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OVERVIEW

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# REVISÃO DE LITERATURA

## INSTITUTIONAL LANDMARKS IN BRAZILIAN RESEARCH ON SOIL EROSION: A HISTORICAL OVERVIEW<sup>(1)</sup>

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### SUMMARY

The problem of soil erosion in Brazil has been a focus of agricultural scientific research since the 19<sup>th</sup> century. The aim of this study was to provide a historical overview of the institutional landmarks which gave rise to the first studies in soil erosion and established the foundations of agricultural research in Brazil. The 19<sup>th</sup> century and beginning of the 20<sup>th</sup> century saw the founding of a series of institutions in Brazil, such as Botanical Gardens, executive institutions, research institutes, experimental stations, educational institutions of agricultural sciences, as well as the creation and diversification of scientific journals. These entities, each in its own way, served to foster soil erosion research in Brazil. During the Imperial period (1808-1889), discussions focused on soil degradation and conserving the fertility of agricultural land. During the First Republic (1889-1930), with the founding of various educational institutions and consolidation of research on soil degradation conducted by the Agronomic Institute of Campinas in the State of São Paulo, studies focused on soil depletion, identification of the major factors causing soil erosion and the measures necessary to control it. During the New State period (1930-1945), many soil conservation practices were developed and disseminated to combat erosion and field trials were set up, mainly to measure soil and water losses induced by hydric erosion. During the Brazilian New Republic (1945-1964), experiments were conducted throughout Brazil, consolidating soil and water conservation as one of the main areas of Soil Science in Brazil. This was followed by scientific conferences on erosion and the institutionalization of post-graduate studies. During the Military Regime (1964-1985), many research and educational institutions were founded, experimental studies intensified, and coincidentally, soil erosion reached alarming levels which led to the development of the no-tillage system.

**Index terms:** historiography, soil conservation, land degradation, soil science.

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## RESUMO: MARCOS INSTITUCIONAIS DA PESQUISA EM EROSÃO DO SOLO NO BRASIL: UMA VISÃO HISTÓRICA

*A percepção do problema da erosão do solo, nas pesquisas brasileiras em ciências agrárias, vem sendo relatada desde o século XIX. Nesse contexto, o objetivo deste trabalho foi realizar uma revisão histórica dos marcos institucionais que fomentaram as pesquisas em erosão do solo no Brasil e deram início às pesquisas agrícolas no país. Ao longo do século XIX e início do século XX, observaram-se a criação de jardins botânicos, instituições executivas, institutos de pesquisa, estações experimentais e instituições de ensino e a elaboração e diversificação de periódicos de comunicação técnico-científica. Esses estabelecimentos atuaram, cada qual a sua maneira, nas pesquisas em erosão do solo no Brasil. No período Imperial (1808-1889), as discussões se concentravam no esgotamento do solo e na manutenção da fertilidade das terras agrícolas. Na Primeira República (1889-1930), com a criação de várias instituições de ensino e com a consolidação do Instituto Agrônomo nas pesquisas sobre a degradação dos solos, os estudos se pautaram na discussão sobre o depauperamento do solo, na identificação dos principais fatores geradores do processo de erosão e nas medidas necessárias para o seu controle. No Estado Novo (1930-1945), foram desenvolvidas e disseminadas inúmeras práticas de conservação do solo para combater a erosão, implantando-se experimentos para medir o volume das perdas, principalmente de terra e água por erosão hídrica. Na República Nova (1945-1964), experimentos foram instalados em praticamente todas as regiões do país. A conservação do solo e a da água se consolidaram como uma das principais áreas da Ciência do Solo no Brasil. Eventos científicos começaram a ser realizados sobre a temática. A pós-graduação foi instituída no país. No Regime Militar (1964-1985), muitas instituições de pesquisa e ensino foram criadas e os trabalhos experimentais foram intensificados. Nesse período, o processo de erosão do solo atingiu patamares alarmantes e o sistema de Plantio Direto foi desenvolvido no país.*

*Termos historiografia, conservação do solo, degradação do solo, ciência do solo.*

## INTRODUCTION

When Brazil was first discovered in 1500, the country's natural resources, including the soil, became the envy of the world. Forests were devastated and the land laid bare for the development of farming and livestock activities, beginning a long process of land exploitation.

As time passed, deforestation (slash and burn) in Brazil and inappropriate soil management practices led to a drop in land fertility, causing and aggravating the problem of soil erosion, especially in the southern and southeastern regions, as intensive farming continued.

