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Soil carbon accumulation in cotton production systems in the Brazilian Cerrado

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ABSTRACT. Sustainable production systems, such as the no-tillage system (NTS), have a tendency to increase organic carbon in the soil. However, in Brazilian cotton production, the conventional tillage system (CTS) is predominant, and long-term studies on cotton crop under the NTS are scarce. The present study aimed to evaluate the effect of soil management and crop rotation systems on the cotton fiber yield as well as on the carbon and nitrogen accumulation in the soil. This study was conducted in the Brazilian savanna over 9 years and consisted of the following four treatments with different soil management systems: the NTS and CTS with the succession or rotation of crops (cotton, soybean, maize, and *Urochloa ruziziensis*). The NTS increased the carbon content by 55% in the top 5 cm after 9 years and increased the carbon stock by approximately 20% at a depth of up to 40 cm. Crop rotation with soybean, maize, and cotton was insufficient to increase the carbon stock in the soil under the CTS. In addition to increasing the fiber yield, the cotton crop in a NTS rotated with soybean + *U. ruziziensis* and with maize + *U. ruziziensis* increases the carbon stock and nitrogen content in soil.

Keywords: *Gossypium hirsutum*; no-tillage; conventional tillage; nitrogen; carbon stock.

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Introduction

By 2050, the world population is expected to exceed 9 billion people (Lal, 2016), and the gradual increase in population size will also increase the demand for food and natural fibers. As the availability of new cultivation areas is limited, the alternative is to intensify crops and increase crop yields in a sustainable way, which is a major challenge for world agriculture.

Brazil is one of the world's major producers of soybean, maize, and cotton, with estimated cultivated areas of 35, 16.4, and 1.1 million hectares, respectively. The Brazilian savanna (Cerrado) comprises more than 200 million hectares, has high potential for use in agriculture, and accounts for a large part of the national production of soybean and maize and for 98.5% of the country's upland cotton, which is grown under rainfed conditions.

In Brazilian cotton production, the conventional tillage system (CTS) with plows and harrows is still widely used. This non-conservationist management system favors soil erosion (Srinivasarao et al., 2014; Corbeels et al., 2016) and reduces the soil organic matter content (Srinivasarao et al., 2014), a fundamental component for soil quality (Srinivasarao et al., 2014). In addition, cotton monoculture still occurs in some areas, although it has decreased due to rotation with soybean and maize.

The use of the CTS has been decreasing in the Cerrado, mainly when soybean is grown in succession with maize. Maize is sometimes intercropped with species of the genus *Urochloa*, producing grains and dry matter forage for meat production, with direct seeding of the crops in succession (Ceccon et al., 2013). Crop rotation, the maintenance of plant residues on the soil surface and the minimal soil movement, all principles of the no-tillage system (NTS) (Pittelkow et al., 2015), are soil conservation practices that have gained prominence in Brazil (Marchão et al., 2009). However, the NTS is little used in Brazilian cotton production because of the lack of information on the benefits of this system for soil and cotton yield.

Production systems that result in reduced carbon losses and increased carbon stock in the soil are essential for sustainable agriculture (Gan, Liang, Wang, & McConkey, 2011). Conservation agricultural practices, by increasing soil organic carbon (C), tend to regulate greenhouse gas from CO_2 emissions (Paustian et al., 2016). However, some studies (Powlson et al., 2014; Corbeels et al., 2016) differ in their results as to the potential of the NTS and other conservation systems to increase C because such an increase depends on the biomass production of the crops and on the inputs of C (Ogle, Swan, & Paustian, 2012) and nitrogen (Yue et al., 2016) to the soil as well as environmental conditions, especially temperature and humidity (Lal, Negassa, & Lorenz, 2015; Piccoli et al., 2016), in addition to soil texture (Piccoli et al., 2016).

The dynamics of C and nitrogen (N) in soil are strictly associated with the management practices adopted and the species cultivated (Gregory et al., 2016). The maintenance and accumulation of C and N in the soil are major challenges in tropical regions due to environmental factors that affect the dynamics of the organic matter. Thus, soil and crop management practices need to be improved with the aim of developing production systems in which the C input is greater than its loss (Srinivasarao et al., 2014; Dignac et al., 2017).

