REVISÃO DE LITERATURA

BRAZILIAN SOIL SCIENCE: FROM ITS INCEPTION TO THE FUTURE, AND BEYOND[1]

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SUMMARY

The present essay is meant to provide some background on the evolution of the soil science community in Brazil, since its inception, to describe its current situation, and to outline a number of opportunities and challenges facing the discipline in decades to come. The origin of Brazilian agronomy dates back to the beginning of the 19th century as a subdiscipline of botany, and its association with chemistry would later establish it as a science. In the middle of the 19th century, agricultural chemistry was born as a result of this association, leading to the establishment of edaphology, a branch of Soil Science. Another branch of Soil Science, known as pedology, was established as an applied and scientific knowledge in Brazil during the middle of the 20th century. During the same period, the Brazilian Soil Science Society (SBCS) was created, merging the knowledge of both branches and gathering all scientists involved. Twenty years after the SBCS foundation, the creation of Graduate Programs made Brazilian Soil Science enter the modern era, generating crucial knowledge to reach the current levels of agricultural productivity. Part of a community composed of 25 Soil Departments, 15 Graduate Programs and a great number of institutions that promote research and technology transfer, Brazilian soil scientists are responsible for developing solutions for sustainable development, by generating, adapting and transferring technology to the benefit of the country. The knowledge produced by SBCS members has been particularly significant for Brazil to achieve the status of most competitive tropical agriculture in the world. In the future decades, Soil Science will still remain topical in discussions regarding environment care and production of food and fibers, in addition, it will be essential and strategic for certain issues, such as water quality, reducing poverty and development of renewable sources of energy.

Index terms: edaphology, pedology, Brazilian Soil Science Society, retrospective and perspective.

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RESUMO: *A CIÊNCIA DO SOLO BRASILEIRA: DO SEU INÍCIO, AO FUTURO E ALÉM*

A presente revisão tem por objetivo apresentar a evolução da Ciência do Solo brasileira desde seu início, descrevendo sua situação atual e delineando oportunidades e desafios para as próximas décadas. A agronomia surgiu no País como uma subárea da botânica no início do século XIX e se aproximou da química, buscando o status *de ciência. Dessa aproximação surgiu a química agrícola, ainda em meados desse século, dando origem a um dos ramos da Ciência do Solo: a edafologia. O outro ramo da Ciência do Solo (pedologia) consolidou-se como conhecimento científico e foi aplicado no País em meados do século XX. Nesse período foi criada a Sociedade Brasileira de Ciência do Solo, englobando todo o conhecimento dos dois ramos e aglutinando todos os cientistas que trabalhavam na área. Com a criação dos programas de pós-graduação, 20 anos depois de fundada a SBCS, a Ciência do Solo brasileira entrou na era da modernidade, e o conhecimento gerado foi fundamental para que o País atingisse o patamar atual de produtividade agrícola. Com uma comunidade de 25 departamentos de solos, 15 programas de pós-graduação e um grande número de instituições de pesquisa e de transferência de tecnologia, os cientistas de solo viabilizam soluções para o crescimento sustentável, gerando, adaptando e transferindo tecnologias em benefício do País. O solo e o conhecimento gerado pelos membros da SBCS contribuíram significativamente para que o Brasil chegasse à condição de agricultura tropical mais competitiva do planeta. Nas próximas décadas, a Ciência do Solo continuará no centro de discussão para a produção de alimentos, fibras e conservação ambiental, mas também será essencial e estratégica para assuntos como a qualidade da água, o combate à pobreza e a produção de fontes renováveis de energia.*

Termos de indexação: edafologia, pedologia, Sociedade Brasileira de Ciência do Solo, retrospectivas e perspectivas.

INTRODUCTION

"*However, the land of the country is very healthful. The country is so well-favoured that if it were rightly cultivated it would yield everything*" (Pero Vaz de Caminha, 1/05/1500).

The first report on Brazilian lands, written by Cabral's scribe and addressed to king Manuel I of Portugal, mentioned the characteristics of soils in the new colony, and their unlimited potential for crop production. In a certain way, this report also foresaw the role of Brazilian soils in the environment and in providing food to future generations. During the 17 and 18th centuries, various explorers, religious men, and natives also described soil characteristics in a rudimentary way, which Schaefer et al. (1997) has termed "pre-pedology". Partly because of this early focus, Soil Science became rapidly, and still remains to this day, the most important field of agricultural science in Brazil.