Even the development and implementation of new agricultural technologies did not solve the problem of soil erosion. Quite on the contrary, since the incorporation of new agricultural areas with the intensification of farming and livestock activities, soil degradation has increasingly become a concern.

Seeking short-term returns, the inability of producers to recognize conservation land management and soil use as integral and essential to their activities, and the lack of interest on behalf of the government in implementing public policies to encourage soil conservation are in part responsible for the continuation, in many parts of the country, of a cycle that perpetuates soil erosion. Furthermore, changing the habits of a society accustomed to using a natural

resource without taking into account its limitations, and establishing new conventions (soil conservation) is a long and slow process that does not always result in a paradigm shift.

Throughout the history of soil erosion research in Brazil, some facts became milestones in the understanding of the evolution of erosion-related issues. However, few studies have tried to give a historical perspective on this important phenomenon (Barretto et al., 2008, 2009; Farias, 2010; Camargo et al., 2010). Basic questions, such as when and why research on soil erosion in Brazil began, are not satisfactorily answered in the literature.

Agricultural research on soil management and conservation, especially on erosion, has been conducted throughout history. Since the Brazilian agricultural research institutes were founded, a lot has been done, but in order to change the way people think, it is essential to know something about the history of soil erosion.

Outlining the history of soil erosion research provides some perspective on how land use and management have changed, simultaneously transforming the relationship between humans and soil. Moreover, it is clear that throughout history various institutionalized and social spheres (research centers and academic institutions, government and society) have been responsible for this issue. Furthermore, based on the various political systems under which Brazil has developed and is still

developing, we can identify what has been done to foster soil erosion research within each sphere. This involves reviewing the institutional landmarks in the history of Brazilian science, and soil science in particular.

In this context, the aim of this study was to review the major events that provided the incentives to conduct soil erosion research in Brazil and led to agricultural research on a national scale.

### **Beginnings of agricultural research in Brazil: end of the Colonial to the Imperial Period (1808-1889)**

Referring to the historical landmarks in Brazilian science and technology, Motoyama (1985) tells us that in the three centuries following the discovery of Brazil there is no record of any significant event in the development of science and technology in the country. Thus, while countries at the leading edge of scientific and technological development (mainly France and England) were making giant strides, finding niches within the context of the vigorous rise of capitalism at the time, Brazil was marking time under the implacable yoke of its Portuguese colonizers. Thus, quite in line with the colonial characteristics of exploitation, exacerbated by slavery, exploitative short-termism took root in Brazil, while knowledge was divorced from action to mold a rhetorical and literary culture.

Dantes (2005) points out that only at the end of the 18<sup>th</sup> century, when the ideas of the Enlightenment were being disseminated, attempts were made to incorporate scientific practices into the Portuguese colonial policies. Expeditions were sent which not only fulfilled military objectives, but also allowed surveys of the natural resources of Brazil, with the aim of revitalizing colonial exploitation. The mechanisms through which scientific activities were implemented in Brazil included the contracting of illustrious Brazilians to survey mineral resources and set up Botanical Gardens to fuel agricultural production.

Botanical Gardens also played a fundamental role in the colonial policy. In a period in which plants and seeds were of great economic value, these institutions were responsible for collecting plants of interest and conducting agricultural experiments. The Botanic Garden of Rio de Janeiro was by far the most important (Bediaga, 2007; Sanjad, 2010).

During the transition from colonial to imperial Brazil, the Brazilian economy was still rooted in agricultural activities. The agricultural system based on slave labor, extensive farming properties and monoculture, was in serious difficulty (Furtado, 2007). Problems such as the prospect of replacing slave labor with other forms of exploitation (use of foreign immigrants) and the paucity of knowledge meant that farmers at that time suffered heavy losses in production because of the soil-degrading and -depleting land use practices they used. The first Brazilian

producers of sugarcane in the northeast and later the coffee producers in Rio de Janeiro were unfortunately responsible for impoverishing the soil, resulting in a threat to the development and sustainability of farming and livestock activities in the 19<sup>th</sup> century (Rodrigues, 1987a).

A series of problems associated with the degradation of agricultural land and pressure from the rural aristocracy in the 1860s led the imperial government to begin an agricultural revitalization process, setting up the Secretariat for Agriculture, Commerce and Public Works and the Imperial Brazilian Institutes of Agriculture (Dantes, 2005). In this context, the problem of soil erosion formed the backdrop against which the institutional framework for the agrarian sciences was initially set up in Brazil.

