AN OVERVIEW OF THE MAIN TOPICS ON NO-TILLAGE RESEARCHES

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ABSTRACT: No-tillage represents a relevant technological advance in agriculture, generating economic and environmental benefits. The main objective of this paper was to perform an overview analysis of academic publications about no-tillage. A bibliometric survey was conducted based on the most cited articles in Web of Science database. Thus, lexical and multiple correspondence analyses were performed with the most frequent words in title, abstract and keyword fields. The results suggest that there is a strong emphasis on no-tillage publications on environmental issues, such as carbon sequestration and greenhouse gas emissions.

KEY WORDS: Agriculture Conservation; Climate Change; Sustainable Crop Rotation.

O PANORAMA DOS PRINCIPAIS TEMAS DAS PESQUISAS SOBRE PLANTIO DIRETO

RESUMO: O plantio direto representa um importante avanço tecnológico para a agricultura, gerando benefícios econômicos e ambientais. Este artigo objetivou realizar uma análise do panorama das publicações acadêmicas sobre o plantio direto. Uma pesquisa bibliométrica foi conduzida com base nos artigos mais citados na plataforma Web of Science. Assim, foram realizadas análises léxicais e de correspondência múltipla a partir das palavras mais frequentes nos campos: título, resumo e palavras-chave, presentes na plataforma. Os resultados sugerem que há

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uma forte ênfase em publicações de plantio direto sobre as questões ambientais, como o sequestro de carbono e as emissões dos gases do efeito estufa.

PALAVRAS-CHAVE: Conservação da agricultura; Mudanças climáticas; Rotação de culturas sustentável.

INTRODUCTION

The plow has been used since the dawn of agricultural activities. However, this contributes to erosion and soil degradation. Hence, alternative approaches are needed to minimize such effects. Among the alternatives, we can emphasize 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 to other countries all over the world. In the case of the United States, there are records of early practice in the mid-1940s (DERPSCH, 1998). The U.S. is in the first position in the ranking of countries with the largest areas cultivated using NTS and; in this case, Brazil ranks in the second position. Brazil has become the leader of the NTS cultivated area in South America, disseminating this technology in the world (DERPSCH; FRIEDRICH, 2009).

NTS is an innovative agricultural production technique if compared with the conventional production system with plowing, because it prevents soil disturbance by not preparing it, and leaves its surface permanently covered with crop residues or straw, due to the adoption of crop rotation (WEST; POST, 2002). This reduces the soil erosion and the nutrient loss that results from the erosion process. NTS interferes in weed development, protecting the soil structure and reducing energy use (PHILLIPS et al., 1980; GERMON; THEVENET, 2001).

This system was developed in order to ensure permanent protection of the soil, using a protective cover on the land surface (CANNELL; HAWES, 1994; PIERI et al., 2002). It also results in higher levels of productivity, having its highest productivity results in tropical or subtropical regions (REICHERT, 2009), as is the case of Brazil.

Besides the productivity, NTS leads to important environmental benefits, such as the reduction of greenhouse gases emissions and carbon sequestration from the atmosphere, considered a decisive step toward sustainable agriculture (ROBERTSON et al., 2000; FAO, 2001).

NTS captures higher levels of carbon than conventional methods (PENDELL et al., 2007). Part of the carbon dioxide 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 study aims to perform an overview analysis of academic publications about no-tillage. This search is justified by the need of better understanding of the current situation and the academic interest concerning NTS.

2 MATERIAL AND METHODOS

This study characterizes an exploratory and descriptive research, applying bibliometric analysis (ANURADHA; SHALINI, 2007; QIU; CHEN, 2009; VON ELM et al., 2009) as the research method. Thus, through the specific procedures to be described, it will lead to an overview of the publications about no-tillage from 2006 to 2011.

Initially, a series of articles were collected with the topics "no-tillage" or "no-till" in Web of Science database, which includes publications from several countries. 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 2006. The titles, abstracts and keywords of the articles selected 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, firstly, they were analyzed by replacing some abbreviations with their respective

definitions. Then, the data were transferred to the software (Sphinx). 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 correlation 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. Words were excluded because they did not represent relevant practices and/or outcomes to the objective of this study.

After the multiple correspondence analyses, the main words cited for the different variables were separated into quadrants, and used to identify the main research themes in each quadrant. The last step of the analysis was to gather all these themes in major groups, summarizing all the data.