In recent years, discussions on the ability of agricultural land to accumulate C as a strategy for mitigating greenhouse gas emissions have increased. During the 21st United Nations Climate Change Conference (COP 21) held in Paris in 2015, the ‘4 per 1000’ proposal was presented, a voluntary initiative by countries to increase C content in the world’s soils, at the rate of 0.4% per year, to a depth of 40 cm (Lal, 2016). According to Luo, Wang, and Sun (2010), the largest accumulation of C in the soil occurs in the layer up to 40 cm deep. The ‘4 per 1000’ initiative assumes that soil and agriculture are part of the solution to C sequestration, and this sequestration is also seen as a way to improve soil resilience to climate change (Minasny et al., 2018).

The comparison between C stocks in fiber and grain production systems in a tropical environment of the Brazilian Cerrado is important to determine the soil potential as a source or sink of C-CO_2. However, the studies carried out to date on C accumulation in the Cerrado do not involve the cotton crop, whose cycle and morphophysiological characteristics are very different from those of soybean and maize.

The objective of this study was to evaluate the effect of soil management and crop rotation systems in the Brazilian Cerrado on the cotton fiber yield and on the carbon and nitrogen accumulation in the soil as well as the potential of production systems to help reach the global target of increasing the soil C content by 0.4% per year.

Material and methods

The study was carried out between August 2005 and October 2014, under rainfed conditions in the experimental area of the Goiás Foundation, municipality of Santa Helena de Goiás, state of Goiás, Brazil (17° 50' 37" S, 50° 35' 52" W, 557 m of altitude). The soil is classified as Dystrophic Red Latosol (Santos et al., 2013), Ferralsol (Food and Agriculture Organization [FAO], 1988), and Oxisol (Soil Survey Staff, 2014). The climate is Aw, according to the Köppen-Geiger climate classification system, with an average rainfall of 1,800 mm, which is concentrated in the period from October to March.

The experiment consisted of four treatments (Table 1) composed of soil management systems and crop rotation or succession. The experimental design was a randomized block design, with four replicates.

Table 1. Description of treatments with soil management systems, crop rotation, and succession for cotton production in the Brazilian Cerrado.

Agricultural year	Treatments					
	1 (CTCM)	2 (CTCSC)	3 (CTCSM)	4 (NTS)		
	Conventional tillage system			No-tillage system		
	Monoculture	Annual rotation	Biennial rotation	Direct seeding system	Direct seeding system	Direct seeding system
2005-2006	Cotton	Cotton	Cotton	Soybean/*U. ruziziensis**	Cotton	Maize/*U. ruziziensis***
2006-2007	Cotton	Soybean	Soybean	Maize/*U. ruziziensis***	Soybean/*U. ruziziensis**	Cotton
2007-2008	Cotton	Cotton	Maize	Cotton	Maize/*U. ruziziensis***	Soybean/*U. ruziziensis**
2008-2009	Cotton	Soybean	Cotton	Soybean/*U. ruziziensis**	Cotton	Maize/*U. ruziziensis***
2009-2010	Cotton	Cotton	Soybean	Maize/*U. ruziziensis***	Soybean/*U. ruziziensis**	Cotton
2010-2011	Cotton	Soybean	Maize	Cotton	Maize/*U. ruziziensis***	Soybean/*U. ruziziensis**
2011-2012	Cotton	Cotton	Cotton	Soybean/*U. ruziziensis**	Cotton	Maize/*U. ruziziensis***
2012-2013	Cotton	Soybean	Soybean	Maize/*U. ruziziensis***	Soybean/*U. ruziziensis**	Cotton
2013-2014	Cotton	Cotton	Maize	Cotton	Maize/*U. ruziziensis***	Soybean/*U. ruziziensis**

*Soybean (1st crop)/*Urochloa ruziziensis* (2nd crop);**Maize (1st crop)/*Urochloa ruziziensis* (2nd crop).