The historiography of Brazilian agrarian science begins with the founding of the Botanical Garden of Rio de Janeiro, the Secretaria de Estado dos Negócios da Agricultura, Comércio e Obras Públicas (State Secretariat for Agriculture, Commerce and Public Works), the Imperial Instituto Bahiano de Agricultura - IIBA (Bahia Imperial Institute of Agriculture), the Imperial Instituto Fluminense de Agricultura - IIFA (Fluminense Imperial Institute of Agriculture), the Imperial Instituto Pernambucano de Agricultura - IIPA (Pernambuco Imperial Institute of Agriculture), Imperial Instituto Sergipano de Agricultura - IISA (Sergipe Imperial Institute of Agriculture), Imperial Instituto Rio-grandense de Agricultura - IIRA (Rio Grande do Sul Imperial Institute of Agriculture) and the Imperial Estação Agronômica de Campinas (Campinas Imperial Agronomic Station) (Albuquerque et al., 1986; Trigo & Kaimowitz, 1994). Schools of agriculture and universities also played a leading role in the development and consolidation of agricultural research during the 20<sup>th</sup> century.

### **Botanical Garden of Rio de Janeiro (1808)**

The first institutional landmark in agricultural research in Brazil was the founding of the Botanical Garden of Rio de Janeiro, initially called the *Real Horto* (Royal Horticultural Gardens), on June 13, 1808, by the royal command of Emperor João VI.

As well as serving as a public leisure facility, the garden hosted research work that was fundamental to advance agronomic knowledge in Brazil. In theory, it was a center for studying all scientific issues and technical problems related to agricultural activities, and housed collections of live plants, a herbarium and laboratories for analyzing and researching agronomic and forestry problems (Lavôr, 1983).

### **Imperial Institutes of Agriculture in Brazil**

Although the founding of the Botanical Garden in Rio de Janeiro in 1808 was a first landmark, no significant advances were made during the colonial period and the first few decades of the Empire, at least in comparison with the great strides towards the



institutionalization of science in Europe in the middle of the 19<sup>th</sup> century. Only after the Botanical Gardens had existed for half a century, the first signs of crisis in the mercantile slave-labor economy appeared, as a result of fluctuations in the prices of Brazil's main exports, credit shortage and an acceleration in the trend to abolish slavery. Decrees were enacted to found the initially five Imperial Institutes of Agriculture across Brazil (in Bahia, Rio de Janeiro, Pernambuco, Sergipe and Rio Grande do Sul), aside from the Imperial Estação Agrônômica de Campinas.

The IIBA was founded by Decree n° 2.500 of November 1<sup>st</sup>, 1859, on the occasion of the visit of Emperor Pedro II to Bahia in the same year. This was before the founding of the Imperial Agricultural School of Bahia in 1875, which owes its existence partly to the Imperial Institute and was designed to solve the problems of labor, capital and the technological backwardness of the Brazilian agricultural production, at a time when Brazilian agriculture was in crisis because of a shrinking international market and a consequent drop in the price paid for Brazilian sugar. The institute in Bahia was also charged with introducing agricultural machinery and implements into Brazil and setting up technical commissions to study the permanent or temporary causes of the decline in agriculture. Prizes were awarded as incentives, and efforts made to facilitate the transportation and sale of agricultural produce.

Furthermore, the IIBA was under pressure from the rural aristocracy, the dominant class at the time, alarmed by the crisis which mainly affected the sugarcane plantations in the northeast, the region of most of their investments. Owners of sugar mills in the Reconcavo Basin, which included the Empire itself, alleged that the reason for the deterioration of the sugar plantations was the shortage of rural credit and the deficiencies of the institutions responsible for protecting interests of the sugar sector, in addition to the shortage of technicians and professionals capable of instructing workers in methods established much earlier in other countries.

The IIPA was short-lived. All we know is that a farm had been purchased for experimental work with sugarcane, and possibly an experimental mill. In fact, our knowledge of the IIPA is limited to its founding, by Decrees n° 2.516 and 2.517, of December 23, 1859, and that it failed to actually commence activities.

The IISA was founded by Decree n° 2.521 of January 20, 1860. It represented an attempt to modernize agricultural practices and establish agricultural education facilities in the State of Sergipe. However, it was never effectively brought into action.

The IIRA, founded by Decree n° 2.816 of August 14, 1861, was also never actually instituted.