3 RESULTS AND DISCUSSIONS

The descriptive results, frequency and multiple correspondence analyses are explored in this Section. In Figure 1 (and Table 1), descriptive and interpretative analyses of the results by visual and quantitative form were performed.
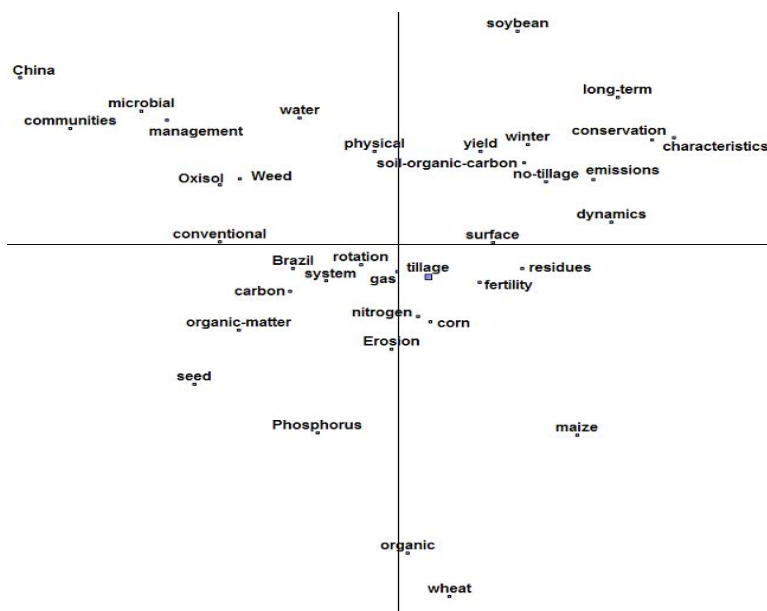
Figure 1. Multiple correspondence analysis of the variable "title"

Source: Search results. Notes: The map shows the positions of the 38 categories; 0.7% of the variance is explained by two axes represented.

Chart 1 contains the summary of the results observed on the analysis of the variable "title".

Chart 1. Summary of the results of the multiple correspondence analysis for the variable "title"

Quadrant	Most cited words (number of citations)	Relevant themes
First	No-tillage (65), long-term (48), yield (26), dynamics (22), conservation (21), emissions (19), surface (20), soybean (15)	Soil conservation, Greenhouse Gases (GHG)
Second	Management (67), water (40), physical (28)	No relation detected
Third	System (100), carbon (85), rotation (62), organic matter (26)	Crop rotation, carbon in the soil
Fourth	Tillage (232), nitrogen (62), residues (34), corn (30), fertility (19)	Corn production, fertility, nitrogen, soil residues, conventional production system

Source: Search results.

For this variable, the first quadrant is related to soil conservation and greenhouse gases themes. The second quadrant has no relation between the words detected by the researches, and the third quadrant contains researches related to crop rotation and carbon in the soil derived from this practice. The last quadrant corresponds to researches on corn production, fertility, nitrogen in the soil and soil residues for this crop, focusing on the conventional production system.

In Figure 2 (and Table 2), descriptive and interpretative analyses of the results (both visually and quantitatively) were performed, generating a correspondence map.
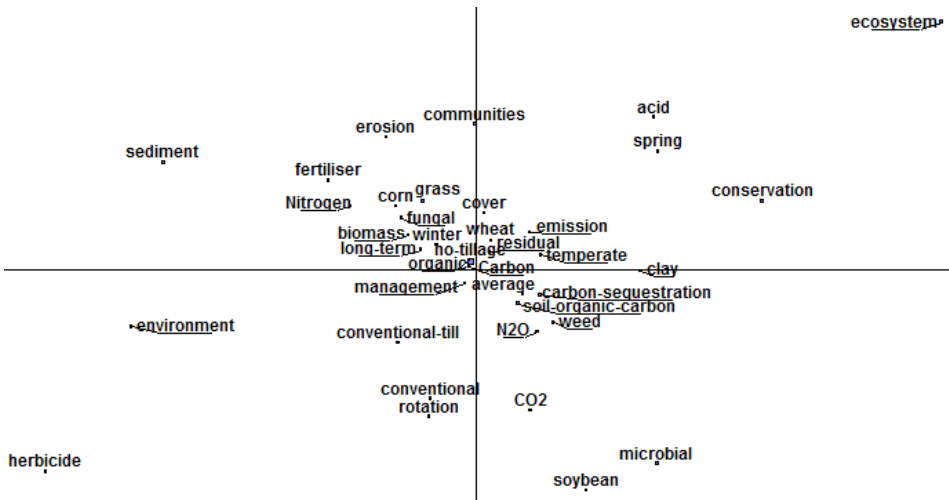

Figure 2. Multiple correspondence analysis of the variable "abstract"

Source: Search results. Notes: The map shows the positions of the 38 categories; 0.3% of the variance is explained by the two axes represented.