In the experimental area, before the beginning of the experiment, cotton was grown for 3 years, and soybean was grown in previous years, always using the conventional tillage system with plows and harrows. At the beginning of the experiment, in August 2005, soil properties within the arable layer (0-0.2 m) were as follows: pH (5.35, $CaCl_2$), P (6.1 mg dm^{-3}, Mehlich-1), K (89.7 mg dm^{-3}), Ca (20.7 $mmol_c$ dm^{-3}), mg (4.2 $mmol_c$ dm^{-3}), cation exchange capacity (6.33 $mmol_c$ dm^{-3}), organic matter (24.2 g kg^{-1}), clay (495 g kg^{-1}), silt (217 g kg^{-1}), sand (288 g kg^{-1}), and bulk density (1.22 mg m^{-3}). In early September 2005, every experimental area received the equivalent of 2,200 kg ha^{-1} of calcitic limestone, with 90% total relative neutralizing power (TRNP), and the area was subjected to subsoiling at a depth of 35 cm, followed by plowing and harrowing.

Each experimental plot measured 576 m^2 (14.4 × 40 m). In August 2009, 2,000 kg ha^{-1} of dolomitic limestone with 85% TRNP was applied, and in October 2009, before sowing the crops, 1,000 kg ha^{-1} of agricultural gypsum was added. In the treatments with conventional tillage, limestone, and gypsum were incorporated with plows and harrows to a depth of 20 cm, and in the NTS, these inputs remained on the surface of the soil.

Annually, in the treatments with conventional soil management, soil tillage was done between the end of September and the beginning of October, after the rains began. Tillage consisted of a run with a 20 cm deep disk harrow, followed by a leveling harrow, and 1 to 2 days before sowing of the soybean, maize, or cotton, another run was performed with the leveling harrow.

During the 9 years, the soybean was sown in the spring in the second half of October after the beginning of the regular rainy season. The spacing between the soybean rows was 45 cm. The maize was sown with 45 cm between rows in late October to early November. The cotton was sown at the end of November until mid-December with a spacing of 80 cm between rows.

The plant population size per hectare ranged from 350,000 to 400,000, from 55,000 to 65,000, and from 80,000 to 100,000 for soybean, maize and cotton, respectively, depending on the cultivar used each year.

For each crop within the crop year, regardless of the treatment, the same cultivars, plant populations, and fertilizers were used, with identical spacing between rows and chemical control of the pests, diseases, and weeds.

The annual average fertilizer applications, in kg ha^{-1}, of N, P_2O_5, and K_2O were 6, 54, and 46 for soybean; 97, 119, and 137 for maize; and 111, 126, and 130 for cotton, respectively. All soybean fertilizer was applied at the time of sowing. In maize and cotton, all phosphate fertilizer was applied at sowing, along with approximately 20 and 50% of N and K_2O, respectively. The remaining N and K_2O were added in two top-dressing fertilizer applications.

After the soybean harvest, in the NTS treatment, the area was cultivated with *Urochloa ruziziensis*. Two days before the mechanized sowing of *U. ruziziensis* (6 kg ha^{-1} of seeds with 100% cultural value), the volunteer soybean plants and weeds were desiccated with paraquat herbicide (400 g ha^{-1} of active ingredient). In the NTS treatment with the maize crop, 7 kg ha^{-1} of *U. ruziziensis,* with a cultural value of 85%, was sown in the same row as the maize, with the forage seeds mixed and placed in the soil together with the maize sowing fertilizer. After the maize was harvested, *U. ruziziensis* was cultivated alone, and was desiccated with glyphosate (1,400 g ha^{-1} of active ingredient) 30 days before the direct seeding of cotton. The *U. ruziziensis* that preceded the maize was also desiccated with the same dose of glyphosate at 30 days before direct seeding.

The cotton was harvested manually, inside each experimental plot, at three random points that consisted of 4 rows of 5 m length. The cotton was ginned and weighed, the data from the three sampling points were summed, and the results were transformed into kg ha^{-1} of fiber.

In October 2014, undisturbed soil samples were collected at depths of 0-5, 6-10, 11-20, 21-30, and 31-40 cm for density calculation, and disturbed samples were collected for the evaluation of N and C. The total C and N contents were determined by dry combustion in a C and N elemental analyzer (Perkin Elmer Elemental Analyzer 2400 Series II) according to the Pregl-Dumas method (Nelson & Sommers 1996). The bulk density and C content were used to calculate the C stock (Mg ha^{-1}) (Blake & Hartge 1986) using the following formula: C content (g kg^{-1}) × bulk density (kg dm^{-3}) × soil layer thickness (m) × 10.