The IIFA was founded in Rio de Janeiro by Decree n° 1.681 of October 3, 1860. At the first meeting of the Board of Directors which took place one month later,

the possibility of incorporating the Botanical Garden of Rio de Janeiro was discussed, in view of the close connection between the functions of the two institutions. A request was sent to the Emperor who promptly granted permission, provided that one of the main functions of the Botanical Gardens would be conserved: that of providing the population with a leisure facility (Silva, 1870).

Full advantage was taken of the physical infrastructure for the following projects: (a) building of greenhouses to produce seedlings to be distributed to farmers, as well as seed production; (b) introduction of animals of various improved species to develop Brazilian livestock; (c) pilot plots for testing agricultural machinery and equipment; (d) trials and experiments of the main cultivated crops and animal forages; and (e) irrigation trials.

Among the contributions of the IIFA, it is known that projects were developed to introduce and select varieties of cultivated crops, e.g., sugarcane and potato. We also know of trials with native and exotic forage plants, e.g., oats, Neopolitan wheat, and giant and black oats from California, used for superior quality hay. Another interesting research project was a comparative study of the nutrient contents of various grasses, including *Jaraguá*, *Colonião*, *Gordura*, *Angola*, and others, in comparison with alfalfa.

The directives of the IIFA were the selection of animals and improvement of grasslands, aimed at transforming wetlands in the province into exuberant pastures for cattle grazing. It is also worth pointing out that experimental work was carried out on soil fertilization (organic fertilizer) and asexual plant production using cuttings from greenhouse plants. We also have records of experiments aimed at reducing germination times for seeds such as bacuri (*Platonia insignis*).

The main services provided to farmers included the distribution of seeds and cuttings of coffee, cocoa, sugarcane, wheat, sorghum, rice, hops, cotton, and fruit and ornamental plants. The beneficiaries were farmers not alone in Rio de Janeiro, but also in the provinces of São Paulo, Minas Gerais and Paraná. On some weekdays, the IIFA organized training courses on how to use plowshare and harrow and other agricultural implements, which were manufactured in the institute's own workshop and sold to anyone interested. The institute facilities also included a chemistry laboratory for analyzing soils and plants.

Of all the projects implemented by the IIFA, perhaps the most important was the creation of a quarterly periodical, not only providing guidance to farmers but also recording the first results of the scientific work undertaken in Brazil. The first issue of the "*Revista Agrícola do Imperial Instituto Fluminense de Agricultura*" (RAIIFA) was published in September, 1869. It contained various articles and items on farming (soil deterioration in the first issue) and also included a section of general information and

an economics and business section, lists of product prices on the domestic and international markets, notes on exchange rates, and changes in the value of banking shares.

The journal RAIFFA published research reports, technical articles, general news items and technical instructions on crop cultivation and soil and livestock management. Interestingly, these instructions were structured in almost the same way as they are in today's periodicals, covering all aspects of the production system, from soil tillage to harvesting, in some cases with indications of intercropping.

The extent of the crisis in large-scale agricultural investments explains the farmers' concern about the economic aspects, commented on by some authors such as Campos (1884) who discussed the purpose of agriculture in the journal section rural economy. Most issues regularly contained useful clues, explaining the impact of crop losses caused by heavy rains. Furthermore, RAIFFA helped to discredit the prevailing paradigm of constant soil fertility without intervention, by disseminating technical and scientific knowledge, as well as addressing other matters of interest to farmers, with the aim of stimulating the nation's activities of agricultural and livestock production.

### Imperial Agronomic Station of Campinas

Founded in 1887 and with a consolidated organizational structure by 1890, the Imperial Agronomic Station of Campinas was short-lived as an "imperial" institution, subdued to republican state control by the provisions of Decree n° 707 of January 8, 1892, and re-named as Agronomic Institute of Campinas (IAC), a reputable research institution that persist to this day.

The first director was the Austrian chemist, Franz Wilhelm Daffert. His technical and scientific contribution<sup>(5)</sup> included studies on the rural economy, chemical composition and fertilization of coffee, chemical composition of forage grasses, sugarcane fertilization, conservation of corral manure, and the control of leaf-cutting ants and coffee drying.

Of particular interest are the efforts of the institution ever since its inauguration, to inform farmers about the latest research findings and provide a number of services, such as analysis of soil, fertilizers, seeds, forage, raw materials, and of industrial products. The "*Boletim da Estação Agronômica de Campinas*" was published regularly from 1889 and annual reports disseminated from 1888, when its activities began.

