the top 10 cm. Different letters on top of bars within a panel are different at $P \leq 0.10$.

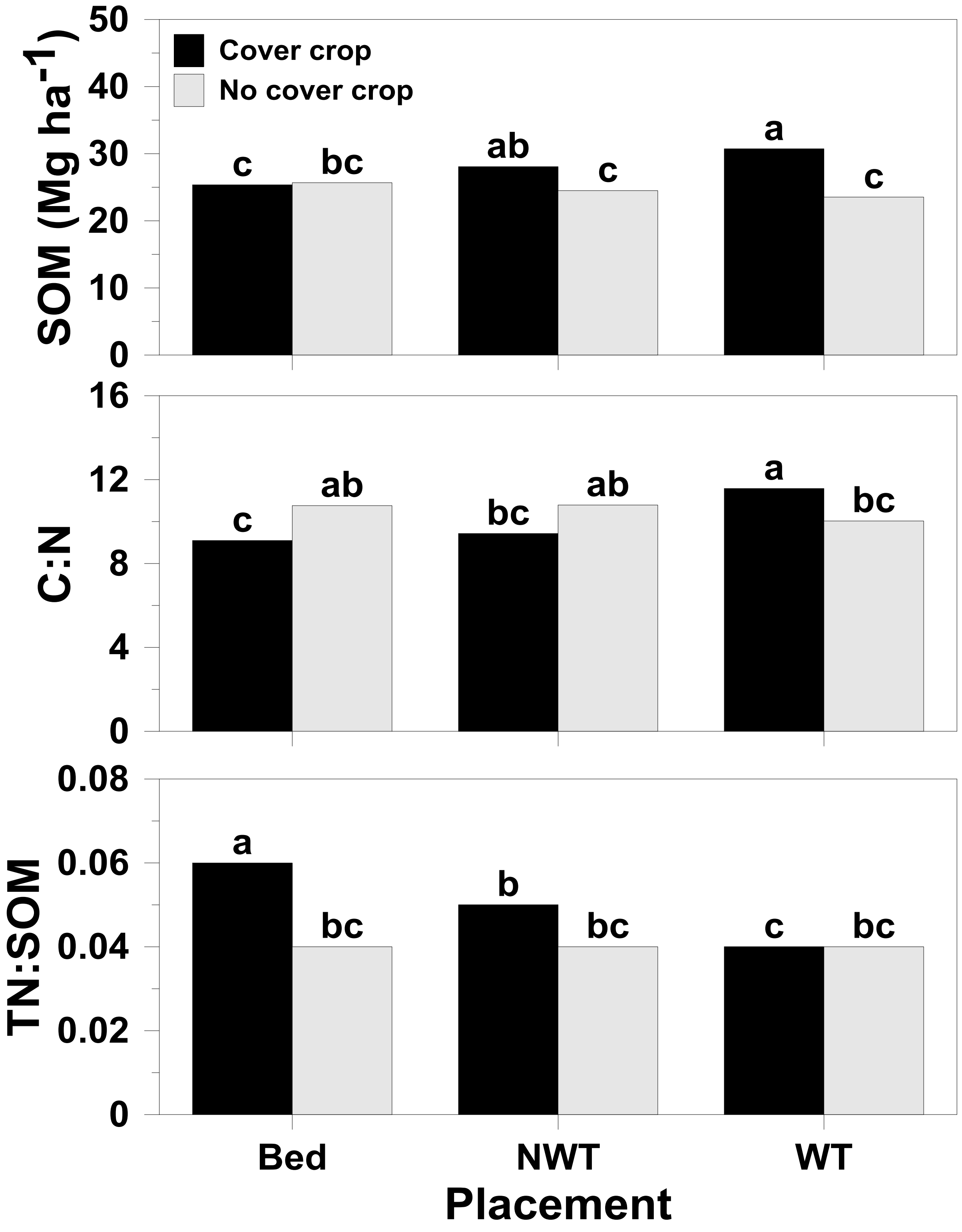

Figure 12. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) effects on soil organic matter (SOM) content, C:N ratio, and TN:SOM ratio in the top 10 cm. Different letters on top of bars within a panel are different at $P \leq 0.10$.

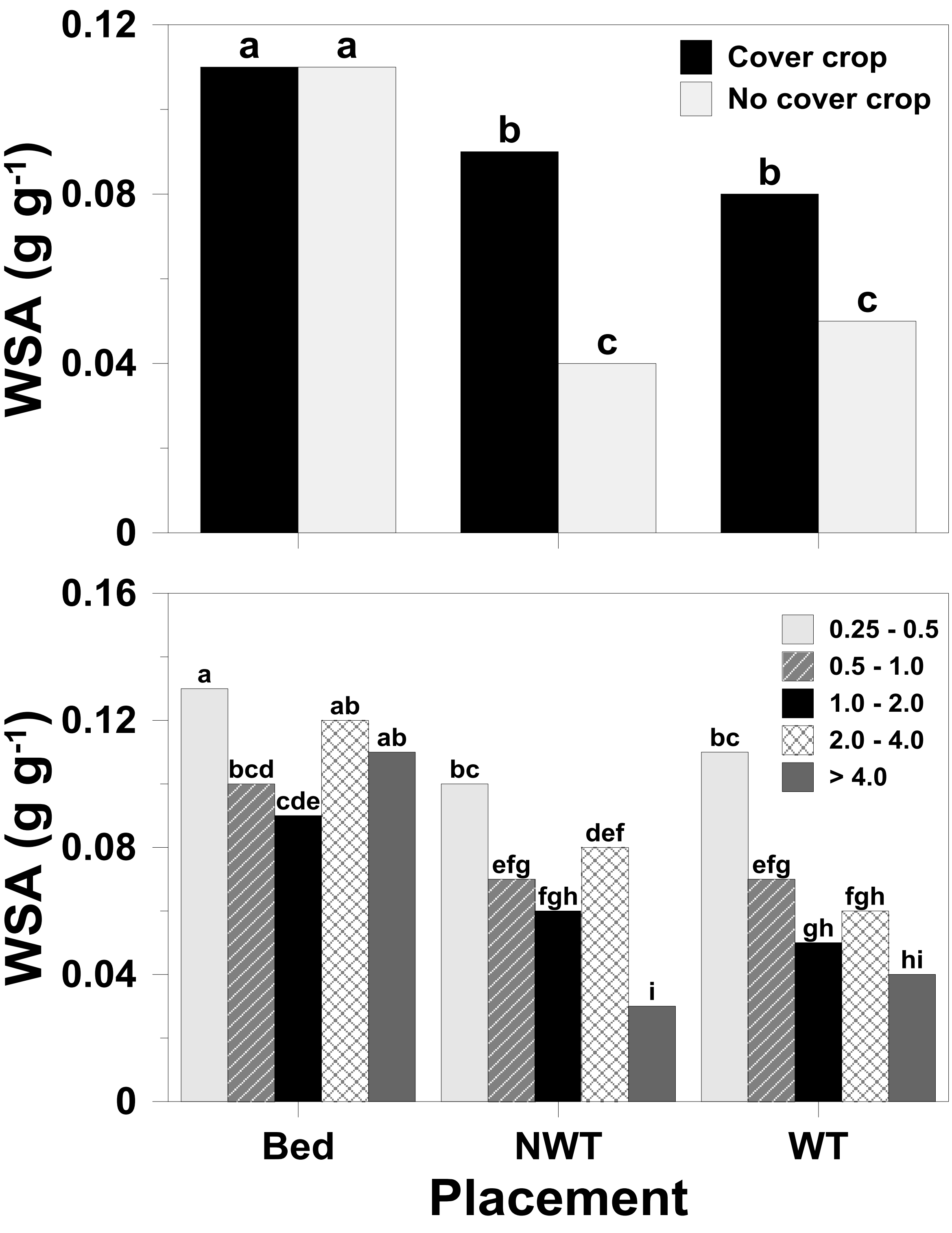

Figure 13. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment (cover crop and no cover crop) or aggregate-size class (0.25-0.5-, 0.5-1.0-, 1.0-2.0-, 2.0-4.0-, and > 4.0-mm) effects on water-stable aggregates (WSA) averaged across soil depths. Different letters on top of bars within a panel are different at $P \leq 0.10$.

