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No-tillage Overview from a Bibliometric Study with Multiple Correspondence Analysis

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ABSTRACT

The no-tillage system (NTS) represents an important technological advance in agriculture generating economic and environmental benefits. However, there is a new orientation of academic interest in issues related to the environment and sustainable development in several areas regarding the NTS. Our aim was thus to perform an overview analysis of academic publications about this system and their focuses. The method adopted was a bibliometric survey at the Web of Science database. The 500 most cited articles on the Web of Science database published between 2006 and 2011 were chosen and lexical and multiple correspondence analyses with the most frequent words in title, abstract and keyword fields were made. The results suggest that there is a strong emphasis on no-tillage publications on environmental issues, such as carbon sequestration and greenhouse gas emissions.
Keywords: Carbon sequestration, emissions, conventional-tillage, sustainable development, agriculture, Brazil.

1. INTRODUCTION

The plow has been used since the dawn of agricultural activities. However, this tool contributes to erosion and soil degradation. Hence, alternative approaches are needed to minimize such effects. Among the alternatives, we can emphasize the development of the No-Tillage System (NTS).

Some countries, such as France, Italy, Portugal, Germany and Belgium began using NTS in the 1960s and, since then, its adoption has spread. In the case of the U.S., there are records of early practice in the mid-40s (Derpsch, 1998). The United States are in the first position in the ranking of countries with the largest cultivated areas using NTS. Brazil ranks in the second position (Derpsch and Friedrich, 2009). Brazil has become the leader of the NTS cultivated area in South America, acting as a disseminator of this technology to the world (Derpsch and Friedrich, 2009).

NTS is an innovative agricultural production technique, which prevents soil disturbance by not preparing the soil, leaving its surface permanently covered with crop residues or straw, due to the adoption of crop rotation (Wes and Post, 2002). NTS interferes in weed development, protecting the soil structure and reducing energy use (Phillips et al. 1980; Germon and Thevenet, 2001).

This system was developed in order to ensure permanent protection of the soil, using a protective cover on the land surface, rather than based on the use of herbicides (Cannell and Hawes, 1994; Pieri et al., 2002). It also results in higher levels of productivity (Pieri et al., 2002), having its highest productivity results in tropical or subtropical regions (Reichert, 2009), as is the case of Brazil.

Besides productivity, NTS leads to important environmental benefits such as the reduction of greenhouse gases emissions and carbon sequestration from the atmosphere, being considered a decisive step toward sustainable agriculture (Robertson, Paul and Harwood, 2000, FAO, 1995).

Pendell et al. (2007) confirm that NTS captures higher levels of carbon than conventional methods. Part of the CO2 captured by the plant is maintained in the straw, which is used to cover the soil. The use of agricultural machinery is also lowered in this system, leading to a reduction in the use of fossil fuels and greenhouse gas emission (Sauerbeck, 2001).

In this context, this paper aims to perform an overview analysis of academic publications about NTS. This search is justified by the need for better understanding of the current situation and the academic interest concerning NTS.

2. METHODOLOGY

This study is characterized as an exploratory and descriptive research, applying the bibliometric analysis as the research method. Although this method presents a series of investigative limitations, it fulfills the needs of this study. Thus, through the specific procedures described below, it will lead to an overview of the publications about NTS from 2006 to 2011.

Initially, a series of papers were collected with the topics “no-tillage” or “no-till” in the Web of Science database. From this listing, the articles were sorted by “times cited”. Next, the 500 most cited articles published between 2006 and 2011 were selected. This period was chosen due to the high growth of publications about the subject, especially after the year 2006. The titles, abstracts and keywords of the selected articles were stocked in a database for lexical and multiple correspondence analyses. This survey was performed in December 10, 2011. The United States was verified to lead the ranking of countries with the highest number of publications on no-tillage, followed by Brazil.