Although activities of agriculture and livestock research had been carried out since 1860 when the Imperial Agricultural Institutes were founded in Brazil, it is important to note the pioneering role of

the Agronomic Institute of Campinas (IAC): it was the first institution to publish information of a more scientific nature and systematized studies.

### First schools of agriculture

The Imperial Escola Agrícola da Bahia (Imperial Agricultural School of Bahia) was the first Brazilian school of agriculture, founded by Decree n° 5.957, of June 23, 1875. The imperial period also saw the founding of the Imperial Escola de Medicina Veterinária e de Agricultura Prática (Imperial School of Veterinary Medicine and Practical Agriculture) on December 29, 1883, in Pelotas. However, the educational activities were suspended in 1885 by order of Antônio da Silva Prados, the then State Secretary for Agriculture, Commerce and Public Works. They were resumed in 1887 under a new name, the Liceu de Agronomia, Artes e Ofícios (later named Liceu Rio-Grandense de Agronomia e Veterinária).

### Soil erosion research during the First Republic (1889-1930)

The modernization of the agricultural export economy of Brazil began around the mid-1870s with the gradual introduction of free-market labor to replace slave labor until slavery was finally abolished in 1888 (Cardoso & Faletto, 1975).

The introduction of free-market labor into the coffee economy resulted in greater social division of labor and strengthened regional centers of industrialization that gave rise to towns and cities. Thus, as explained by Furtado (2007), the monetarization of the economy opened up new market perspectives for industrial and consumer goods, including agricultural tools and implements, which had been imported. But it is a mistake to think that the agrarian aristocracy was completely crushed by the new alliance of forces resulting from the Proclamation of the Republic. It is true that, from a political viewpoint, there was concern to supplant representatives of the old regime and break up the institutions associated with them. The Ministry of Agriculture was abolished in 1892 and became a simple administrative agency of the Ministry for Industry, Transport and Public Works. The Imperial Agricultural Institutes suffered the same fate and disappeared or underwent a succession of crises until the first decade of the 20<sup>th</sup> century, when the agrarian oligarchy reasserted its power and gradually reoccupied its predominant position in the power structure, from which it had never been entirely isolated (Rodrigues, 1987b).

The void left by the agricultural institutions was partially filled by the National Agricultural Society, founded in 1897 and based on republican ideals. Modeled on its homonymous French counterpart, it soon took the initiative of creating a periodical ("A

<sup>(5)</sup> For further information, see Camargo et al. (2010).

*Lavoura*”) specialized in agricultural matters, and set up an experimental site on a farm in Jacarepaguá in the State of Rio de Janeiro.

In this period, soil erosion began to be perceived as a question of fertility loss, which could be solved by the use of inputs.

Another landmark event in this period was the founding of schools of agriculture, aimed at qualifying professionals to deal with the problems associated with soil degradation and fertility. The Faculty of Agronomy of the Federal University of Rio Grande do Sul (UFRGS) was founded in 1889; the School of Agriculture “Luiz de Queiroz” (ESALQ) in 1901; the School of Agriculture in Lavras, now Federal University of Lavras (UFLA), in 1908; and, in 1926, the School of Agriculture and Veterinary Medicine (ESAV), now the Federal University of Viçosa (UFV).

As early as 1909, ESALQ created a periodical, “*O Solo*”, whose first few issues contained articles discussing topics related to soil erosion. In 1926, another publication, “*Revista de Agricultura*”, was launched and also published important studies on erosion, including a paper by Mendes (1928) on soil erosion in coffee plantations in the State of São Paulo.

By this time, soil erosion was significantly contributing to the deterioration of coffee plantations in a number of regions of the country, largely because Brazilian coffee production was characterized by nomadism and exploitative agriculture (Marques, 1951a). Since the Brazilian economy of the First Republic was mainly coffee-based, crop-related issues were treated as priority and investments were made to develop techniques of controlling soil erosion, taking the first steps in the direction of a national movement of soil conservation.

### **Soil erosion research under the New State (1930-1945)**

After the Revolution of 1930, an institutional framework was developed for implementing a scientific and technological approach to Brazilian agriculture, when the wealth accumulation pattern of the Brazilian economy changed, with increasing emphasis on domestic industrialization. This was accompanied by shifts in power relations within the dominant social and political groups (Santos, 1989).