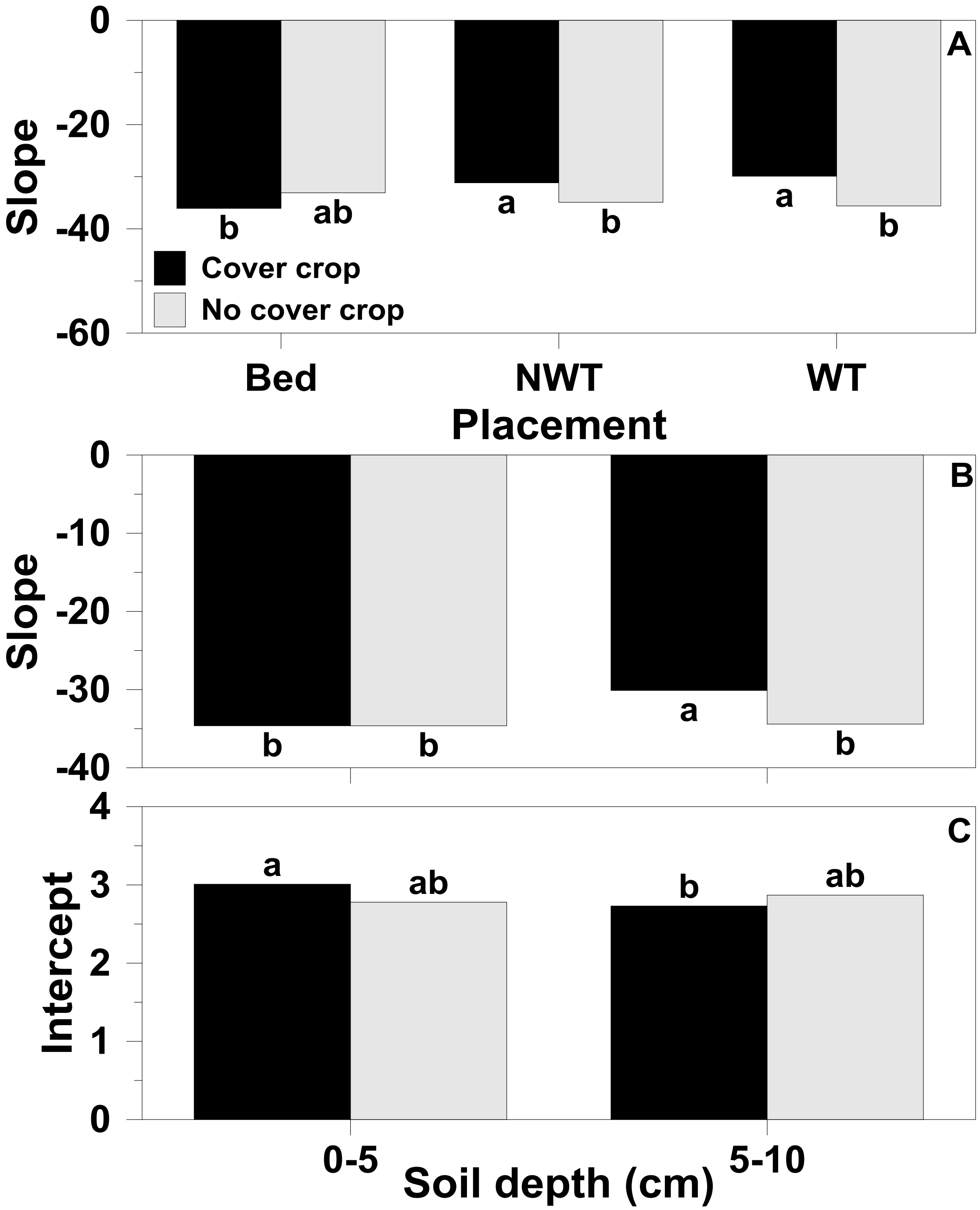

Figure 14. Sample placement [top of bed (Bed), no-wheel track (NWT), and wheel track (WT)] and treatment effects on the slope (A) characterizing the linear relationship between the natural logarithm of the measured soil water potential and gravimetric water content, averaged across soil depths (0-5 and 5-10 cm), and treatment (cover crop and no cover crop) and sample depth effects on the slope (B) and intercept (C) characterizing the linear relationship between the natural logarithm of the measured soil water potential and gravimetric water content, averaged across sample placement. Different letters on top of bars within a panel are different at $P \leq 0.10$.

Conclusions

All-locations Data Set

While CC benefits to soils under cultivated agriculture have been widely documented, CC benefits to soil health in the LMRV region of eastern Arkansas remain under-studied. This field study sought to fill a gap in research by evaluating the effects of CC (with and without a cover crop) on soil and hydraulic properties in the top 10 cm of cultivated, loessial and alluvial soils in the LMRV region of eastern Arkansas. Results of this study did not support the hypothesis that SOM and TC would be greater under CC compared to NCC. While TC concentration and content and SOM concentration were numerically greater under CC than NCC, SOM and TC were unaffected by CC treatment. Similarly, results did not support the hypothesis that BD would be greater, while OIR would be lowest, under NCC compared to CC, where soil BD and hydraulic properties (i.e., OIR and SSIR) were unaffected by CC treatment.

Results of this study partially supported the hypothesis that TWSA and water retention capacity would be greater under CC compared to NCC. Although TWSA was unaffected by treatment, thus not supporting the hypothesis, WSA differed by size class, with the largest and smallest size classes being greater than the two smallest intermediate size classes. Additionally, the hypothesis that water retention capacity would be greater under CC than NCC was supported, with more soil water stored in the top 10 cm when the soil was dry under CC compared to NCC.

Results provided valuable insight into the need for continued research in the LMRV region of eastern Arkansas. The all-locations data set served as a survey of agricultural sites utilizing CC in the LMRV with locations intentionally chosen to result in large variability. Therefore, if significant differences occur, those differences represent widespread implications despite large, inherent, soil property variability. The inherent variability of this study highlights a need for additional studies that analyze and compare the various parameters that go into a single field’s management to better understand CC benefits in conjunction with these practices over time. Despite large, expected variability, results demonstrated that CC systematically affected select soil physical, chemical, and hydraulic properties across a large geographic area.

Stevens-only Data Set

Results generally supported hypotheses regarding near-surface soil and hydraulic properties in the top 10 cm. In general, averaged across CC treatments, extractable soil nutrients were numerically lower in the bed than in the furrows. However, extractable soil nutrients demonstrated few consistent trends within CC treatments across measurement placements. Although soil TC concentration and content and SOM concentration were greater under CC than NCC, they were unaffected by placement, thus partially rejecting the hypothesis that soil TC and SOM would be greater in the bed compared to the furrows. Although SOM content was affected by placement, results further rejected the hypothesis because SOM content was lower in the bed than in the other two placements.

Results partially supported the hypothesis that soil BD would be greater, while infiltration would be lower, in WT furrows compared to in the bed and NWT furrows. Soil BD was greater in the WT compared to the other two placements. Infiltration parameters (i.e., OIR, slope, intercept) were greater in the bed compared to WT and NWT placements, except for SSIR which was unaffected by placement, partially supporting the hypothesis because, although infiltration was lower in the WT placement compared to in the bed, OIR in the WT did not differ from the NWT placement.

Results partially supported the hypothesis that WSA and water retention capacity would be lower in WT furrows compared to in the bed and NWT furrows. Water-stable aggregate concentrations in the CC-WT placement were lower than in the other two placements within the CC treatment. However, WSA in the NCC-NWT and -WT combinations were lower than, while CC-B and NCC-B combinations were greater than, all other treatment-placement combinations. Additionally, WSA in both WT and NWT placements had generally decreasing WSA with increasing size class, while WSA in all size classes in the bed were greater than for all other placement-size class combinations. Water retention was affected by treatment within placement and by treatment between soil depths, with the CC-NWT, CC-WT, and CC-5-10-cm combinations having the largest change in water content as the matric potential changed.

The large number of soil properties that did not differ between CC treatments was likely due to the variation in background management practices, the variation in CC species and cash crop species, and the variation in CC duration, which ranged from less than one year to greater than 19 years. Despite inherent variability, results clearly demonstrated that CC positively affect physical, chemical, and hydraulic properties across a large area. The additional above- and belowground biomass provided to the soil by the CC growing in the bed affected soil physical, chemical, and hydraulic properties in the furrows in CC treatments, as roots are able to extend vertically as well as horizontally to explore for water and nutrients. With continued management under CC, soil physical, chemical, and hydraulic properties in the top 10 cm measured in the current study will likely continue to differentiate between CC treatments if CC use persists consistently, such that significant differences will likely be identified at some time in the future.

Appendices

Appendix A: All-locations soil properties data set.