In the case of the variable "abstract", the main themes observed were related to the variable "title", mainly related to crop rotation, corn conventional production systems and GHG emissions. The main difference is that, in the case of the variable "abstract", GHG emissions are specifically related to wheat production. Chart 2 shows a summary of the results from this analysis of the variable "abstract".

Chart 2. Summary of the results of the multiple correspondence analysis for the variable "abstract"

Quadrant	Most cited words (number of citations)	Relevant themes
First	Residual (212), wheat (208), emissions (189)	Environment, GHG emissions in wheat production
Second	No-tillage (369), organic (282), carbon (266), nitrogen (203), corn (175)	Carbon and nitrogen in the soil, fertility, corn production
Third	Management (224), conventional-till (169), rotation (125), conventional (99)	Conventional production systems
Fourth	Carbon sequestration (265), soil organic carbon (240), average (164), N_2O (157)	No relation detected

Source: Search results.

The first quadrant contains research themes related to the environment and GHG emissions in wheat production. The residuals in the soil are also considered. The second quadrant contains mainly researches related to carbon and nitrogen in the soil in NTS, soil fertility and corn production using NTS. The third quadrant shows researches related to conventional production systems. In the last quadrant, no detectable relation was found between the research themes.

The last multiple correspondence analysis was performed with the most cited keywords obtained from the articles. In Figure 3 (and Table 3), descriptive and interpretative analyses of the results, both visually and quantitatively, were performed, generating a correspondence map for the variable "keyword".
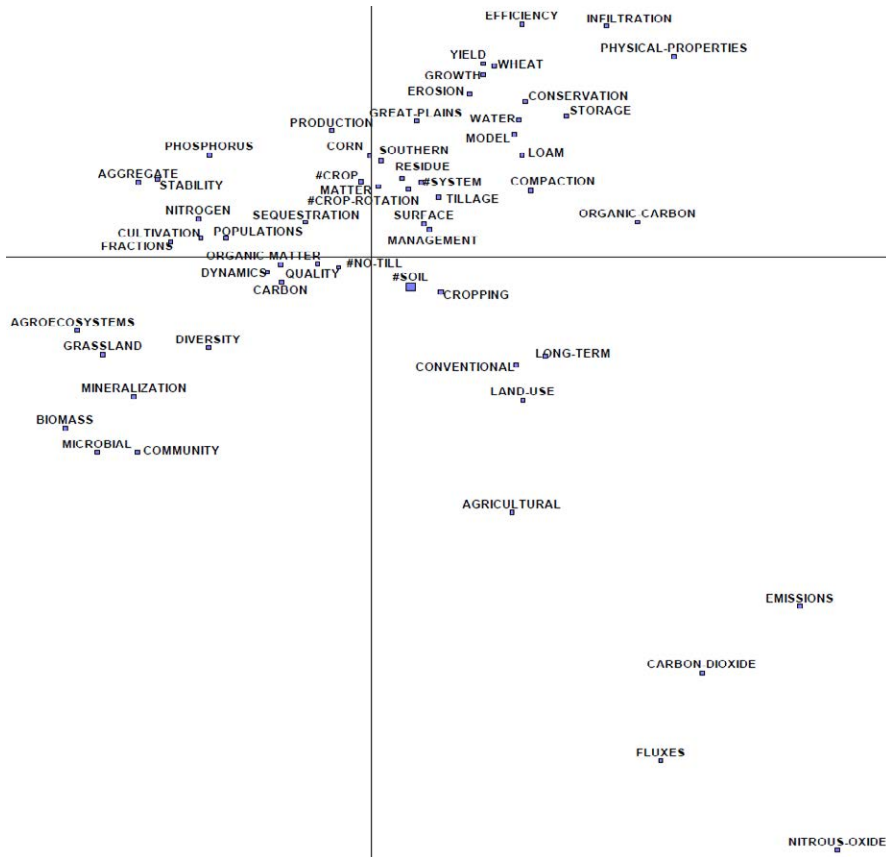
Figure 3. Multiple correspondence analysis of the variable "keyword"

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

Chart 3 contains a summary of the results observed in the analysis of this variable.