According to Carvalho (1992), this heavy industrialization triggered urbanization in Brazil; it increased the food demand, which, together with the continuing need to obtain foreign currency by boosting agricultural exports, resulted in an aggressive governmental policy of modernization of the administrative structures entailing newly created departments, institutes, foundations, and public corporations. In this way, agricultural research was adapted to the new government policy, and new cultivars were developed for the respective soil types.

The Centro Nacional de Ensino e Pesquisas Agrônomicas - CNEPA (National Agronomic Teaching and Research Center) was founded in Rio de Janeiro by Decree nº 982 of December 23, 1938. It was attached to the Ministry of Agriculture and represented a milestone in state interventionism in scientific research. By the CNEPA, agricultural research and experimentation on the one hand, and agronomic education at various levels of specialization on the other, were linked and coordinated by a single administrative body (Rodrigues, 1987c).

Part of the CNEPA were the Escola Nacional de Agronomia (National School of Agronomics), Instituto de Química Agrícola (Institute of Agricultural Chemistry), Instituto de Ecologia Agrícola (Institute of Agricultural Ecology), Instituto de Experimentação Agrícola (Institute of Agricultural Experimentation), Instituto de Óleos (Institute of Oils), Instituto de Fermentação (Institute of Fermentation), Escola Nacional de Veterinária (National School of Veterinary Medicine) and a network of regional Agronomic Institutes. In 1943, CNEPA was restructured to incorporate the Serviço Nacional de Pesquisas Agrônomicas - SNPA (National Agronomic Research Department), set up to coordinate and direct agronomic research in Brazil. SNPA succeeded in consolidating the federal research system by means of centralized administration and regionalized implementation, for which the prevalent interventionist policy of the New State period made way.

In this period of falling coffee production concerns over the problems caused by soil erosion were intensified. Countless publications throughout Brazil contained articles and studies on erosion, alerting about its effects on agricultural land. Some of these studies were published in the “Agricultural Notes” issued by the Agriculture, Industry and Commerce Agency of the State of São Paulo, with titles such as, “Effects of erosion” in 1934; “Land erosion” in 1939; and “Damage caused by soil erosion” in 1941. The journal “*O Solo*” published a paper entitled “Erosion and its effects” by Fonseca Filho (1934).

Another important landmark in raising awareness of soil erosion research was the founding in 1939 of the periodical “*Revista Ceres*”, by ESAV (now Federal University of Viçosa - UFV). In the period from 1939 to 1945, a number of papers on erosion were published, e.g., of Freitas (1940), de Marques (1941, 1943a,b) and Resende (1943).

During this period, Abramides Neto & Borgonovi (1941) published a paper on the importance of terracing for erosion control, further consolidating the approach of soil conservation in Brazil. Furthermore, it was at this time that João Quintiliano de Avelar Marques began working on soil conservation in Brazil.

Marques (1941, 1943a,b) outlined the approaches of the Soil Conservation Department in the United States and submitted a project proposal for Brazil.



He was also responsible for developing and organizing the first experimental soil and water conservation stations in Brazil.

### **Beginning of experimental soil erosion studies in Brazil (1943)**

The School of Agriculture and Veterinary Medicine (now the Federal University of Viçosa - UFV) was founded in 1942 as an experimental soil conservation station (Marques, 1943b) and housed the first floodwater collectors in experimental plots for measuring soil and water losses resulting from hydric erosion.

The Soil Conservation Section of the IAC was founded in 1943. Throughout the 1940s, over 40 experimental plots were set up in the municipalities of Campinas, Pindorama, Mococa, and Ribeirão Preto to assess the impacts of erosion (Marques, 1951b).

In addition, the Soil Conservation, Irrigation and Drainage Division of the State of Minas Gerais set up experimental plots in the Forest Gardens of Belo Horizonte. During the same period, encouraged by the Ministry of Agriculture, the state authorities in Minas Gerais set up erosion plots at experimental stations in Sete Lagoas, Água Limpa and Lavras.

Experimental plots with collectors to monitor eroded material were also installed under private initiative in Pesqueiro, State of Pernambuco.

### **Soil erosion research under the New Republic (1945-1964)**

During this period, two institutions played a decisive role in soil erosion research: the IAC and the National Agronomic Research Department (SNPA). At the IAC, a Soil Conservation Section dealt in detail with the issue, whereas the SNPA set up a Soil Commission.