The data were subjected to analysis of variance, and the means were compared by Tukey's test at 5% significance. Fiber yield was analyzed by comparing the cotton monoculture treatment with the conventional tillage and cotton in the NTS treatments, considering only the results obtained from 2007-

2008, when the NTS had already been cultivated with soybean (1st crop)/*U. ruziziensis* (2nd crop) in 2005-2006 and with maize (1st crop)/*U. ruziziensis* (2nd crop) in 2006-2007. The NTS treatment was arranged in three different ways since the beginning of the experiment: i) cotton, soybean + *U. ruziziensis*, and maize + *U. ruziziensis*; ii) soybean + *U. ruziziensis*, maize + *U. ruziziensis*, and cotton; iii) maize + *U. ruziziensis*, cotton, and soybean + *U. ruziziensis*. As of the third year of the experiment, this strategy allowed the possibility of comparing the cotton yield in the NTS and in the monoculture during every year. For fiber yield, the year effect was considered in the analysis of variance. Within each year, the means of the treatments were compared by Student's t-test at 5% significance.

Results and discussion

Significant differences were observed in the C and N concentrations in the soil between the different soil management and use systems (Table 2), especially in the surface layers. Although the different depths were not compared, the highest C contents were obtained in the soil surface, mainly at 0-5 cm, and progressively decreased with increasing depth, regardless of the soil preparation and management system (Table 2). Similar behavior was observed by Corbeels et al. (2016). According to Corazza, Silva, Resck, and Gomes (1999), the most significant changes in C in the tropical Cerrado soils relative to the inputs or outputs occur in the surface layers.

The C content at the 0-5 cm depth was significantly higher in the NTS than in the treatments with CTS, with or without crop rotation. In the NTS, a greater accumulation of C occurs in the soil surface layer due to crop residues (Corbeels et al., 2016), which can also be attributed to the abundant root system of pasture grasses. *U. ruziziensis* produced straw for soil cover and direct seeding, which resulted in a longer period of use and protection of soil. In the NTS, the C content was approximately 55% higher than that found in the CTS treatments. In cotton monocultures, or in the soybean-cotton or soybean-maize-cotton rotations, all under the CTS, no difference was observed in the C content in the analyzed layers, except for the 6-10 cm layer (Table 2). In the 6-10, 11-20, and 21-30 cm layers, although a difference was observed in the C content between some treatments, the magnitude of the variations was small compared to the 0-5 layer. In the CTS, the organic matter of the crop residues of each studied production system was incorporated into the soil to approximately 20 cm of depth, through plowing and harrowing. These processes favor the decomposition of organic matter (Lal, Negassa, & Lorenz, 2015), especially of the less stable organic compounds. Therefore, the conventional tillage treatments, whether the soybean-cotton or soybean-maize-cotton rotation, were not sufficient to increase the C content in the top surface layer. From 11 cm to 30 cm depth, no difference was observed between the treatments because this layer is greatly influenced by the plant roots. However, at depths from 31 to 40 cm, soil under the NTS presented higher C content than that under conventional tillage, probably due to the high development capacity of the *U. ruziziensis* roots, which allowed them to reach greater depths.

The highest N content was obtained in soil under the NTS (Table 2) in the 0-5 cm layer, where the level of N was almost 50% higher than that found in the CTS treatments. At the remaining depths, no difference was observed between the treatments. Piccoli et al. (2016) observed higher C and N levels in the soil under conservation management compared to conventional management, and the differences were also found in the top 5 cm of the soil surface. Under conventional tillage, the inclusion of soybean in the rotation was not effective at increasing the N content in the soil. In the cotton monoculture over the 9 years, 996 kg ha^{-1} of mineral N were added to the system, while in the NTS, that value was 649 kg ha^{-1}. Despite receiving 347 kg ha^{-1} less mineral N, the soil N content under the NTS was higher, equivalent to 320 kg ha^{-1}. This accumulation of N can be attributed not only to the absence of soil rotation but also to the nutrient cycling potential of *U. ruziziensis* (Pacheco, Monteiro, Petter, Nóbrega, & Santos, 2017).