In order to adjust and to prepare the texts for the lexical analysis and word count, first the texts were analyzed by replacing some abbreviations with their respective definitions. Then, the data were transferred to the software Sphinx 4.5. The counting of the most cited words was then performed, as well as the regrouping of similar and complementary concepts. Each variable from the database (titles, abstracts and keywords) was submitted to the same procedures, generating a categorical variable with the most cited words for each one.

With the categorical variables with the most cited words in the texts, a multiple correspondence analysis was performed to identify the correlational proximity between the words, concepts and definitions. Based on the first preliminary results of the multiple correspondence analyses, words were identified that did not present contextual significance. A reduction of words was performed based on the researchers' judgment. Words were excluded because they did not represent relevant practices and/or outcomes to the objective of this study. The descriptive results, frequency and multiple correspondence analyses are explored in the next Section.

3. MULTIPLE CORRESPONDENCE ANALYSIS

The first multiple correspondence analysis was performed with the most cited words (selected according to the criteria explained in Section 2) in the titles of the selected articles. This can be observed in the map of multiple correspondences in Figure 1.

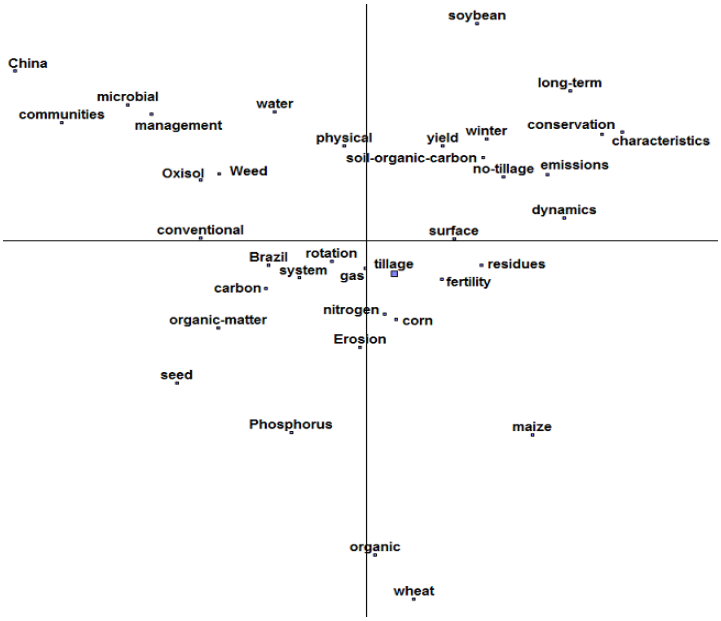

Figure 1. Multiple correspondence analysis of the variable "title".
Source: Search results. Notes: The map shows the positions of the 38 categories; 0.7% of the variance is explained by two axes represented.

In Figure 1, descriptive and interpretative analyses of the results by visual and quantitative form were performed. The most cited words are listed, as well as the number of appearances of each one enclosed in parentheses. In the first quadrant, the words observed are: no-tillage (65), long-term (48), yield (26), dynamics (22), conservation (21), emissions (19), surface (20), soybean (15), soil organic carbon (14), winter (13), characteristics (12). Therefore, the studies focused on no-tillage are considered to be more strongly related to issues regarding soil conservation, greenhouse gas emissions that cause global warming and organic carbon in the soil.

In the second quadrant, the words highlighted are: management (67), water (40), physical (28), communities (25), microbial (21), China (15), weed (15), conventional (12), oxisol (10). In the third quadrant, the words grouped were: system (100), carbon (85), rotation (62), organic-matter (26), seed (21), Brazil (22), erosion (15), gas (11), phosphorus (11). Finally, in the fourth quadrant, the following words can be observed: tillage (232), nitrogen (62), residues (34), corn (30), fertility (19), maize (10). Thus, the fourth quadrant concentrates words related to fertility, nitrogen uptake and soil residues, with focus on maize cultivation.

The second multiple correspondence analysis was performed with the most cited words of the abstracts in the selected articles. Its map of correspondence is shown in Figure 2.