The Soil Conservation Section of the IAC used the network of experimental stations to gather information on soil and water erosion losses and to develop basic research projects aimed at performing surveys and drafting conservation plans. It became the institution with the greatest track record in soil erosion research, and the only institution to conduct systematic, ongoing research from the 1940s. Its efforts were concentrated on acquiring knowledge of recently-developed conservation practices to control erosion (such as terracing), and farming methods and crop characteristics to help control erosion. Based on these research projects, Marques (1960) estimated that at that time Brazil was losing around 500 million metric tons of soil annually by laminar erosion.

The main studies were published in "*Bragantia*", the IAC's own very influential scientific periodical. It was founded in 1941 and became one of the leading publications in Brazil for soil conservation studies. The papers published during this period presented data of soil and water losses obtained in erosion plots, testing the conservation practices developed at that time (Marques & Bertoni, 1961; Marques et al., 1961).

In the fifties, experimental plots were set up at the School of Agriculture "Luiz de Queiroz" (ESALQ) of the University of São Paulo (USP). Cesar & Manfrinato (1954) used six plots to study the effects of vinasse (waste liquor from sugar production) on soil erosion.

Another decisive institutional landmark in soil erosion research was the founding of the Brazilian Society of Soil Science (SBSC) after the 1<sup>st</sup> Brazilian Congress of Soil Science (CBCS), held in Rio de Janeiro on December 20, 1947. In theory, the main activities of the SBSC were to focus on organizing the CBCS congress, as an opportunity to present research findings and debate the main soil-related issues and challenges in Brazil. To improve the dissemination of its guidelines, in 1976 the SBSC founded the "*Boletim Informativo da SBSC*", and in 1977, the "*Revista Brasileira de Ciência do Solo*", which became one of the main publications for soil erosion studies in Brazil.

The sixties saw the establishment of post-graduate courses in agrarian sciences at the UFV and ESALQ. This motivated soil erosion research at some universities with postgraduate programs and the cooperation among these institutions resulted in significant progress of the Brazilian agricultural research.

### **Soil erosion research under The Military Regime (1964-1985)<sup>(6)</sup>**

Capitalism expanded under the Military Regime, fostered by a new wealth accumulation pattern, favoring industry which became the dynamic focus of the economy. During this period, absolute priority was given to manufacturing consumer durables and non-durables (Rodrigues, 1987c).

In rural regions, this industrial production was based on the technology packages of the *Green Revolution*. However, these technological packages encouraged monoculture and intensive soil mechanization, causing farmers to use them inappropriately, accelerating the process of land degradation in Brazil.

As soil erosion worsened during the sixties, seventies and eighties, experimental plots were set up in the Federal District and in the states of Ceará, Mato Grosso do Sul, Paraná, Paraíba, Pernambuco, Rio Grande do Sul and Santa Catarina for conducting research on soil preparation and management practices.

<sup>(6)</sup> From this period onward, since other studies deal directly or indirectly with this subject, such as those of Barretto et al. (2008, 2009), Silva et al. (2009), Farias (2010), Derpsch et al. (2010) and Camargo et al. (2010), we chose a more succinct approach in view of the volume of information available.



According to Barretto et al. (2008), from the end of the seventies onwards, the IAC maintained its substantial institutional influence, but the proportional productivity of other research centers increased, especially of the institutions in southern Brazil, such as the Federal University of Rio Grande do Sul (UFRGS) and the Agricultural Research Institute of Paraná State (IAPAR). The latter finally became the two most representative geographic hubs of Brazilian soil erosion research in terms of the number of papers published.

From 1970 onward, UFRGS consolidated its role as reference center by its increasing productivity and the greatest number of papers published on accelerated soil erosion. In the eighties, two geographic regions became leading in scientific production on accelerated soil erosion. The first was the southeast, represented by the IAC and later by the USP, the “Júlio de Mesquita Filho” State University (UNESP) of São Paulo, and a number of units of the Brazilian Agricultural Research Corporation (Embrapa); the second was the southern region, represented mainly by UFRGS, IAPAR, Federal University of Santa Maria (UFSM) and the State University of Santa Catarina (UDESC), which dominated the publication of Brazilian scientific papers on soil erosion and conservation (Barreto et al., 2009).

This period also saw the first trials of no-tillage farming (direct planting) in Brazil (Borges, 1993; Cardoso, 2003; Landers 2007; Denardin et al., 2008), and in view of the dramatic increase in the damage caused by soil erosion, demonstrating the need to adopt more effective techniques of control, no-tillage became an increasingly popular method among farmers in the seventies, as highlighted by Herbert Bartz (Silva et al., 2009). Research and extension studies were also initiated in this decade.