Chart 3. Summary of the results of the multiple correspondence analysis for the variable "keyword"

Quadrant	Most cited words (number of citations)	Relevant themes
First	Management (119), crop rotation (54), conservation (51), residue (50), yield (35), water (33)	Crop rotation, management, soil conservation
Second	Nitrogen (88), sequestration (54), corn (51)	Carbon sequestration, nitrogen, corn production
Third	No-till (106), organic matter (100), carbon (79), microbial (51)	Organic matter and microorganisms
Fourth	Agricultural (37), emissions (30), carbon dioxide (19)	GHG emissions from agriculture

Source: Search results.

The main themes observed for this variable were GHG emissions, crop rotation, carbon in the soil and fertility for corn production. This variable also showed a new theme: microorganisms in the soil and their relation with organic matter.

The first quadrant of the variable "keyword" analysis contains research themes related to crop rotation, management of NTS, and soil conservation related to this production system. The second quadrant corresponds to research themes related to carbon sequestration and nitrogen in the soil in corn production systems. The third quadrant shows researches related to soil microorganisms and their interaction with organic matter. The last quadrant is related to GHG emissions from agricultural production, mainly carbon dioxide.

As a final result of the analysis, the aggregation of the main research themes on all the three multiple correspondence analyses (of the variables "title", "abstract" and "keyword"), the existence of the three major research groups were detected. These are shown in Figure 4, along with their subgroups.
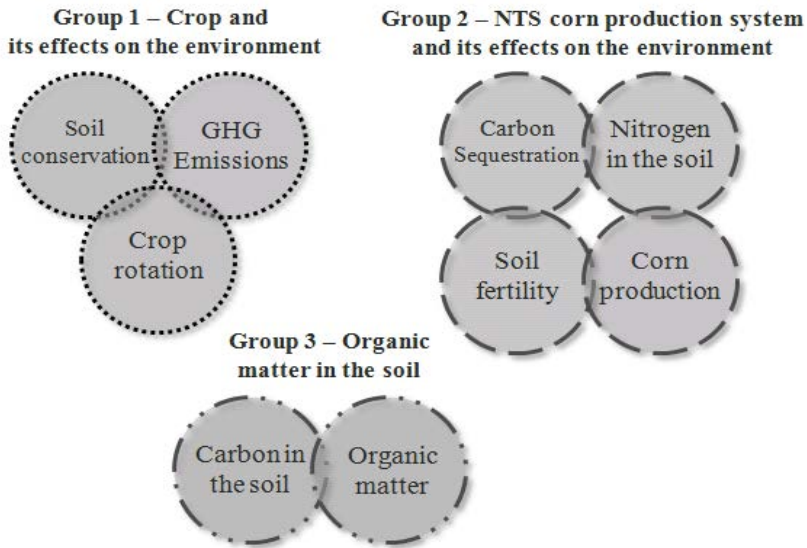
Figure 4. Main research groups and subgroups identified by the analysis
Source: Prepared by the authors based on search results.

The first group is composed of the subgroups "soil conservation", "GHG emissions" and "crop rotation". Hence, it was named "crop rotation and its effects on the environment". Among all the other NTS techniques, the interest in crop rotation, specifically, shows its importance to agricultural production systems that do not use plowing.

The second group, denominated "NTS corn production system and its effects on the environment", considers the different techniques of the NTS system, unlike the first group, but focusing on a specific product: corn. This is due to the high importance of this crop for a variety of reasons: the large area of corn planted in the main countries that use NTS, such as Brazil and USA; the variety of products which use corn as raw material; and its importance as one of the main crops in a crop rotation system. The subgroups of this group are: "carbon sequestration", "nitrogen in the soil", "soil fertility" and "corn production".

The last group, called "organic matter in the soil", is composed of two subgroups: "carbon in the soil" and "organic matter". This group is related to the research of the impact of microorganisms on the soil and the effects of organic matter in the soil, regarding NTS production systems.

4 FINAL CONSIDERATIONS

NTS is observed in this study as a topic that has attracted academic interest in the world in the last years. However, the directions of academic researches related to it have changed in recent years. From an initial assessment of the publications related to no-tillage 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 final considerations allow observing that the multiple correspondence analysis, performed with the most cited words of the titles, abstracts and keywords of the 500 articles selected showed that recent studies have directed their attention to environmental issues, as well as traditional economic issues. The researches were part of three main groups, identified through multiple correspondence analysis: crop rotation and its effects on the environment; NTS corn production system and its effects on the environment; and organic matter in the soil.

The main limitations of this study are related to the limited number of articles selected and the stipulated period of analysis. Even though these weaknesses are present, the methodology used provided interesting and important 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 no-tillage.

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