Location	Field ID #	Trt	Rep	ASWC (cm^{3} cm^{-3})	OIR (cm min^{-1})	Slope	Intercept	SSIR (cm min^{-1})	BD (g cm^{-3})
Chappell	1	CC	1	0.2	0.0	-0.2	-1.8	0.00	1.39
Chappell	1	CC	2	0.2	0.1	-0.1	-1.9	0.06	1.33
Chappell	1	CC	3	0.2	0.2	0.0	-1.4	0.15	1.29
Chappell	2	NCC	1	0.2	0.0	-0.2	-1.8	0.01	1.31
Chappell	2	NCC	2	0.2	0.6	0.2	-2.0	0.00	1.40
Chappell	2	NCC	3	0.1	0.2	0.0	-1.4	0.33	1.34
Chappell	3	CC	1	0.1	0.1	-0.1	-1.7	0.07	1.42
Chappell	3	CC	2	0.1	0.1	-0.1	-1.0	0.07	1.39
Chappell	3	CC	3	0.1	0.1	-0.1	-1.8	0.07	1.39
Taylor	1	NCC	1	0.1	0.1	-0.2	-1.2	0.04	1.25
Taylor	1	NCC	2	0.1	0.1	-0.1	-1.7	0.02	1.30
Taylor	1	NCC	3	0.1	0.1	-0.1	-2.1	0.03	1.21
Taylor	2	CC	1	0.1	0.1	-0.1	-1.8	0.08	1.21
Taylor	2	CC	2	0.1	0.1	-0.1	-1.8	0.02	1.20
Taylor	2	CC	3	0.1	0.1	-0.1	-1.7	0.04	1.24
Taylor	3	CC	1	0.2	0.1	0.0	-2.5	0.08	1.33
Taylor	3	CC	2	0.1	0.1	-0.2	-1.0	0.02	1.36
Taylor	3	CC	3	0.1	0.0	-0.1	-2.4	0.03	1.31
Taylor	4	CC	1	0.1	0.2	-0.1	-0.8	0.13	1.32
Taylor	4	CC	2	0.2	0.0	-0.1	-2.0	0.00	1.27
Taylor	4	CC	3	0.2	0.1	-0.1	-1.5	0.02	1.31
LMCRS1	R	CC	1	0.2	0.1	-0.1	-2.3	0.04	1.24
LMCRS1	R	CC	2	0.2	0.0	-0.1	-2.4	0.03	1.20
LMCRS1	R	CC	3	0.2	0.0	-0.1	-2.4	0.04	1.21
LMCRS1	V	CC	1	0.3	0.0	-0.1	-2.2	0.02	1.21
LMCRS1	V	CC	2	0.3	0.1	-0.1	-2.3	0.04	1.20
LMCRS1	V	CC	3	0.2	0.1	-0.1	-1.4	0.08	1.15
LMCRS1	Can	CC	1	0.2	0.0	-0.1	-2.3	0.00	1.23
LMCRS1	Can	CC	2	0.3	0.0	0.0	0.0	0.00	1.24
LMCRS1	Can	CC	3	0.3	0.0	-0.1	-2.1	0.01	1.24
LMCRS1	F	CC	1	0.2	0.0	-0.1	-2.1	0.02	1.20
LMCRS1	F	CC	2	0.2	0.0	-0.1	-2.4	0.02	1.20
LMCRS1	F	CC	3	0.2	0.1	-0.1	-1.7	0.06	1.21
LMCRS2	CC	CC	1	0.2	0.1	-0.1	-1.6	0.02	1.25
LMCRS2	CC	CC	2	0.2	0.1	-0.1	-1.8	0.04	1.20
LMCRS2	CC	CC	3	0.2	0.1	0.0	-2.1	0.08	1.23
LMCRS2	NCC	NCC	1	0.2	0.1	-0.1	-1.3	0.06	1.27
LMCRS2	NCC	NCC	2	0.2	0.1	-0.1	-1.6	0.02	1.30
LMCRS2	NCC	NCC	3	0.2	0.0	0.0	-3.3	0.03	1.34
Stevens	1CC	CC	1	0.1	0.3	-0.1	-0.9	0.08	1.15
Stevens	1CC	CC	2	0.1	0.3	0.0	-1.3	0.00	1.16
Stevens	1CC	CC	3	0.1	0.1	-0.2	-1.3	0.01	1.17
Stevens	1NCC	NCC	1	0.1	0.2	-0.1	-1.2	0.00	1.19
Stevens	1NCC	NCC	2	0.1	0.1	-0.1	-1.5	0.04	1.24
Stevens	1NCC	NCC	3	0.1	0.1	0.1	-1.6	0.06	1.23
Stevens	2CC	CC	1	0.1	0.1	-0.1	-1.7	0.04	1.23
Stevens	2CC	CC	2	0.2	0.1	-0.1	-1.6	0.03	1.22
Stevens	2CC	CC	3	0.1	0.1	-0.1	-2.0	0.03	1.27

Appendix A (cont.)

Location	Field ID #	Trt	Rep	ASWC (cm^3 cm^{-3})	OIR (cm min^{-1})	Slope	Intercept	SSIR (cm min^{-1})	BD (g cm^{-3})
Stevens	2NCC	NCC	1	0.1	0.0	-0.2	-1.1	0.00	1.29
Stevens	2NCC	NCC	2	0.1	0.1	-0.1	-2.2	0.04	1.30
Stevens	2NCC	NCC	3	0.2	0.0	-0.1	-2.1	0.00	1.30
Stevens	3	CC	1	0.1	0.1	-0.2	-1.3	0.00	1.26
Stevens	3	CC	2	0.1	0.1	-0.1	-1.4	0.02	1.25
Stevens	3	CC	3	0.1	0.1	-0.2	-1.3	0.01	1.31

Location	Field ID #	Trt	Rep	Sand (g g^{-1})	Silt (g g^{-1})	Clay (g g^{-1})	[P] (mg kg^{-1})	[K] (mg kg^{-1})	[Ca] (mg kg^{-1})
Chappell	1	CC	1	0.59	0.33	0.08	201.9	257.6	625.1
Chappell	1	CC	2	0.46	0.46	0.08	409.3	611.2	861.8
Chappell	1	CC	3	0.47	0.43	0.10	36.0	250.5	750.2
Chappell	2	NCC	1	0.49	0.38	0.13	29.5	114.1	1580.2
Chappell	2	NCC	2	0.61	0.33	0.06	36.9	111.2	2144.7
Chappell	2	NCC	3	0.62	0.32	0.06	34.3	100.7	1285.3
Chappell	3	CC	1	0.41	0.51	0.08	58.4	125.9	1107.7
Chappell	3	CC	2	0.44	0.49	0.07	34.3	135.4	1096.5
Chappell	3	CC	3	0.50	0.44	0.06	52.3	102.1	529.4
Taylor	1	NCC	1	0.12	0.80	0.08	58.4	123.8	1043.2
Taylor	1	NCC	2	0.16	0.77	0.07	48.3	109.7	1009.0
Taylor	1	NCC	3	0.10	0.80	0.10	85.8	194.6	1440.7
Taylor	2	CC	1	0.12	0.82	0.06	78.7	147.9	1427.6
Taylor	2	CC	2	0.10	0.84	0.06	61.7	154.7	1379.9
Taylor	2	CC	3	0.11	0.83	0.06	65.9	115.9	1333.9
Taylor	3	CC	1	0.24	0.63	0.13	95.3	252.7	1768.7
Taylor	3	CC	2	0.23	0.63	0.14	68.6	181.5	1783.5
Taylor	3	CC	3	0.17	0.67	0.16	81.1	258.6	2056.7
Taylor	4	CC	1	0.24	0.66	0.10	27.1	139.5	1459.9
Taylor	4	CC	2	0.23	0.69	0.08	52.0	184.8	1521.8
Taylor	4	CC	3	0.24	0.68	0.08	49.0	247.6	1480.7
LMCRS1	R	CC	1	0.13	0.76	0.11	25.9	105.5	1492.3
LMCRS1	R	CC	2	0.14	0.75	0.11	25.5	106.3	1461.3
LMCRS1	R	CC	3	0.13	0.77	0.10	26.6	120.5	1409.4
LMCRS1	V	CC	1	0.15	0.76	0.09	42.4	142.4	1416.2
LMCRS1	V	CC	2	0.13	0.78	0.09	40.7	120.2	1393.0
LMCRS1	V	CC	3	0.16	0.75	0.09	32.8	94.5	1448.7
LMCRS1	Can	CC	1	0.14	0.75	0.11	32.8	137.8	1439.3
LMCRS1	Can	CC	2	0.13	0.75	0.12	36.2	112.5	1637.7
LMCRS1	Can	CC	3	0.17	0.73	0.10	34.1	138.3	1646.2
LMCRS1	F	CC	1	0.14	0.75	0.11	36.2	123.5	1445.4
LMCRS1	F	CC	2	0.14	0.74	0.12	36.2	93.0	1534.1
LMCRS1	F	CC	3	0.16	0.73	0.11	34.2	101.4	1520.8
LMCRS2	CC	CC	1	0.11	0.73	0.16	19.3	112.0	1239.3
LMCRS2	CC	CC	2	0.14	0.71	0.16	23.5	129.6	1159.8
LMCRS2	CC	CC	3	0.17	0.68	0.15	35.0	143.4	1092.6
LMCRS2	NCC	NCC	1	0.13	0.70	0.17	18.8	105.3	1306.1
LMCRS2	NCC	NCC	2	0.14	0.69	0.17	22.2	102.4	1464.1
LMCRS2	NCC	NCC	3	0.13	0.72	0.16	18.8	99.5	1225.5
Stevens	1CC	CC	1	0.21	0.72	0.07	45.2	190.2	1303.6

Appendix A (cont.)

Location	Field ID #	Trt	Rep	Sand (g g^{-1})	Silt (g g^{-1})	Clay (g g^{-1})	[P] (mg kg^{-1})	[K] (mg kg^{-1})	[Ca] (mg kg^{-1})
Stevens	1CC	CC	2	0.24	0.70	0.07	48.2	197.2	1298.5
Stevens	1CC	CC	3	0.20	0.72	0.08	51.2	243.1	1372.3
Stevens	1NCC	NCC	1	0.23	0.71	0.07	70.4	174.1	1411.5
Stevens	1NCC	NCC	2	0.20	0.72	0.09	56.7	176.6	1493.3
Stevens	1NCC	NCC	3	0.20	0.73	0.08	53.1	166.6	1430.1
Stevens	2CC	CC	1	0.14	0.68	0.18	101.0	300.0	2043.0
Stevens	2CC	CC	2	0.12	0.67	0.21	91.9	347.2	2243.0
Stevens	2CC	CC	3	0.12	0.66	0.21	67.5	272.1	2072.1
Stevens	2NCC	NCC	1	0.14	0.64	0.22	86.7	331.3	2062.5
Stevens	2NCC	NCC	2	0.12	0.64	0.24	65.4	300.7	2181.5
Stevens	2NCC	NCC	3	0.12	0.66	0.22	78.7	357.2	2209.4
Stevens	3	CC	1	0.23	0.70	0.07	71.0	118.9	1105.1
Stevens	3	CC	2	0.23	0.71	0.07	56.7	103.0	1469.7
Stevens	3	CC	3	0.22	0.70	0.08	51.6	109.5	1079.8