In the seventies and beginning of the eighties, a significant number of institutions were already carrying out comparative studies on management practices, such as conventional and minimum soil tillage and no-tillage, as well as the use of cover plants, in order to assess the effects of these practices on soil and water losses.

### **Soil erosion research under The New Republic (1985 to the present)**

While on the one hand the scientific and technical advances led to increases in productivity of land, work and capital, on the other, even today, they are also leading to the exhaustion and degradation of the soil by the inappropriate and intensive use of this key natural resource.

From 1985 to the present, a significant number of soil erosion studies have concentrated on comparing conventional tillage, minimum tillage and no-tillage (direct planting) systems. The findings supported the use of no-tillage as an effective way of controlling erosion losses, giving rise to the development of

countless public policies aimed at the implementation and expansion of this technique throughout Brazil.

Beginning in the 1990s, there was a drop in the number of research projects analyzing soil, water and nutrient losses by erosion in collection plots under natural rainfall conditions. At many former study sites, these kinds of research project were brought to an end or scaled down, as was the case at the IAC: of the 108 experimental plots existing in the 1940s, only 29 are currently still in use at the Campinas unit.

According to Barreto et al. (2009), work on the Universal Soil Loss Equation (USLE) dominated the papers published during the 1990s and this kind of work is still well-represented even today. In the same period, studies began on other erosion prediction models, such as the Water Erosion Prediction Project (WEPP) and the Cesium 137 method, as well as qualitative methods to determine estimation indices of the amount of erosion.

In the 21<sup>st</sup> century, work related to the environmental, economic, political and social effects of soil erosion has gained importance (Telles et al., 2011, 2013). Based on the findings, the concept of no-tillage has been expanded and now incorporates the sowing and harvest processes, intended to minimize or eliminate altogether the interval between these two activities, thus increasing the number of annual harvests, building up and/or maintaining soil fertility and controlling the effects of soil erosion in increasingly effective ways. This has provided the basis for the current view of the no-tillage system as a tool of soil conservation (Denardin et al., 2011).

Thus, given the current state of soil erosion research in Brazil, with its countless experimental findings from various regions of the country, some published, others not, many rather selective and little publicized, our concern should be to bring compile all available information.

Furthermore, one of the great challenges for soil conservation in the 21<sup>st</sup> century is the use of agricultural machinery. In pursuit of greater efficiency, there is a demand for agricultural technologies involving the use of bigger and bigger multifunctional machines. However, when used on terraces, these machines encounter operational obstacles which are removed or pushed aside, with little or no scientific basis that would justify this approach. From an institutional viewpoint, research institutions and the private sector should join forces to better understand the erosion process in light of the challenges this paradigm shift brings with the described changeover to bigger machines with frequent removal of terraces.

Moreover, those involved in soil and water conservation should direct their efforts to introduce and implement public policies related to erosion control, mainly by encouraging the adoption of the no-tillage system. Complementary conservation practices for managing runoff and controlling hydric

erosion should be adopted to bring the Brazilian agriculture increasingly in line with a sustainable development.

## FINAL CONSIDERATIONS

1. During the imperial era, the agrarian sciences focused on the problem of soil erosion and nutrient depletion caused by the lack of knowledge, mainly on the part of sugarcane producers in the northeast and the coffee growers of Rio de Janeiro.

2. Under the First Republic, erosion was treated as a question of fertility loss that could be overcome by inputs.

3. In the New State period, the number of soil erosion research projects increased, driven by the steep decline in the productivity of Brazilian coffee plantation.

4. The New Republic was a period in which a number of experimental stations were set up by agrarian institutions to gather information on soil erosion. The Brazilian Society of Soil Sciences was founded at the end of 1947 during the first national congress held in Rio de Janeiro. The first post-graduate courses in agrarian sciences were established.

5. From 1964 to the end of the Military Regime in 1985, many research institutes were founded and studies intensified, in an attempt to slow down the process of soil erosion in Brazil.

6. The technologies applied to agriculture, whether involving modifications of the cropping or the management systems, constitute a new paradigm for soil conservation.

7. At present, over 70 years since the first experiments and surveys of soil erosion in Brazil, studies on this topic need to push the envelope of the agrarian sciences even further, encompassing other fields of knowledge, such as economics, politics and sociology. Such an interdisciplinary approach could shed light on the various facets of this ever-present global problem, which affects not only soil-related aspects but also various social spheres.

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