The C stock followed the same trend as the C content, with higher amounts accumulating in the more superficial layers of the soil, and this was emphasized in the NTS (Table 3). At the 6-10 and 11-20 cm layers, no differences existed in the C stocks between the NTS and CTS, but at a depth of 31-40, the largest C stock was observed in the soil under the NTS. The results indicate that cotton cultivation in the NTS in the tropical regions of the Brazilian Cerrado favored C input to the soil. This effect is probably attributable not only to the absence of soil tillage but also to the dry matter inputs from the cultivation of *U. ruziziensis*, a forage grass that produces high amounts of shoot and root dry matter (Souza, Fernandes, Souza-Schlick, & Rosolem, 2014). According to Corbeels et al. (2016), in the NTS, the shoot and root residues increase the stabilization of C due to greater soil aggregation, which has a synergistic effect on C sequestration.

Table 2. Carbon and nitrogen contents (g kg^{-1}) in the soil after 9 years with different systems of soil management, rotation, and succession of crops for the cotton crop.

Treatments	Depth (cm)									
	0-5		6-10		11-20		21-30		31-40	
	C	N	C	N	C	N	C	N	C	N
CTCM[1]	13.6 b	1.0 b	13.9 ab	1.0 a	12.2 a	0.9 a	9.3 ab	0.6 a	7.3 b	0.4 a
CTCSC[2]	13.9 b	0.9 b	12.7 c	1.0 a	12.3 a	1.0 a	8.2 b	0.6 a	6.9 b	0.5 a
CTCSM[3]	13.9 b	1.0 b	12.9 bc	1.0 a	13.3 a	0.9 a	9.3 ab	0.6 a	7.3 b	0.5 a
NTS[4]	21.5 a	1.5 a	14.3 a	1.0 a	13.6 a	0.9 a	10.5 a	0.7 a	8.4 a	0.5 a
Mean	15.7	1.1	13.4	1.0	12.8	0.9	9.3	0.6	7.48	0.5
CV	6.33	12.67	4.02	8.14	6.88	8.57	10.28	16.29	3.17	12.14

[1]Conventional tillage and cotton monoculture; [2]conventional tillage and annual cotton-soybean-cotton rotation; [3]conventional tillage and biennial cotton-soybean-maize rotation; and [4]cotton in no-tillage system [soybean (1st crop) + *Urochloa ruziziensis* (2nd crop)/maize (1st crop) + *U. ruziziensis* (2nd crop)/cotton (1st crop)]. Means followed by the same letter in each column do not differ by Tukey's test at the 5% significance level.

Table 3. Soil carbon stock (Mg ha^{-1}) after 9 years under different systems of soil management, rotation, and succession of crops for the cotton crop.

Treatments	Depth (cm)					
	0-5	6-10	11-20	21-30	31-40	Total (0-40)
CTCM[1]	8.7 b	9.0 a	16.0 a	12.2 ab	9.0 b	54.8 b
CTCSC[2]	8.9 b	8.0 a	17.8 a	10.9 b	8.5 b	54.4 b
CTCSM[3]	9.2 b	8.3 a	16.7 a	11.9 ab	8.8 b	54.7 b
NTS[4]	13.8 a	9.8 a	18.2 a	13.7 a	10.3 a	65.7 a
Mean	10.1	8.8	17.2	12.2	9.1	57.4
CV	11.11	9.07	6.31	9.37	3.52	3.25

[1]Conventional tillage and monoculture of cotton; [2]conventional tillage and annual cotton-soybean-cotton rotation; [3]conventional tillage and biennial cotton-soybean-corn rotation; and [4]cotton in the no-tillage system [soybean (1st crop) + *Urochloa ruziziensis* (2nd crop)/maize (1st crop) + *U. ruziziensis* (2nd crop)/cotton (1st crop). Means followed by the same letter in each column do not differ by the Tukey's test at the 5% significance level.