Location	Field ID #	Trt	Rep	[Mg] (mg kg^{-1})	[S] (mg kg^{-1})	[Na] (mg kg^{-1})	[Fe] (mg kg^{-1})	[Mn] (mg kg^{-1})
Chappell	1	CC	1	111.9	13.3	6.5	375.4	178.1
Chappell	1	CC	2	199.0	18.0	6.1	468.5	138.1
Chappell	1	CC	3	158.9	20.1	5.5	209.7	165.8
Chappell	2	NCC	1	200.2	17.3	8.1	174.0	277.4
Chappell	2	NCC	2	60.4	11.4	5.1	122.2	215.6
Chappell	2	NCC	3	57.3	10.6	4.6	140.2	221.6
Chappell	3	CC	1	81.5	10.1	7.6	194.6	408.8
Chappell	3	CC	2	74.2	10.2	6.4	168.1	430.3
Chappell	3	CC	3	63.4	12.1	8.3	212.8	277.3
Taylor	1	NCC	1	153.4	10.8	15.6	311.1	110.7
Taylor	1	NCC	2	111.1	10.0	12.7	270.5	116.1
Taylor	1	NCC	3	138.2	13.4	15.6	332.4	160.0
Taylor	2	CC	1	319.3	14.7	11.8	326.9	170.2
Taylor	2	CC	2	282.6	12.3	12.5	284.0	151.7
Taylor	2	CC	3	292.4	12.7	15.6	307.5	166.6
Taylor	3	CC	1	385.6	15.2	14.4	406.8	111.3
Taylor	3	CC	2	353.4	13.1	17.7	335.7	126.4
Taylor	3	CC	3	378.6	16.2	16.1	356.8	154.2
Taylor	4	CC	1	309.1	10.2	13.9	286.5	90.4
Taylor	4	CC	2	286.9	10.1	8.9	334.2	86.8
Taylor	4	CC	3	277.9	9.9	9.3	388.3	76.4
LMCRS1	R	CC	1	347.5	6.8	23.6	172.4	198.7
LMCRS1	R	CC	2	335.3	7.0	21.7	158.8	192.8
LMCRS1	R	CC	3	372.1	5.8	15.6	162.0	199.7
LMCRS1	V	CC	1	333.3	9.5	19.6	198.9	203.6
LMCRS1	V	CC	2	328.2	7.5	32.9	190.7	205.7
LMCRS1	V	CC	3	344.8	8.2	22.2	173.6	207.5
LMCRS1	Can	CC	1	326.9	9.3	16.7	168.9	202.8
LMCRS1	Can	CC	2	372.9	8.3	20.3	175.2	199.5
LMCRS1	Can	CC	3	394.2	10.6	24.0	182.1	199.7
LMCRS1	F	CC	1	328.2	7.0	18.1	181.9	197.4
LMCRS1	F	CC	2	352.4	5.8	39.0	176.6	188.8

Appendix A (cont.)

Location	Field ID #	Trt	Rep	[Mg] (mg kg^{-1})	[S] (mg kg^{-1})	[Na] (mg kg^{-1})	[Fe] (mg kg^{-1})	[Mn] (mg kg^{-1})
LMCRS1	F	CC	3	358.5	8.3	20.7	189.1	213.6
LMCRS2	CC	CC	1	542.4	5.3	27.1	151.8	144.9
LMCRS2	CC	CC	2	517.2	5.4	21.3	142.8	127.1
LMCRS2	CC	CC	3	485.9	6.6	26.0	147.4	108.4
LMCRS2	NCC	NCC	1	567.8	7.3	48.1	154.1	142.5
LMCRS2	NCC	NCC	2	566.1	5.6	43.6	166.5	131.8
LMCRS2	NCC	NCC	3	528.7	6.3	42.9	158.0	148.3
Stevens	1CC	CC	1	225.4	9.3	11.4	269.6	84.3
Stevens	1CC	CC	2	197.4	8.3	9.4	267.5	84.3
Stevens	1CC	CC	3	214.8	9.4	10.8	264.9	71.4
Stevens	1NCC	NCC	1	238.3	10.7	18.3	357.3	100.9
Stevens	1NCC	NCC	2	236.4	10.4	13.9	288.1	84.0
Stevens	1NCC	NCC	3	220.6	11.4	16.6	301.5	77.5
Stevens	2CC	CC	1	390.7	12.8	32.0	291.8	76.4
Stevens	2CC	CC	2	458.7	11.7	35.3	283.9	88.8
Stevens	2CC	CC	3	461.8	10.2	40.4	267.5	74.4
Stevens	2NCC	NCC	1	437.4	11.2	28.3	274.2	80.1
Stevens	2NCC	NCC	2	527.7	14.3	54.4	267.6	80.6
Stevens	2NCC	NCC	3	507.3	12.5	41.8	271.7	86.0
Stevens	3	CC	1	100.0	11.3	8.3	240.5	253.8
Stevens	3	CC	2	87.9	11.1	8.7	223.5	226.3
Stevens	3	CC	3	89.9	13.4	12.8	181.9	191.5

Location	Field ID #	Trt	Rep	[Zn] (mg kg^{-1})	[Cu] (mg kg^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (kg ha^{-1})
Chappell	1	CC	1	33.4	4.7	281.3	358.8	870.7
Chappell	1	CC	2	78.3	1.7	542.7	810.2	1142.6
Chappell	1	CC	3	4.7	1.0	46.2	322.0	964.2
Chappell	2	NCC	1	3.3	1.5	38.8	149.9	2074.8
Chappell	2	NCC	2	2.5	1.1	51.7	155.8	3005.0
Chappell	2	NCC	3	2.9	1.3	46.0	134.9	1722.3
Chappell	3	CC	1	3.5	1.6	82.9	178.5	1570.3
Chappell	3	CC	2	2.6	1.3	47.8	188.3	1525.6
Chappell	3	CC	3	2.4	0.9	72.5	141.6	734.6
Taylor	1	NCC	1	3.3	1.9	72.9	154.5	1301.9
Taylor	1	NCC	2	2.6	1.7	62.6	142.1	1307.4
Taylor	1	NCC	3	4.2	2.2	104.1	236.1	1747.4
Taylor	2	CC	1	5.6	1.7	95.2	178.9	1726.4
Taylor	2	CC	2	5.5	1.7	73.9	185.2	1652.5
Taylor	2	CC	3	5.5	1.6	81.5	143.5	1651.2
Taylor	3	CC	1	6.6	2.0	126.5	335.4	2347.8
Taylor	3	CC	2	6.3	2.6	93.3	246.9	2426.5
Taylor	3	CC	3	7.2	2.8	106.3	339.2	2697.7
Taylor	4	CC	1	4.3	2.1	35.8	184.3	1928.9
Taylor	4	CC	2	5.1	2.0	66.1	235.0	1934.4
Taylor	4	CC	3	4.6	1.7	64.4	325.0	1943.3
LMCRS1	R	CC	1	1.2	1.3	32.1	131.1	1854.2
LMCRS1	R	CC	2	1.4	1.3	30.7	128.1	1760.0
LMCRS1	R	CC	3	1.4	1.3	32.1	145.6	1703.6

Appendix A (cont.)

Location	Field ID #	Trt	Rep	[Zn] (mg kg^{-1})	[Cu] (mg kg^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (kg ha^{-1})
LMCRS1	V	CC	1	1.5	1.4	51.2	171.9	1709.4
LMCRS1	V	CC	2	1.6	1.4	48.7	143.8	1666.3
LMCRS1	V	CC	3	1.4	1.4	37.7	108.8	1666.8
LMCRS1	Can	CC	1	1.3	1.3	40.3	169.2	1767.4
LMCRS1	Can	CC	2	1.3	1.3	44.7	139.0	2023.5
LMCRS1	Can	CC	3	1.4	1.4	42.3	171.4	2040.6
LMCRS1	F	CC	1	1.4	1.4	43.5	148.3	1735.5
LMCRS1	F	CC	2	1.4	1.4	43.5	111.7	1842.4
LMCRS1	F	CC	3	1.5	1.4	41.6	123.2	1847.7
LMCRS2	CC	CC	1	1.0	1.1	24.0	139.5	1543.3
LMCRS2	CC	CC	2	0.9	1.0	28.3	155.9	1395.4
LMCRS2	CC	CC	3	0.9	0.9	43.0	176.1	1341.3
LMCRS2	NCC	NCC	1	1.0	1.1	23.9	133.8	1658.6
LMCRS2	NCC	NCC	2	1.0	1.2	28.8	133.0	1900.6
LMCRS2	NCC	NCC	3	0.9	1.1	25.1	133.1	1639.6
Stevens	1CC	CC	1	1.6	1.1	52.0	218.7	1499.3
Stevens	1CC	CC	2	1.4	1.1	55.7	228.0	1501.3
Stevens	1CC	CC	3	1.4	1.3	60.1	285.1	1609.4
Stevens	1NCC	NCC	1	1.8	1.3	83.8	207.3	1680.7
Stevens	1NCC	NCC	2	1.4	1.3	70.1	218.3	1845.8
Stevens	1NCC	NCC	3	1.4	1.2	65.2	204.4	1754.1
Stevens	2CC	CC	1	2.4	5.5	123.8	367.7	2504.1
Stevens	2CC	CC	2	2.3	2.0	112.4	424.4	2741.7
Stevens	2CC	CC	3	1.9	1.9	85.5	344.5	2622.9
Stevens	2NCC	NCC	1	2.2	1.9	111.8	427.4	2660.4
Stevens	2NCC	NCC	2	2.1	2.0	84.9	390.3	2831.5
Stevens	2NCC	NCC	3	2.1	2.0	102.1	463.3	2865.5
Stevens	3	CC	1	2.4	1.7	89.5	149.9	1393.6
Stevens	3	CC	2	1.8	1.6	70.6	128.3	1831.3
Stevens	3	CC	3	2.4	1.7	67.5	143.2	1412.7

