DOI: 10.5433/1679-0359.2018v39n6p2843

Farmers' views on the use and management of soil and its relation to the return of erosion in no-tillage system

Visão de produtores rurais sobre o uso e manejo do solo e sua relação com o retorno da erosão em sistema de plantio direto

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Abstract

The no-tillage system (NTS), until now considered an effective management tool for the control of erosion, has gradually increased the loss of soil. The objective of this research is to identify and understand the probable causes of the return of erosion in rural properties under the NTS in three municipalities in northern Paraná. For this research, a questionnaire was used to collect information on soil management and the use of agricultural terraces. Data collection was completed with 145 landowners and NTS users, along with rural extension and agricultural cooperatives. The results demonstrated that the return of erosion is likely due to the absence of crop rotation in favor of repetitive year-to-year planting of the same plant species (early soybean/maize [second harvest]/wheat), soil revolving to decompress the surface layer, and the elimination of agricultural terraces and the consequential downslope planting.
Key words: Soil degradation. Soil management. Soil coverage. Agricultural terraces.

Resumo

O sistema plantio direto (SPD), até então considerado um manejo eficiente no controle da erosão, tem apresentado aumento gradativo da perda de solo. Assim, o estudo teve por objetivo levantar e entender as prováveis causas do retorno da erosão em áreas sob SPD, em propriedades rurais de três municípios do norte paranaense. Para tal, foi aplicado um questionário para o levantamento de informações referentes ao manejo do solo e uso do terraço agrícola. O levantamento de dados foi realizado com 145 proprietários de terras e usuários do SPD, selecionados junto à extensão rural e cooperativas agrícolas. Os resultados permitiram concluir que o retorno da erosão se deve a ausência de rotação de culturas em prol de uma repetitividade ano a ano da mesma espécie vegetal (soja precoce/milho segunda safra ou trigo); do revolvimento do solo para descompactação da camada superficial; da eliminação dos terraços agrícolas e consequente plantio em desnível.
Palavras-chave: Degradação do solo. Manejo do solo. Cobertura do solo. Terraço agrícola.

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Received: June 07, 2018 - Approved: Sept. 05, 2018

Agribusiness is the main economic activity of the state of Paraná, which has an area equivalent to 2.3% of the brazilian territory and generates nearly one-third of the state's gross domestic product (GDP) (SEAB, 2003). This is a relevant factor that contributes to improving the life in the countryside and in the cities of the state.

The northern region of the state stands out as the main producer of grains (soybeans, corn, second harvest corn, wheat, coffee, and beans) because of soil fertility and the adoption of technologies that produce high rates of agricultural productivity. Agriculture in this region began approximately 75 years ago, mainly with cotton and coffee crops (TAVARES FILHO et al., 2012). However, after the "Black Frost" of 1975, which wiped out most of the coffee plantations, a new technological model based on intense mechanization (conventional tillage, plowing, and harrowing), highly soluble mineral fertilizers, and agrochemicals was prioritized for grain production. This model increased crop productivity, but generated environmental problems, highlighting soil degradation by erosion, organic matter loss, arable layer spraying, and compaction (TAVARES FILHO; RINSCHEDE, 2009; TAVARES FILHO et al., 2012).

Thus, society's growing concern for the environment has bolstered the need for adopting new forms of soil management and conservation technologies such as the no-tillage system (NTS). Since its implementation, this management system has proved to be effective in reducing soil, water, and nutrient losses by erosion, preserving and improving soil structure, and increasing nutrient cycling and biological activity (SILVA; DE MARIA, 2011; SILVA et al., 2014). This set of factors contributed to the expansion of NTS areas, practiced worldwide, to more than 120 million hectares (FRIEDRICH et al., 2012).

However, currently, most of the soil cultivated under the NTS needs to recover or conservation practices must be implemented, as, because of the intensive use of these soils for grain production, erosion problems previously controlled by the same practice have resurfaced (BERTOL et al., 2007; PANACHUKI et al., 2011; SILVA; DE MARIA, 2011).