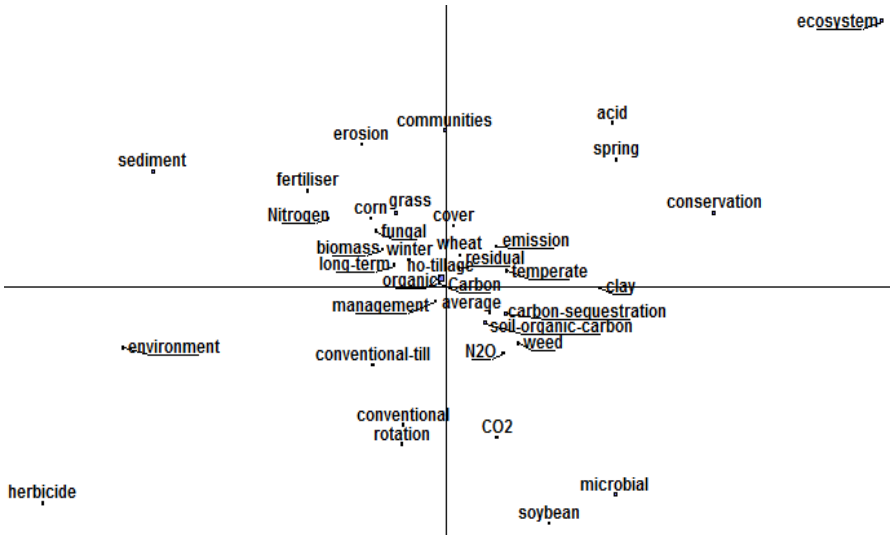

Figure 2. Multiple correspondence analysis of the variable "abstract".
Source: Search results. Notes: The map shows the positions of the 38 categories; 0.3% of the variance is explained by two axes represented.

In the first quadrant of Figure 2, the main words of the abstracts are: residual (212), wheat (208), emissions (189), cover (109), acid (97), temperate (91), spring (75), conservation (46), ecosystem (44). The results suggest that this grouping presents greater concern with environmental issues and emissions, especially in wheat growth. In the second quadrant, the words grouped were: no-tillage (369), organic (282), carbon

(266), nitrogen (203), corn (175), long-term (142), grass (123), communities (123), winter (120), fungal (105), biomass (102), fertilizer (102), erosion (66), sediment (56). This quadrant is distinguished by a higher concentration of terms focused on issues related to carbon and nitrogen, soil fertility, organic aspects of the soil and erosion.

In the third quadrant, the main words were: management (224), conventional-till (169), rotation (125), conventional (99), environment (57), herbicide (30). The results are not very expressive in this quadrant, suggesting that there is a greater focus on management and administration, as well as traditional practices of planting and crop rotation. In the fourth quadrant, the words grouped were: carbon-sequestration (265), soil organic carbon (240), average (164), N_2O (157), clay (120), CO_2 (114), microbial (104), soybean (86), weed (83).

The last multiple correspondence analysis was performed with the most cited keywords obtained from the articles. Its map of correspondence can be seen in Figure 3.