Location	Field ID #	Trt	Rep	Mg (kg ha^{-1})	S (kg ha^{-1})	Na (kg ha^{-1})	Fe (kg ha^{-1})	Mn (kg ha^{-1})	Zn (kg ha^{-1})
Chappell	1	CC	1	155.8	18.5	9.0	522.9	248.0	46.5
Chappell	1	CC	2	263.8	23.9	8.1	621.0	183.1	103.9
Chappell	1	CC	3	204.2	25.8	7.0	269.5	213.1	6.0
Chappell	2	NCC	1	262.8	22.7	10.6	228.5	364.2	4.4
Chappell	2	NCC	2	84.6	16.0	7.1	171.2	302.1	3.5
Chappell	2	NCC	3	76.8	14.2	6.2	187.9	296.9	3.9
Chappell	3	CC	1	115.5	14.4	10.8	275.9	579.5	5.0
Chappell	3	CC	2	103.2	14.2	8.9	233.9	598.8	3.7
Chappell	3	CC	3	87.9	16.8	11.5	295.2	384.7	3.4
Taylor	1	NCC	1	191.5	13.4	19.5	388.3	138.2	4.2
Taylor	1	NCC	2	144.0	13.0	16.4	350.5	150.4	3.4
Taylor	1	NCC	3	167.6	16.3	18.9	403.1	194.1	5.1
Taylor	2	CC	1	386.1	17.8	14.3	395.3	205.8	6.8
Taylor	2	CC	2	338.4	14.7	15.0	340.1	181.7	6.6
Taylor	2	CC	3	361.9	15.7	19.3	380.7	206.2	6.8
Taylor	3	CC	1	511.8	20.2	19.1	540.1	147.8	8.8

Appendix A (cont.)

Location	Field ID #	Trt	Rep	Mg (kg ha^{-1})	S (kg ha^{-1})	Na (kg ha^{-1})	Fe (kg ha^{-1})	Mn (kg ha^{-1})	Zn (kg ha^{-1})
Taylor	3	CC	2	480.8	17.8	24.1	456.7	172.0	8.5
Taylor	3	CC	3	496.5	21.3	21.2	468.0	202.3	9.4
Taylor	4	CC	1	408.4	13.4	18.3	378.6	119.5	5.6
Taylor	4	CC	2	364.7	12.8	11.3	424.8	110.3	6.5
Taylor	4	CC	3	364.7	13.0	12.2	509.6	100.2	6.0
LMCRS1	R	CC	1	431.8	8.5	29.3	214.2	246.9	1.5
LMCRS1	R	CC	2	403.8	8.5	26.1	191.3	232.2	1.6
LMCRS1	R	CC	3	449.8	7.0	18.9	195.8	241.3	1.7
LMCRS1	V	CC	1	402.3	11.5	23.7	240.0	245.8	1.8
LMCRS1	V	CC	2	392.6	9.0	39.4	228.1	246.0	1.9
LMCRS1	V	CC	3	396.7	9.4	25.6	199.7	238.7	1.6
LMCRS1	Can	CC	1	401.4	11.4	20.6	207.4	249.0	1.5
LMCRS1	Can	CC	2	460.7	10.2	25.1	216.5	246.5	1.6
LMCRS1	Can	CC	3	488.7	13.2	29.8	225.7	247.5	1.8
LMCRS1	F	CC	1	394.1	8.5	21.7	218.4	237.0	1.7
LMCRS1	F	CC	2	423.2	6.9	46.8	212.1	226.7	1.7
LMCRS1	F	CC	3	435.6	10.0	25.2	229.7	259.6	1.8
LMCRS2	CC	CC	1	675.5	6.6	33.7	189.0	180.5	1.2
LMCRS2	CC	CC	2	622.3	6.5	25.6	171.8	152.9	1.1
LMCRS2	CC	CC	3	596.5	8.1	31.9	180.9	133.0	1.1
LMCRS2	NCC	NCC	1	721.0	9.3	61.1	195.7	180.9	1.3
LMCRS2	NCC	NCC	2	734.9	7.2	56.6	216.2	171.0	1.3
LMCRS2	NCC	NCC	3	707.3	8.4	57.4	211.5	198.4	1.2
Stevens	1CC	CC	1	259.3	10.6	13.1	310.1	97.0	1.9
Stevens	1CC	CC	2	228.3	9.6	10.8	309.2	97.5	1.7
Stevens	1CC	CC	3	251.9	11.0	12.6	310.7	83.8	1.7
Stevens	1NCC	NCC	1	283.8	12.8	21.8	425.5	120.1	2.1
Stevens	1NCC	NCC	2	292.2	12.8	17.2	356.0	103.8	1.8
Stevens	1NCC	NCC	3	270.6	14.0	20.3	369.8	95.1	1.8
Stevens	2CC	CC	1	478.8	15.7	39.2	357.6	93.6	2.9
Stevens	2CC	CC	2	560.6	14.4	43.2	347.0	108.5	2.9
Stevens	2CC	CC	3	584.5	13.0	51.2	338.7	94.2	2.4
Stevens	2NCC	NCC	1	564.2	14.5	36.5	353.7	103.3	2.9
Stevens	2NCC	NCC	2	685.0	18.6	70.7	347.3	104.6	2.7
Stevens	2NCC	NCC	3	658.0	16.2	54.2	352.3	111.5	2.7
Stevens	3	CC	1	126.1	14.2	10.4	303.3	320.1	3.0
Stevens	3	CC	2	109.6	13.8	10.8	278.5	281.9	2.3
Stevens	3	CC	3	117.6	17.6	16.7	238.0	250.6	3.1

Location	Field ID #	Trt	Rep	Cu (kg ha^{-1})	[TC] (g kg^{-1})	[TN] (g kg^{-1})	[SOM] (g kg^{-1})	TC (Mg ha^{-1})	TN (Mg ha^{-1})
Chappell	1	CC	1	6.5	9.6	0.9	17.8	13.3	1.3
Chappell	1	CC	2	2.2	13.7	1.5	25.8	18.2	1.9
Chappell	1	CC	3	1.3	13.5	1.4	25.5	17.3	1.9
Chappell	2	NCC	1	1.9	18.0	1.7	34.1	23.6	2.2
Chappell	2	NCC	2	1.5	12.3	1.2	20.0	17.3	1.6
Chappell	2	NCC	3	1.8	10.2	1.1	20.4	13.6	1.5
Chappell	3	CC	1	2.2	7.9	0.8	16.1	11.2	1.2
Chappell	3	CC	2	1.8	7.1	0.8	16.1	9.9	1.1

Appendix A (cont.)

Location	Field ID #	Trt	Rep	Cu (kg ha^{-1})	[TC] (g kg^{-1})	[TN] (g kg^{-1})	[SOM] (g kg^{-1})	TC (Mg ha^{-1})	TN (Mg ha^{-1})
Chappell	3	CC	3	1.2	6.1	0.7	13.5	8.4	1.0
Taylor	1	NCC	1	2.4	3.8	0.4	10.8	4.8	0.5
Taylor	1	NCC	2	2.3	3.2	0.4	9.5	4.1	0.5
Taylor	1	NCC	3	2.7	5.9	0.7	13.0	7.2	0.9
Taylor	2	CC	1	2.0	11.2	1.1	22.8	13.5	1.4
Taylor	2	CC	2	2.0	10.0	1.0	20.5	12.0	1.2
Taylor	2	CC	3	2.0	8.3	0.9	17.9	10.3	1.1
Taylor	3	CC	1	2.7	13.2	1.3	26.1	17.5	1.7
Taylor	3	CC	2	3.5	10.3	1.0	21.0	14.0	1.4
Taylor	3	CC	3	3.6	13.6	1.3	26.1	17.8	1.7
Taylor	4	CC	1	2.8	10.5	1.1	19.0	13.9	1.4
Taylor	4	CC	2	2.5	12.8	1.2	24.1	16.3	1.6
Taylor	4	CC	3	2.3	12.1	1.1	22.0	15.9	1.5
LMCRS1	R	CC	1	1.6	6.6	0.6	17.7	8.1	0.8
LMCRS1	R	CC	2	1.6	6.8	0.6	18.0	8.1	0.7
LMCRS1	R	CC	3	1.6	5.9	0.6	16.2	7.1	0.7
LMCRS1	V	CC	1	1.7	6.8	0.6	16.1	8.2	0.7
LMCRS1	V	CC	2	1.7	7.6	0.7	18.1	9.1	0.8
LMCRS1	V	CC	3	1.6	7.3	0.7	17.4	8.4	0.8
LMCRS1	Can	CC	1	1.6	6.1	0.6	16.6	7.4	0.7
LMCRS1	Can	CC	2	1.7	5.3	0.6	15.3	6.6	0.7
LMCRS1	Can	CC	3	1.8	7.0	0.6	18.2	8.7	0.8
LMCRS1	F	CC	1	1.7	5.3	0.5	15.7	6.4	0.6
LMCRS1	F	CC	2	1.7	5.9	0.5	15.6	7.1	0.6
LMCRS1	F	CC	3	1.7	10.0	0.8	21.0	12.1	0.9
LMCRS2	CC	CC	1	1.3	4.4	0.5	16.3	5.4	0.6
LMCRS2	CC	CC	2	1.2	3.8	0.4	15.2	4.6	0.5
LMCRS2	CC	CC	3	1.1	4.8	0.5	17.6	5.9	0.6
LMCRS2	NCC	NCC	1	1.4	3.5	0.5	15.3	4.5	0.7
LMCRS2	NCC	NCC	2	1.5	3.2	0.7	14.5	4.2	0.9
LMCRS2	NCC	NCC	3	1.5	3.1	0.3	14.7	4.1	0.3
Stevens	1CC	CC	1	1.3	15.9	1.5	21.8	18.3	1.8
Stevens	1CC	CC	2	1.3	10.2	1.3	22.7	11.8	1.5
Stevens	1CC	CC	3	1.5	9.6	1.1	21.1	11.2	1.2
Stevens	1NCC	NCC	1	1.5	9.8	0.9	21.1	11.7	1.0
Stevens	1NCC	NCC	2	1.6	8.8	0.8	20.8	10.8	1.0
Stevens	1NCC	NCC	3	1.5	9.8	1.0	21.3	12.0	1.2
Stevens	2CC	CC	1	6.8	14.7	1.2	29.5	18.0	1.5
Stevens	2CC	CC	2	2.4	19.6	1.5	25.4	24.0	1.9
Stevens	2CC	CC	3	2.4	11.4	1.0	25.6	14.5	1.3
Stevens	2NCC	NCC	1	2.5	11.6	1.1	25.5	15.0	1.4
Stevens	2NCC	NCC	2	2.6	11.0	1.0	26.0	14.3	1.3
Stevens	2NCC	NCC	3	2.5	13.2	1.2	27.4	17.1	1.5
Stevens	3	CC	1	2.2	9.5	0.9	19.8	11.9	1.2
Stevens	3	CC	2	2.0	10.0	1.0	19.3	12.5	1.2
Stevens	3	CC	3	2.3	8.9	0.9	19.3	11.7	1.2