Tests comparing erosion losses between different management systems have demonstrated that the NTS reduces soil and water losses by on average 84 and 58.7%, respectively, when compared to systems that prioritize soil tillage (BERTOL et al., 2007; PANACHUKI et al., 2011).

The problem addressed in this research is the return of erosion in areas under the NTS in north Paraná. The hypotheses suggest that erosion reappeared because of the following factors: 1) the abandonment of the basic principles of NTS (diversification of plant species through crop rotation, soil mobilization exclusively in the sowing line, and permanent soil coverage); 2) the no-use of traditionally recommended conservation practices, such as terracing and cultivation in contour lines; and 3) the economic conditions related to previous circumstances that led rural producers to neglect the recommended technical-scientific orientations.

In this context, this research aims to outline and understand the probable causes of the return of erosion in areas under NTS in rural properties of three municipalities in the north of Paraná.

The study was carried out in the municipalities of Londrina (district of Lerrovile; 23°08'47"S and 51°19'11"), Tamarana (23°43'00"S and 51°05'00"W), and Ortigueira (24°12'30"S and 50°56'58"W). According to the Köeppen classification, the climate in the region is type Cfa (temperate humid with hot summers), with an average temperature and rainfall of 18.5 °C and 1490 mm, respectively. The relief is classified as wavy.

The soils of these municipalities originate from basalt, belong predominantly to the Latosols class, and are characterized by low activity clay, with a reduced differentiation between the horizons and

microgranular structure, comprising angular and subangular aggregates.

Information on soil management and use of agricultural terraces was obtained from data collected from the municipality of Londrina in 2009. Data collection extended to the municipalities of Tamarana and Ortigueira in 2012.

The methodology used consisted of elaborating upon and subsequently applying a survey based on Tavares Filho; Rinschede's study (2009) with 145 rural producers, landowners, and NTS users. The producers were selected from information obtained from the rural extension and agricultural cooperatives of the region. The survey addressed the following items: 1) General information: a) Schooling; b) Property sizes; 2) Information on the management of the area: Does the NTS practiced on the property include permanent land coverage, crop rotation, and soil mobilization exclusively in the sowing line? To respondents who answered "Yes" the following questions were asked: a) Is the soil "well" covered with straw when sowing, in a way that more straw than soil is seen? (b) Does crop rotation comprise an alternation of plant species with each new planting in the same agricultural area?; c) If crop rotation is not performed as indicated by the survey, which crops are used annually in the area?; d) How is the soil mobilized exclusively in the sowing line? Is another type of implement used in the area?; 3) Information about the agricultural terrace: In your opinion, is it necessary to use agricultural terrace (contour lines) in the area? To respondents who answered "No" the following questions were asked: a) In your opinion, can soil management be carried out downslope without the presence of a terrace in the area?; b) In your opinion, what kind of improvement is there in the area when a terrace is present?; c) What is the conservation practice used on the property without terraces?

From 145 questionnaires answered by NTS users (Table 1 - Item 1), it was found that 41% have basic education, 53% have high school education, and 6% have higher-level education, with a degree in agronomy. From the data it was found that 37% of the respondents have properties ≤ 30 ha, 38% have properties between 30 and 100 ha, and 25% have properties ≥ 100 ha.

All of the respondents (100%) stated that the NTS management carried out on the property area (Table 1 – Item 2) included a permanent land cover, diversification of plant species through crop rotation, and soil mobilization exclusively in the sowing line. However, when the questions were more specific, 70% of the respondents stated that they observed reduced residual straw on the soil surface when sowing a new crop and 97% stated that the crop rotation did not include alternating plant species with each new planting, such that the same crops, for example, soybean (early), second harvest corn, and wheat, were used annually. In addition, 88% of the producers declared that they used an implement (scarifier, plow, or harrow) every 3 years, to break the more compact surface layer of the soil.