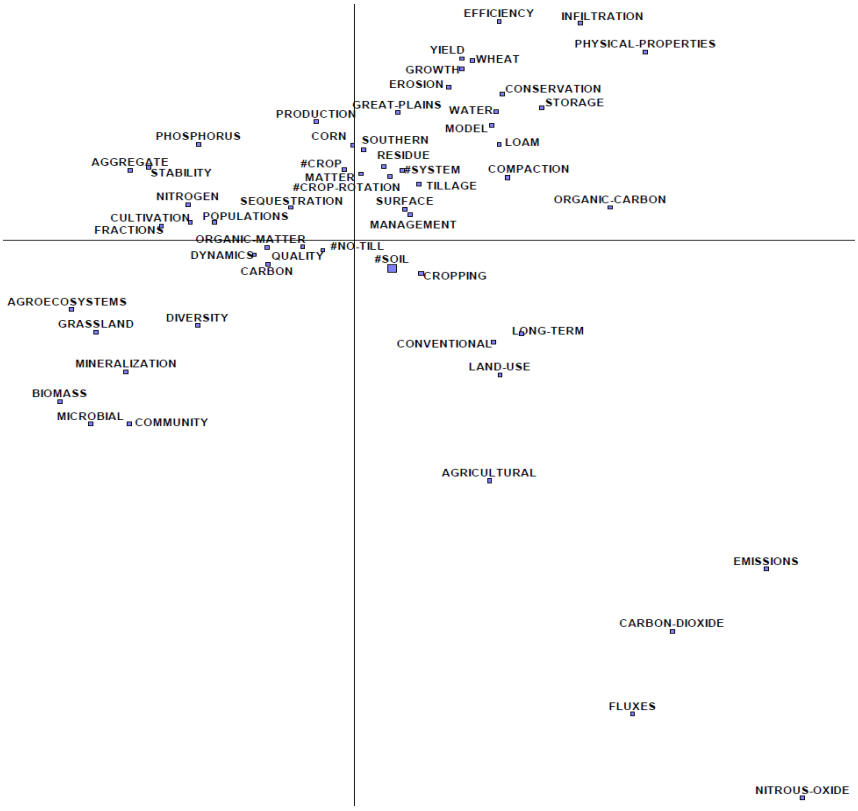

Figure 3. Multiple correspondence analysis of the variable "keywords".
Source: Search results. Notes: The map shows the positions of the 38 categories; 0.8% of the variance is explained by two axes represented; quantities below 10 appearances are shown in text.

In the first quadrant of Figure 3, the words grouped were: tillage (151), management (119), crop-rotation (54), conservation (51), residue (50), yield (35), water (33), matter (32), physical-properties (28), wheat (27), storage (23), organic-carbon (21), erosion

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(21), infiltration (20), growth (20), great-plains (18), compaction (16), surface (16), efficiency (<10), model (<10), southern (<10), loan (<10), system (<10). In this quadrant, the largest concentration of terms in the map can be observed. The results suggest a great diversity of subjects, such as: residual analysis, crop rotation, management and yield, soil conservation, soil compaction, organic carbon, water use, and focus on wheat crops. In the second quadrant, the words grouped were: nitrogen (88), sequestration (54), corn (51), fractions (30), stability (29), production (23), phosphorus (19), populations (17), crop (<10), aggregate (<10), cultivation (<10). The grouped words refer to carbon sequestration, nitrogen in the soil and maize cultivation.

The words grouped in the third quadrant were: no-till (106), organic-matter (100), carbon (79), microbial (51), biomass (50), mineralization (24), grassland (20), quality (19), agroecosystems (18), diversity (18), dynamics (<10), community (<10). This quadrant has a higher concentration of terms related to organic matter, no-tillage, carbon, biomass and microorganisms. In the fourth quadrant, the words grouped were: agricultural (37), emissions (30), carbon-dioxide (19), nitrous-oxide (17), conventional (17), fluxes (16), soil (<10), cropping (<10), long-term (<10), land-use (<10).

4. CONCLUSIONS

NTS is observed in this study as a topic that has attracted academic interest in the world in the last years. But the directions of academic researches related to it have changed in recent years. From an initial assessment of the publications related to NTS from 2006 to 2011, it was clear that the direction given by researchers relates to a major concern with environmental issues, besides the traditional economic focus on productivity.

The objective of this study was to present an overview of academic publications related to NTS. Final considerations allow observing that the multiple correspondence analysis, performed with the most cited words of the titles, abstracts and keywords of the 500 selected articles showed that recent studies have directed their attention to environmental issues, as well as traditional economic issues. Certain crops and countries were observed to have specific directions; it was also noted that the researches focused on issues such as carbon sequestration and greenhouse gas emissions.

The main limitations of this study are related to the limited number of selected articles, and the stipulated period of analysis. Even though these weaknesses are present, the methodology used provided interesting and important new insights into the NTS area, and is the initial step of a series of analyses of the increasing interest in this topic and the direction it is following. Future investigations can consider a larger sample of articles and other periods of analysis in order to make a comparative and evolutionary analysis of publications about NTS.

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