Appendix A (cont.)

Location	Field ID #	Trt	Rep	SOM (Mg ha^{-1})	C:N	TC:SOM	TN:SOM	pH	EC (dS m^{-1})
Chappell	1	CC	1	24.8	10.4	0.5	0.05	5.58	0.121
Chappell	1	CC	2	34.2	9.4	0.5	0.06	5.48	0.148
Chappell	1	CC	3	32.8	9.4	0.5	0.06	5.32	0.134
Chappell	2	NCC	1	44.7	10.6	0.5	0.05	6.20	0.167
Chappell	2	NCC	2	28.0	10.6	0.6	0.06	7.04	0.138
Chappell	2	NCC	3	27.4	9.4	0.5	0.05	6.93	0.120
Chappell	3	CC	1	22.8	9.4	0.5	0.05	6.67	0.116
Chappell	3	CC	2	22.4	9.2	0.4	0.05	6.85	0.137
Chappell	3	CC	3	18.7	8.5	0.5	0.05	5.81	0.100
Taylor	1	NCC	1	13.5	8.8	0.4	0.04	5.98	0.138
Taylor	1	NCC	2	12.3	8.6	0.3	0.04	6.10	0.122
Taylor	1	NCC	3	15.8	8.2	0.5	0.06	6.62	0.168
Taylor	2	CC	1	27.6	9.9	0.5	0.05	6.63	0.229
Taylor	2	CC	2	24.6	9.7	0.5	0.05	6.72	0.225
Taylor	2	CC	3	22.1	9.7	0.5	0.05	6.74	0.208
Taylor	3	CC	1	34.6	10.2	0.5	0.05	6.20	0.211
Taylor	3	CC	2	28.6	10.2	0.5	0.05	6.10	0.214
Taylor	3	CC	3	34.2	10.8	0.5	0.05	6.10	0.248
Taylor	4	CC	1	25.1	9.9	0.6	0.06	6.40	0.146
Taylor	4	CC	2	30.7	10.3	0.5	0.05	6.12	0.147
Taylor	4	CC	3	28.9	10.7	0.6	0.05	6.41	0.132
LMCRS1	R	CC	1	22.0	10.7	0.4	0.03	7.21	0.106
LMCRS1	R	CC	2	21.7	11.1	0.4	0.03	7.29	0.098
LMCRS1	R	CC	3	19.6	10.3	0.4	0.04	7.44	0.092
LMCRS1	V	CC	1	19.5	11.2	0.4	0.04	7.63	0.106
LMCRS1	V	CC	2	21.6	10.8	0.4	0.04	7.59	0.102
LMCRS1	V	CC	3	20.1	10.3	0.4	0.04	7.61	0.100
LMCRS1	Can	CC	1	20.4	10.2	0.4	0.04	7.65	0.116
LMCRS1	Can	CC	2	18.9	9.7	0.4	0.04	7.67	0.118
LMCRS1	Can	CC	3	22.6	10.9	0.4	0.04	7.77	0.113
LMCRS1	F	CC	1	18.9	10.6	0.3	0.03	7.49	0.097
LMCRS1	F	CC	2	18.8	11.4	0.4	0.03	7.63	0.111
LMCRS1	F	CC	3	25.5	12.9	0.5	0.04	7.46	0.094
LMCRS2	CC	CC	1	20.3	9.4	0.3	0.03	7.42	0.081
LMCRS2	CC	CC	2	18.3	8.6	0.3	0.03	7.16	0.091
LMCRS2	CC	CC	3	21.6	9.4	0.3	0.03	6.95	0.087
LMCRS2	NCC	NCC	1	19.5	6.5	0.2	0.04	7.03	0.109
LMCRS2	NCC	NCC	2	18.8	4.6	0.2	0.05	7.22	0.118
LMCRS2	NCC	NCC	3	19.7	12.4	0.2	0.02	7.11	0.089
Stevens	1CC	CC	1	25.0	10.4	0.7	0.07	6.35	0.176
Stevens	1CC	CC	2	26.3	7.8	0.5	0.06	6.34	0.135
Stevens	1CC	CC	3	24.8	9.1	0.5	0.05	6.52	0.164
Stevens	1NCC	NCC	1	25.2	11.3	0.5	0.04	6.68	0.196
Stevens	1NCC	NCC	2	25.7	10.9	0.4	0.04	6.76	0.195
Stevens	1NCC	NCC	3	26.1	10.1	0.5	0.05	6.50	0.231
Stevens	2CC	CC	1	36.2	11.9	0.5	0.04	6.43	0.247
Stevens	2CC	CC	2	31.0	12.9	0.8	0.06	6.68	0.272
Stevens	2CC	CC	3	32.4	10.9	0.5	0.04	6.76	0.192
Stevens	2NCC	NCC	1	33.0	10.6	0.5	0.04	6.52	0.253
Stevens	2NCC	NCC	2	33.7	10.7	0.4	0.04	6.68	0.270

Appendix A (cont.)

Location	Field ID #	Trt	Rep	SOM (Mg ha^{-1})	C:N	TC:SOM	TN:SOM	pH	EC (dS m^{-1})
Stevens	2NCC	NCC	3	35.5	11.4	0.5	0.04	6.65	0.284
Stevens	3	CC	1	24.9	10.1	0.5	0.05	6.51	0.140
Stevens	3	CC	2	24.1	10.5	0.5	0.05	6.81	0.173
Stevens	3	CC	3	25.2	9.7	0.5	0.05	6.50	0.150

Appendix B: All-locations aggregate stability data set.

Location	Field ID	Treatment	Soil Depth (cm)	Rep	TWSA ($g\ g^{-1}$)
Chappell	1	CC	0 - 5	1	0.74
Chappell	1	CC	0 - 5	2	0.81
Chappell	1	CC	0 - 5	3	0.79
Chappell	1	CC	5 - 10	1	0.56
Chappell	1	CC	5 - 10	2	0.86
Chappell	1	CC	5 - 10	3	0.80
Chappell	2	NCC	0 - 5	1	0.74
Chappell	2	NCC	0 - 5	2	0.84
Chappell	2	NCC	0 - 5	3	0.88
Chappell	2	NCC	5 - 10	1	0.84
Chappell	2	NCC	5 - 10	2	0.80
Chappell	2	NCC	5 - 10	3	0.85
Chappell	3	CC	0 - 5	1	0.77
Chappell	3	CC	0 - 5	2	0.64
Chappell	3	CC	0 - 5	3	0.38
Chappell	3	CC	5 - 10	1	0.80
Chappell	3	CC	5 - 10	2	0.86
Chappell	3	CC	5 - 10	3	0.49
Taylor	1	NCC	0 - 5	1	0.30
Taylor	1	NCC	0 - 5	2	0.35
Taylor	1	NCC	0 - 5	3	0.33
Taylor	1	NCC	5 - 10	1	0.74
Taylor	1	NCC	5 - 10	2	0.17
Taylor	1	NCC	5 - 10	3	0.13
Taylor	2	CC	0 - 5	1	0.89
Taylor	2	CC	0 - 5	2	0.69
Taylor	2	CC	0 - 5	3	0.71
Taylor	2	CC	5 - 10	1	0.82
Taylor	2	CC	5 - 10	2	0.77
Taylor	2	CC	5 - 10	3	0.64
Taylor	3	CC	0 - 5	1	0.70
Taylor	3	CC	0 - 5	2	0.60
Taylor	3	CC	0 - 5	3	0.70
Taylor	3	CC	5 - 10	1	0.79
Taylor	3	CC	5 - 10	2	0.61
Taylor	3	CC	5 - 10	3	0.65
Taylor	4	CC	0 - 5	1	0.80
Taylor	4	CC	0 - 5	2	0.84
Taylor	4	CC	0 - 5	3	0.78
Taylor	4	CC	5 - 10	1	0.73
Taylor	4	CC	5 - 10	2	0.84
Taylor	4	CC	5 - 10	3	0.77
LMCRS1	R	CC	0 - 5	1	0.33
LMCRS1	R	CC	0 - 5	2	0.50
LMCRS1	R	CC	0 - 5	3	0.51
LMCRS1	R	CC	5 - 10	1	0.30
LMCRS1	R	CC	5 - 10	2	0.30
LMCRS1	R	CC	5 - 10	3	0.29
LMCRS1	V	CC	0 - 5	1	0.14
LMCRS1	V	CC	0 - 5	2	0.17

Appendix B (cont.)