From the results, 74% of the respondents consider that using the agricultural terrace (Table 1 – Item 3) following the NTS is sufficient to control erosion, without needing to use a terrace in the area. In addition, 81% considered that removing the terraces facilitates soil management and the downslope application of defensive agents, without causing soil problems, thus increasing machine efficiency according to 72% of the interviewees.

Currently, NTS is practiced in 80% of the areas cultivated with grains in Brazil and in 90% of the areas of Paraná. However, erosion problems have been observed.

The information obtained in this study is in agreement with Tavares Filho; Rinschede (2009) and demonstrated that 74% of respondents consider that NTS alone is sufficient for controlling erosion, and agricultural terracing is not necessary. Moreover, according to the interviewed producers, the presence of terraces hinders soil management and pesticide application, thus reducing the efficiency

of using machines. However, contrary to these affirmations, Silva; De Maria (2011) and Colozzi et al. (2017) reported that mechanical practices such as contouring, terracing, and level cultivation are essential for erosion control.

Table 1. Survey and responses obtained from 145 rural NTS users.

Rural NTS Users Producers			
Total answers obtained	**Number**		**%**
1) General information			
a) Schooling	Elementary education	60	41
	High school	77	53
	Higher education	08	06
b) Property size	Properties ≤ 30 ha	53	37
	30< properties <100 ha	55	38
	Properties ≥ 100 ha	37	25
2) Area Management Information			
Does the NTS include permanent soil coverage, crop rotation, and soil mobilization exclusively on the sowing line?	Yes	145	100
	No	00	00
2.1) For respondents who answered "Yes":			
a) Is there reduced straw on the surface of the soil, when sowing?	Yes	102	70
	No	43	30
b) Does crop rotation involve a rotation of plant species with each new planting in the same agricultural area?	Yes	05	03
	No	140	97
c) Which crops are used annually in the area if crop rotation is not performed as indicated by the survey?	Soybean, second harvest corn, wheat	141	97
d) How is the soil mobilized exclusively in the sowing line? Is there any other implement used in the area?	Yes. Scarifier, plow, or harrow are used every 3 years, to break the more compact surface layer	128	88
	No. Not used.	17	12
3) Information on the use of agricultural terraces in the area			
In your opinion, is it necessary to use agricultural terraces (contour lines) in the NTS area?	Yes	38	26
	No	107	74
3.1) For respondents who answered "No":			
a) Without the terraces, what conservation practices are used on the property?	"Direct planting with mulch."	107	74
b) Can soil management and pesticide application be managed "downslope" without a terrace in the area?	Yes	118	81
	No	27	19
c) What kind of improvement is observed in the area without the terraces?	"Increased efficiency in the use of machines."	105	72

Information about the support pillars of the NTS indicated that, in practice, the producers do not use the guidelines indicated by the research, and consider the NTS as an efficient conservationist technology in erosion control.

According to the producers, the decision to not adopt crop-rotation systems is based on economic criteria, which are considered in order to obtain high yields of early soybean and second harvest corn. Thus, the technical, scientific benefits of crop rotation are not considered because of the influence of the market value of the grain on the decisions of the producers.

Flexibility and profitability in the market, the ease of sale in the future, the possibility of an exchange for inputs, and the greater value of the product can be highlighted among the factors that lead to producers choosing an agricultural crop, placing soy in a prominent position.

Wheat is recurrent in the crop sequence not only because of its commercial viability but also because it contributes to the reduction of weeds, and the use of defensive products used in wheat crops helps to control some of the invasive herbs that affect soybeans, the crop that is sown after wheat.

Silva et al. (2014) compared the management systems after 22 years of cultivation and demonstrated that the visible porosity of the aggregates was directly influenced by crop management, such that the succession engendered soil with a more compact appearance and roots visibly deformed morphologically when compared to the soil present in culture rotation. Rotation promotes crop diversification, with different root systems and greater biomass production, providing greater aeration and infiltration of water in the soil, affecting the maintenance and improvement of its structural quality.