Based on the initial soil organic matter content (24.2 g kg^{-1}), the van Bemmelen factor (0.58), and initial bulk density (1.22 kg dm^{-3}) in the 0-20 cm layer, the C stock was estimated (Blake & Hartge, 1986) at the beginning of the study based on soil managed until then under a conventional tillage system, and a value of 34.2 Mg ha^{-1} of C was obtained. Therefore, after 9 years of cotton cultivation in the CTS, with or without crop rotation, the C stock did not increase in the up to 20-cm depth (Table 3). Thus, by inference, production systems under the CTS with plows and harrows, with or without cotton, soybean, and maize rotation, did not positively affect the carbon balance and were not sufficient to improve the carbon stock in the soil area where most of the roots of the soybean, maize and cotton plants are concentrated and where the crop residues are incorporated when plowing and harrowing; that is, the input and the decomposition remained in equilibrium. In the NTS, the stock increased 22.2% after 9 years in the 0-20 cm layer (Table 3).

The soil management system based on the NTS resulted in the largest total C stock up to 40 cm deep, corresponding to 65.7 Mg ha^{-1} (Table 3). The C stock under the NTS differed from that observed in the CTS. However, the results obtained in CTS treatments did not vary among them, indicating that the addition of soybean and maize was not sufficient to increase the C stock under conventional tillage. According to Corbeels et al. (2016), the monoculture of soybean or maize, without a second crop, is one of the main reasons for the reduction of soil C. When studying the effects of integration systems in Latosol with 63% clay, Salton et al. (2014) showed that the continuous CTS decreased the C stock over the years. By promoting soil disaggregation, the CTS results in lower protection of C due to an increase in the microbial activity of organic matter decomposition (Six, Conant, Paul, & Paustian, 2002). According to Boddey et al. (2010), in addition to increasing the C and N input to the soil, the NTS increases the C stock.

Although the soil C accumulation was not determined over the years, after 9 years, an approximate increase of 10.9 Mg ha^{-1} of C in the soil was observed when cotton cultivation was adopted in the NTS, compared to other treatments with conventional tillage, regardless of the use of rotation with soybean and maize crops. Therefore, the estimated annual increase in C in the soil was 1.2 Mg ha^{-1}. This accumulation surpasses the estimate of Minasny et al. (2017), who reported that it is possible to obtain mean annual rates between 0.2 and 0.5 Mg ha^{-1}, and that, in some more favorable areas, this rate may reach 0.6 Mg ha^{-1} $year^{-1}$. Corbeels et al. (2016) found increased annual rates ranging from 0.32 to 1.46 Mg ha^{-1} of C at depths up to 40 cm in the Brazilian Cerrado soils cultivated under the NTS with soybeans in the first crop and with maize, sorghum, or millet in the second crop, without cotton in the crop rotation schemes.

In the present study, after 9 years, the increase in the C stock at the up to 40-cm depth was approximately 20%, which is five times greater than the target set in the '4 per 1000' initiative (Lal, 2016). This increase indicates the potential for cotton cultivation in the NTS under rotation with soybean + *U. ruziziensis* and maize + *U. ruziziensis* in contributing positively to the goal proposed in COP 21 (Lal, 2016).

When the treatments with soybean, maize, and cotton rotation in the CTS and NTS, whose fertilization and phytosanitary management were identical in each agricultural year, were compared, the NTS significantly increased the C and N input to the soil, contributing to the mitigation of greenhouse gases (GHG) because, according to Salton et al. (2014), Lal (2016) and Minasny et al. (2017), agricultural practices favoring soil conservation, with an increase in C storage, contribute to reducing GHG emissions. In addition, the increase in C content and stock is an important indicator of soil quality and yield improvement because, according to Srinivasarao et al. (2014), increasing the C stock in the soil in the root zone is important for restoring soil quality. In the case of the two systems compared above, the following differences existed: the lack of soil preparation and turning and the cultivation of *U. ruziziensis* in the NTS, which generated straw for the sowing of maize and cotton.

The cotton fiber yield was significantly influenced by the year and by the management system (Figure 1). In the 2007/8, 2008/9, and 2013/14 crops, the fiber yield was higher for the cotton cultivated under the NTS, while in the 2009/10, 2010/11, 2011/12, and 2012/13 crops, no significant difference was observed between the NTS and CTS (Figure 1). After 7 years, the total fiber yield was 13,958 kg ha^{-1} in the NTS, whereas in monoculture with the CTS, the total fiber yield was 12,698 kg ha^{-1}; that is, in the NTS, the higher fiber yield (1,260 kg ha^{-1}), was practically equivalent to a whole new crop. According to Corbeels et al. (2016), the increase of crop yield under the NTS is one of the main reasons for the adoption of a conservationist soil management system, with positive impacts on the mitigation of global warming.