Location	Field ID	Treatment	Soil Depth (cm)	Rep	TWSA (g g^{-1})
LMCRS1	V	CC	0 - 5	3	0.22
LMCRS1	V	CC	5 - 10	1	0.21
LMCRS1	V	CC	5 - 10	2	0.24
LMCRS1	V	CC	5 - 10	3	0.26
LMCRS1	Can	CC	0 - 5	1	0.16
LMCRS1	Can	CC	0 - 5	2	0.17
LMCRS1	Can	CC	0 - 5	3	0.17
LMCRS1	Can	CC	5 - 10	1	0.23
LMCRS1	Can	CC	5 - 10	2	0.34
LMCRS1	Can	CC	5 - 10	3	0.18
LMCRS1	F	CC	0 - 5	1	0.15
LMCRS1	F	CC	0 - 5	2	0.13
LMCRS1	F	CC	0 - 5	3	0.28
LMCRS1	F	CC	5 - 10	1	0.17
LMCRS1	F	CC	5 - 10	2	0.19
LMCRS1	F	CC	5 - 10	3	0.34
LMCRS2	CC	CC	0 - 5	1	0.19
LMCRS2	CC	CC	0 - 5	2	0.31
LMCRS2	CC	CC	0 - 5	3	0.33
LMCRS2	CC	CC	5 - 10	1	0.18
LMCRS2	CC	CC	5 - 10	2	0.18
LMCRS2	CC	CC	5 - 10	3	0.19
LMCRS2	CC	NCC	0 - 5	1	0.15
LMCRS2	CC	NCC	0 - 5	2	0.16
LMCRS2	CC	NCC	0 - 5	3	0.18
LMCRS2	CC	NCC	5 - 10	1	0.25
LMCRS2	CC	NCC	5 - 10	2	0.57
LMCRS2	CC	NCC	5 - 10	3	0.22
Stevens	1CC	CC	0 - 5	1	0.54
Stevens	1CC	CC	0 - 5	2	0.58
Stevens	1CC	CC	0 - 5	3	0.42
Stevens	1CC	CC	5 - 10	1	0.54
Stevens	1CC	CC	5 - 10	2	0.59
Stevens	1CC	CC	5 - 10	3	0.49
Stevens	1NCC	NCC	0 - 5	1	0.52
Stevens	1NCC	NCC	0 - 5	2	0.48
Stevens	1NCC	NCC	0 - 5	3	0.58
Stevens	1NCC	NCC	5 - 10	1	0.56
Stevens	1NCC	NCC	5 - 10	2	0.52
Stevens	1NCC	NCC	5 - 10	3	0.72
Stevens	2CC	CC	0 - 5	1	0.42
Stevens	2CC	CC	0 - 5	2	0.50
Stevens	2CC	CC	0 - 5	3	0.65
Stevens	2CC	CC	5 - 10	1	0.37
Stevens	2CC	CC	5 - 10	2	0.48
Stevens	2CC	CC	5 - 10	3	0.47
Stevens	2NCC	NCC	0 - 5	1	0.47
Stevens	2NCC	NCC	0 - 5	2	0.65
Stevens	2NCC	NCC	0 - 5	3	0.44
Stevens	2NCC	NCC	5 - 10	1	0.38

Appendix B (cont.)

Location	Field ID	Treatment	Soil Depth (cm)	Rep	TWSA (g g^{-1})
Stevens	2NCC	NCC	5 - 10	2	0.51
Stevens	2NCC	NCC	5 - 10	3	0.38
Stevens	3	CC	0 - 5	1	0.57
Stevens	3	CC	0 - 5	2	0.70
Stevens	3	CC	0 - 5	3	0.69
Stevens	3	CC	5 - 10	1	0.52
Stevens	3	CC	5 - 10	2	0.55
Stevens	3	CC	5 - 10	3	0.51

Appendix C: Stevens-only soil properties data set.

Field ID	Trt	Plcmt	Rep	ASWC ($cm^3\ cm^{-3}$)	OIR ($cm\ min^{-1}$)	Slope	Intercept	SSIR ($cm\ min^{-1}$)	BD ($g\ cm^{-3}$)
1CC	CC	W	1	8.6	0.1	-0.2	-1.4	0.02	1.29
1CC	CC	W	2	11.6	0.1	-0.2	-1.4	0	1.32
1CC	CC	W	3	7.4	0.1	-0.1	-1.5	0.03	1.31
1CC	CC	NWT	1	13.5	0.1	-0.2	-1.7	0	1.14
1CC	CC	NWT	2	12.5	0.1	-0.1	-1.6	0.03	1.32
1CC	CC	NWT	3	10.1	0.1	-0.1	-1.8	0.03	1.24
1CC	CC	B	1	8.1	0.3	-0.1	-0.9	0.08	1.15
1CC	CC	B	2	7.9	0.3	0.0	-1.3	0	1.16
1CC	CC	B	3	7.2	0.1	-0.2	-1.3	0.01	1.17
1NCC	NCC	W	1	6.5	0.1	-0.2	-1.1	0	1.28
1NCC	NCC	W	2	8.2	0.1	-0.1	-1.8	0.04	1.36
1NCC	NCC	W	3	9.9	0.1	-0.1	-1.8	0.03	1.19
1NCC	NCC	NWT	1	7.8	0.1	-0.2	-1.5	0.01	1.22
1NCC	NCC	NWT	2	8.2	0.1	-0.1	-1.7	0.03	1.19
1NCC	NCC	NWT	3	8.6	0.1	-0.1	-1.6	0.03	1.22
1NCC	NCC	B	1	8.8	0.2	-0.1	-1.2	0	1.19
1NCC	NCC	B	2	6.7	0.1	-0.1	-1.5	0.04	1.24
1NCC	NCC	B	3	7.4	0.1	0.1	-1.6	0.06	1.23

Field ID	Trt	Plcmt	Rep	Sand ($g\ g^{-1}$)	Silt ($g\ g^{-1}$)	Clay ($g\ g^{-1}$)	[P] ($mg\ kg^{-1}$)	[K] ($mg\ kg^{-1}$)	[Ca] ($mg\ kg^{-1}$)
1CC	CC	W	1	0.18	0.72	0.10	84.5	127.8	1134.7
1CC	CC	W	2	0.22	0.68	0.10	84.4	138.9	1290.0
1CC	CC	W	3	0.22	0.68	0.11	60.9	166.3	1476.5
1CC	CC	NWT	1	0.22	0.70	0.08	101.8	120.0	1168.5
1CC	CC	NWT	2	0.23	0.65	0.12	66.4	126.6	1420.7
1CC	CC	NWT	3	0.21	0.71	0.09	93.1	162.7	1276.4
1CC	CC	B	1	0.21	0.72	0.07	45.2	190.2	1303.6
1CC	CC	B	2	0.24	0.70	0.07	48.2	197.2	1298.5
1CC	CC	B	3	0.20	0.72	0.08	51.2	243.1	1372.3
1NCC	NCC	W	1	0.20	0.73	0.08	69.5	119.0	1118.0
1NCC	NCC	W	2	0.23	0.68	0.09	59.6	115.9	1352.7
1NCC	NCC	W	3	0.19	0.73	0.08	74.5	130.8	1288.8
1NCC	NCC	NWT	1	0.21	0.72	0.07	73.5	125.7	1313.6
1NCC	NCC	NWT	2	0.18	0.74	0.08	81.5	162.0	1458.9
1NCC	NCC	NWT	3	0.20	0.74	0.07	66.5	137.4	1282.9
1NCC	NCC	B	1	0.23	0.70	0.07	70.4	174.1	1411.5
1NCC	NCC	B	2	0.20	0.71	0.09	56.7	176.6	1493.3
1NCC	NCC	B	3	0.20	0.73	0.08	53.1	166.6	1430.1

Appendix C (cont.)

Field ID	Trt	Plcmt	Rep	[Mg] (mg kg^{-1})	[S] (mg kg^{-1})	[Na] (mg kg^{-1})	[Fe] (mg kg^{-1})	[Mn] (mg kg^{-1})	[Zn] (mg kg^{-1})
1CC	CC	W	1	166.8	16.2	21.0	520.1	66.6	1.5
1CC	CC	W	2	178.7	22.0	21.2	453.3	74.5	1.6
1CC	CC	W	3	211.2	12.2	19.1	348.3	87.5	1.7
1CC	CC	NWT	1	159.0	12.1	17.6	549.8	74.2	1.5
1CC	CC	NWT	2	206.6	12.6	23.2	452.5	83.9	1.6
1CC	CC	NWT	3	177.7	10.4	12.3	461.5	60.1	1.4
1CC	CC	B	1	225.4	9.3	11.4	269.6	84.3	1.6
1CC	CC	B	2	197.4	8.3	9.4	267.5	84.3	1.4
1CC	CC	B	3	214.8	9.4	10.8	264.9	71.4	1.4
1NCC	NCC	W	1	176.0	12.3	24.4	348.4	87.1	2.1
1NCC	NCC	W	2	208.2	11.2	23.0	285.6	78.8	1.4
1NCC	NCC	W	3	187.4	11.2	15.5	393.7	84.5	1.6
1NCC	NCC	NWT	1	196.6	10.8	17.1	376.3	89.5	1.9
1NCC	NCC	NWT	2	222.2	10.0	13.6	394.2	94.0	1.6
1NCC	NCC	NWT	3	198.0	8.7	12.8	340.6	85.6	1.6
1NCC	NCC	B	1	238.3	10.7	18.3	357.3	100.9	1.8
1NCC	NCC	B	2	236.4	10.4	13.9	288.1	84.0	1.4
1NCC	NCC	B	3	220.6	11.4	16.6	301.5	77.5	1.4