Cunha et al. (2007) evaluated the effects of some crop rotation systems on the physical attributes of the soil and concluded that systems that included soybean/wheat succession resulted in higher soil compaction compared to systems that included grasses such as rice/corn. Albuquerque et al. (1995) also recorded higher soil density in soybean/wheat succession in the surface layer, than in rotations that included crops such as oats/peas/corn. Stone; Silveira (2001) also found higher density, microporosity, and lower macroporosity in soybean/wheat succession in the soil surface layer under NTS, while the system of rice intercropped with calopogonium-beans provided higher macroporosity and lower microporosity values.

Soybean and wheat are crops with lower biomass production when compared to millet and corn crops. The C/N ratio of the organic residues present in the soil is one of the main factors controlling the speed of the decomposition process. Thus, soybean has rapid biomass decomposition on the soil surface because of its low C/N ratio. In the NTS, the larger and longer the residual straw left on the soil surface, the better the effect on its physical attributes.

The use of implements in soil mobilization, every three years soon after the winter culture, was a common practice among the producers. This is related to the occurrence of compaction, as the early soybean is sown immediately at the beginning of the summer rains, with moisture conditions that favor this process over time. In addition, during the planting of the second harvest corn, rainfall is scarce, and the water supply for the crop will depend on the deepening of its root system, which should find water in the deeper layers of the soil (>30 cm deep), a factor that also leads the producer to promote soil tillage.

However, studies have demonstrated that the effect of tillage is the short term and the modification resulting from this practice, whether or not reduced, is preserved in the soil structure three years later (SILVEIRA JÚNIOR et al., 2012; SILVA et al., 2014). In addition, soil tillage leaves the soil vulnerable to deformation by the traffic of agricultural machines, and re-compaction is observed after one or two traffic operations (SILVEIRA JÚNIOR et al., 2012).

Fidalski et al. (2015) evaluated a dystroferric Red Latosol cropped under NTS for 17 years, after a single mechanical intervention (plowing and harrowing), complemented with liming. The authors reported that soil density reduction, along with changes in chemical attributes, did not increase crop yield, indicating that occasional soil rotation and lime incorporation were not determinant factors for high yields.

Debiase et al. (2010) observed lower yields of corn and soybean under conditions of water stress in scarified NTS compared to no-scarified, which according to the authors occurred because of the lower seed germination rates as a consequence of the reduced water availability in the revolved surface layer.

Thus, it is clear that the instructions indicated for the NTS are not being applied by the rural producers, and so the results presented support research from other authors, who report that intensive mechanization for grain production has caused erosion problems in areas under the NTS (PANACHUKI et al., 2011; SILVA; DE MARIA, 2011).

According to Franchini et al. (2012) and Silva et al. (2014), the NTS is beneficial for soil attributes in numerous ways, taking into account the basic principles of the system, such as minimum soil tillage, permanent soil coverage, and crop diversification through rotation. In addition, the soil does not need to be mobilized to break compacted layers. This practice increases production costs, because of the cost of fuel and labor. In addition, the breakdown of the soil structure causes loss of soil, water, and nutrients because of erosion, as currently evident in agricultural areas.

The return of erosion in NTS areas in northern Paraná is due to the absence of crop rotation while favoring a yearly repetition of crops such as early soybean/second harvest corn/wheat. Such practices promote the emergence of compact layers, causing the farmer to turn the soil through scarification, plowing or harrowing, along with an elimination of agricultural terraces to facilitate the work of the machines, which consequently leads to downslope planting.

Acknowledgments

The authors thank the 145 producers who participated in the research, CAPES for granting the Master's and post-doctoral scholarships to the first and second authors, respectively, and CNPq for the Productivity in Research grant to the third author.

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