The results indicate that cotton cultivation under the NTS is an important technology for farmers to change the process of land use and management. In addition to increasing cotton yield and soil carbon accumulation, NTS provides greater productive resilience and helps maintain or expand world trade for a society increasingly demanding sustainable production processes.

New crop rotation and succession schemes that diversify the cultivation of cover crops for the NTS need to be studied, with an aim to increase the potential of the N and C inputs in the soil and to improve the productive sustainability of the crops, including cotton. In addition, because they are deep, the Latosols of the Brazilian Cerrado can store carbon at greater depths, depending on the cultivated species and the soil management system, and these findings should be considered in future studies.

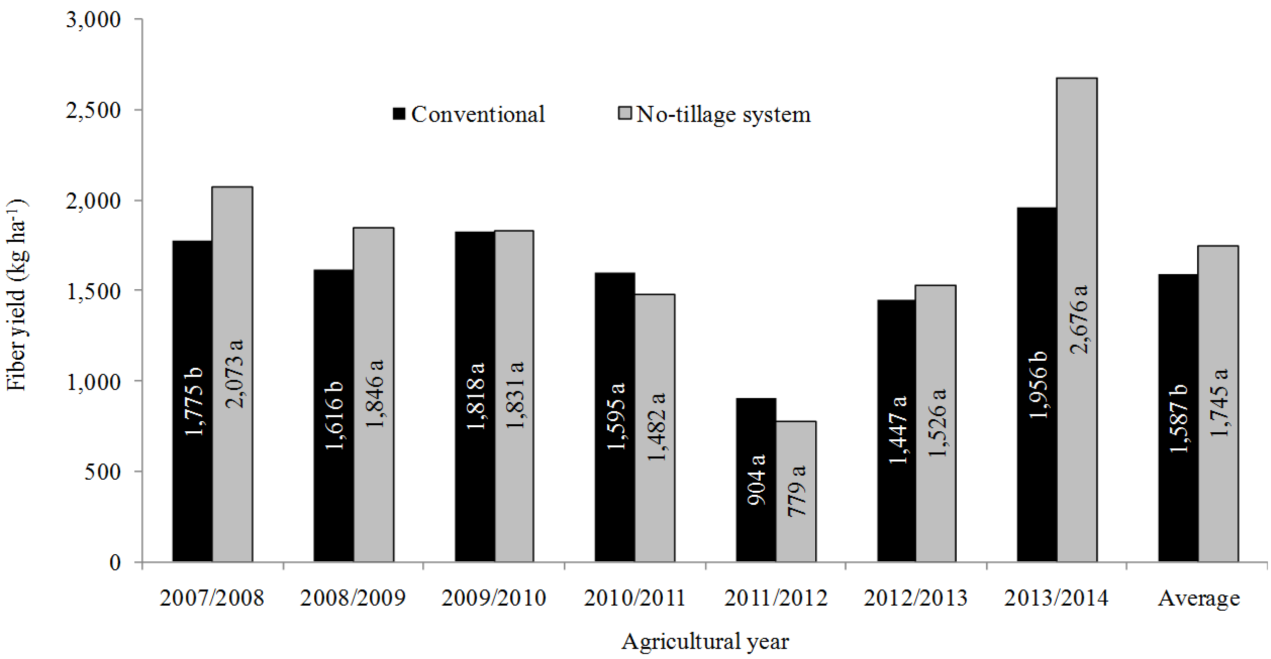

Figure 1. Cotton fiber yield (kg ha^{-1}) from 7 years of cultivation in the Brazilian Cerrado under the no-tillage system and a conventional tillage system with monoculture. Within each year, the means of the treatments were compared by Student's t-test, at 5% significance.

Conclusion

After 9 years of research under field conditions, the present study showed that cotton cultivated under the no-tillage system, in addition to showing an increased fiber yield, also increases the N content in the top 5 cm of the soil and the organic carbon stock at up to 40-cm depth. The C accumulation in tropical Brazilian soil cultivated with cotton under the NTS exceeds by almost five times the goal of the '4 per 1000' initiative presented during the 21st United Nations Climate Change Conference.

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