Field ID	Trt	Plcmt	Rep	[Cu] (mg kg^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (kg ha^{-1})	Mg (kg ha^{-1})	S (kg ha^{-1})
1CC	CC	W	1	0.7	108.8	164.6	1461.5	214.9	20.9
1CC	CC	W	2	1.0	111.2	183.0	1698.7	235.4	28.9
1CC	CC	W	3	1.3	80.0	218.3	1938.7	277.4	16.0
1CC	CC	NWT	1	0.4	116.0	136.8	1331.2	181.1	13.7
1CC	CC	NWT	2	1.1	87.4	166.7	1870.9	272.0	16.6
1CC	CC	NWT	3	1.1	115.8	202.1	1586.2	220.9	12.9
1CC	CC	B	1	1.1	52.0	218.7	1499.3	259.3	10.6
1CC	CC	B	2	1.1	55.7	228.0	1501.3	228.3	9.6
1CC	CC	B	3	1.3	60.1	285.1	1609.4	251.9	11.0
1NCC	NCC	W	1	1.1	89.1	152.6	1433.2	225.6	15.8
1NCC	NCC	W	2	1.2	81.2	157.9	1842.7	283.6	15.3
1NCC	NCC	W	3	1.1	88.5	155.4	1531.0	222.6	13.3
1NCC	NCC	NWT	1	1.2	89.3	152.9	1597.0	239.0	13.1
1NCC	NCC	NWT	2	1.3	97.2	193.1	1739.2	264.9	12.0
1NCC	NCC	NWT	3	1.2	81.3	167.9	1567.5	242.0	10.6
1NCC	NCC	B	1	1.3	83.8	207.3	1680.7	283.8	12.8
1NCC	NCC	B	2	1.3	70.1	218.3	1845.8	292.2	12.8
1NCC	NCC	B	3	1.2	65.2	204.4	1754.1	270.6	14.0

Appendix C (cont.)

Field ID	Trt	Plcmt	Rep	Na (kg ha^{-1})	Fe (kg ha^{-1})	Mn (kg ha^{-1})	Zn (kg ha^{-1})	Cu (kg ha^{-1})	[TC] (g kg^{-1})	[TN] (g kg^{-1})
1CC	CC	W	1	27.1	669.9	85.8	1.9	0.9	9.2	0.8
1CC	CC	W	2	27.9	596.9	98.1	2.0	1.4	13.1	1.1
1CC	CC	W	3	25.1	457.3	114.9	2.3	1.7	10.7	0.9
1CC	CC	NWT	1	20.0	626.3	84.6	1.7	0.4	11.0	1.0
1CC	CC	NWT	2	30.5	595.9	110.5	2.2	1.5	10.0	1.0
1CC	CC	NWT	3	15.3	573.5	74.7	1.8	1.3	10.0	1.2
1CC	CC	B	1	13.1	310.1	97.0	1.9	1.3	15.9	1.5
1CC	CC	B	2	10.8	309.2	97.5	1.7	1.3	10.2	1.3
1CC	CC	B	3	12.6	310.7	83.8	1.7	1.5	9.6	1.1
1NCC	NCC	W	1	31.3	446.7	111.7	2.7	1.4	6.8	0.7
1NCC	NCC	W	2	31.3	389.0	107.4	1.9	1.7	6.9	0.7
1NCC	NCC	W	3	18.5	467.6	100.3	1.9	1.3	9.4	0.9
1NCC	NCC	NWT	1	20.8	457.5	108.8	2.3	1.4	9.4	1.0
1NCC	NCC	NWT	2	16.2	470.0	112.1	2.0	1.6	11.9	1.0
1NCC	NCC	NWT	3	15.6	416.2	104.6	2.0	1.5	8.1	0.7
1NCC	NCC	B	1	21.8	425.5	120.1	2.1	1.5	9.8	0.9
1NCC	NCC	B	2	17.2	356.0	103.8	1.8	1.6	8.8	0.8
1NCC	NCC	B	3	20.3	369.8	95.1	1.8	1.5	9.8	1.0

Field ID	Trt	Plcmt	Rep	[SOM] (g kg^{-1})	TC (Mg ha^{-1})	TN (Mg ha^{-1})	SOM (Mg ha^{-1})	C:N	TC:SOM
1CC	CC	W	1	21.5	11.8	1.0	27.7	11.4	0.4
1CC	CC	W	2	24.6	17.3	1.5	32.4	11.6	0.5
1CC	CC	W	3	24.6	14.1	1.2	32.3	11.7	0.4
1CC	CC	NWT	1	22.7	12.6	1.2	25.9	10.5	0.5
1CC	CC	NWT	2	22.6	13.2	1.4	29.8	9.6	0.4
1CC	CC	NWT	3	23.1	12.4	1.5	28.7	8.2	0.4
1CC	CC	B	1	21.8	18.3	1.8	25.0	10.4	0.7
1CC	CC	B	2	22.7	11.8	1.5	26.3	7.8	0.4
1CC	CC	B	3	21.1	11.2	1.2	24.8	9.1	0.5
1NCC	NCC	W	1	16.5	8.7	1.0	21.2	9.1	0.4
1NCC	NCC	W	2	17.7	9.4	0.9	24.0	10.2	0.4
1NCC	NCC	W	3	21.5	11.1	1.0	25.5	10.8	0.4
1NCC	NCC	NWT	1	20.3	11.4	1.2	24.7	9.5	0.5
1NCC	NCC	NWT	2	22.9	14.2	1.2	27.3	12.0	0.5
1NCC	NCC	NWT	3	17.7	9.9	0.9	21.6	10.9	0.5
1NCC	NCC	B	1	21.1	11.7	1.0	25.2	11.3	0.5
1NCC	NCC	B	2	20.8	10.8	1.0	25.7	10.9	0.4
1NCC	NCC	B	3	21.3	12.0	1.2	26.1	10.1	0.5

Appendix C (cont.)

Field ID	Trt	Plcmt	Rep	TN:SOM	pH	EC (dS m^{-1})
1CC	CC	W	1	0.04	5.61	0.224
1CC	CC	W	2	0.05	5.48	0.235
1CC	CC	W	3	0.04	5.85	0.169
1CC	CC	NWT	1	0.05	5.67	0.165
1CC	CC	NWT	2	0.05	5.90	0.163
1CC	CC	NWT	3	0.05	5.87	0.153
1CC	CC	B	1	0.07	6.35	0.176
1CC	CC	B	2	0.06	6.34	0.135
1CC	CC	B	3	0.05	6.52	0.164
1NCC	NCC	W	1	0.05	6.39	0.183
1NCC	NCC	W	2	0.04	6.45	0.169
1NCC	NCC	W	3	0.04	6.32	0.178
1NCC	NCC	NWT	1	0.05	6.42	0.176
1NCC	NCC	NWT	2	0.04	6.48	0.182
1NCC	NCC	NWT	3	0.04	6.70	0.157
1NCC	NCC	B	1	0.04	6.68	0.196
1NCC	NCC	B	2	0.04	6.76	0.195
1NCC	NCC	B	3	0.05	6.50	0.231

Appendix D: Stevens-only aggregate stability data set.

Field ID	Treatment	Placement	Soil Depth (cm)	Rep	TWSA (g g^{-1})
1CC	CC	W	0 - 5	1	0.42
1CC	CC	W	0 - 5	2	0.43
1CC	CC	W	0 - 5	3	0.37
1CC	CC	W	5 - 10	1	0.41
1CC	CC	W	5 - 10	2	0.43
1CC	CC	W	5 - 10	3	0.42
1CC	CC	NWT	0 - 5	1	0.75
1CC	CC	NWT	0 - 5	2	0.27
1CC	CC	NWT	0 - 5	3	0.45
1CC	CC	NWT	5 - 10	1	0.51
1CC	CC	NWT	5 - 10	2	0.36
1CC	CC	NWT	5 - 10	3	0.40
1CC	CC	B	0 - 5	1	0.54
1CC	CC	B	0 - 5	2	0.58
1CC	CC	B	0 - 5	3	0.42
1CC	CC	B	5 - 10	1	0.54
1CC	CC	B	5 - 10	2	0.59
1CC	CC	B	5 - 10	3	0.49
1NCC	NCC	W	0 - 5	1	0.18
1NCC	NCC	W	0 - 5	2	0.35
1NCC	NCC	W	0 - 5	3	0.20
1NCC	NCC	W	5 - 10	1	0.16
1NCC	NCC	W	5 - 10	2	0.24
1NCC	NCC	W	5 - 10	3	0.27
1NCC	NCC	NWT	0 - 5	1	0.19
1NCC	NCC	NWT	0 - 5	2	0.23
1NCC	NCC	NWT	0 - 5	3	0.19
1NCC	NCC	NWT	5 - 10	1	0.23
1NCC	NCC	NWT	5 - 10	2	0.25
1NCC	NCC	NWT	5 - 10	3	0.23
1NCC	NCC	B	0 - 5	1	0.52
1NCC	NCC	B	0 - 5	2	0.48
1NCC	NCC	B	0 - 5	3	0.58
1NCC	NCC	B	5 - 10	1	0.56
1NCC	NCC	B	5 - 10	2	0.52
1NCC	NCC	B	5 - 10	3	0.72