Caminha's report about the never-ending fertility of Brazilian soils had a lasting influence until the beginning of the 19th century. Some have argued that it has even caused the lack of support in Brazil for the development of the discipline of agronomy until then (Rodrigues, 1987). By the middle of the 19th century, problems emerged in the production of sugar cane and coffee, which were essential products for the Brazilian economy at that time. To deal with the unfolding crisis, agricultural science and chemistry became closely associated, resulting in the development of agricultural chemistry, and in the onset of research on soil fertility and plant nutrition (Domingues, 1995). Furthermore, the process led to the creation of the Imperial Agricultural Institutes of Bahia (1859) and Rio de Janeiro (1860), later followed by the creation of the Agronomic Stations of Campinas (1887) and Barbacena (1888), as stated in official reports (Brasil, 1888).

After 1889 and the establishment of the republic, soil science became integrated in the curriculum of the new agronomy schools founded at the end of the century, in particular in courses of agriculture, chemistry, and mineralogy. In 1928, the first Soil Department was created in Viçosa, at the Superior School of Agriculture and Veterinary Medicine (currently the Federal University of Viçosa). On the research side, a major event was the creation of the Chemistry Institute (1918), which later became the Agricultural Chemistry Institute in 1934, focusing on fertilizer certification and soil analysis. In 1943, the Institute was subsumed under the National Service of Agronomic Research, while retaining, among others, a section exclusively devoted to soils. This section led to the creation of the Soil Committee, an organization that aimed to map Brazilian soils. In 1947, this Soil Committee organized the first

Brazilian Soil Science Congress, leading to the creation of the Brazilian Soil Science Society (SBCS). The SBCS is now the most important scientific society in the field of agricultural sciences in Brazil, with 63 years of continuous activity and a strong organization. It has members in teaching, research and continuing education institutes, producing the technology and knowledge-base demanded by the most competitive agriculture in the tropics.

The future holds a prominent role for Brazilian soil in what regards production of food, fibers and fuels, water quality, food safety and environmental sustainability. The scientific production of the Brazilian Soil Science Society will assure the knowledge demanded by the primary sector of Brazilian economy. Interestingly, as Soil Science in the USA, England (Baveye et al., 2006), Australia and New Zealand (Harteminck et al., 2008) gives signs of decline, Brazilian Soil Science Society and Soil Science itself experience a very substantial expansion (Baveye et al., 2010).

In this context, this essay is meant to provide some background on the evolution of the soil science community in Brazil, since its inception, to describe its current situation, and to outline a number of opportunities and challenges facing the discipline in decades to come. First, the history of Brazilian Soil Science over the past 200 years is briefly reviewed, highlighting the origins of Science and Soil Science in Brazil, then we describe the current background under which Brazilian soil scientists frame their work, and finally, we try to outline what is in store for the broad community of soil scientists in one of the largest agricultural area of the world.

FROM THE ORIGINS OF SCIENCE TO SOIL SCIENCE

From the discovery of Brazil to the end of the 18th century, there were no signs of the scientific revolution that had occurred earlier in the northern hemisphere, and technological development of Brazil was almost inexistent due to the prevalent social-economic model, based on slavery (Motoyama, 2004). Natural science was predominant, focusing more on observation than science itself. Agriculture research emerged with the construction of botanical gardens, which aimed at the conservation and trade of plant samples, and the development of research dealing with plant maintenance. The first botanical garden was built in Recife, during the Dutch invasion (1630–1654). During the colonization, the first garden built on Portuguese orders was set in Belém, in 1798, shortly followed by the construction of others in Pernambuco and Rio de Janeiro, establishing a Brazilian-Portuguese network. Bediaga (2007) argues that these gardens were part of measures taken to value agriculture by using science, thus diversifying products and improving the economy of the colony.

When the Portuguese court sheltered in Brazil, king John VI (1767-1826) participated in colony improvements. The creation of Real Horto (Botanical Garden of Rio de Janeiro) in 1808, for example, focused not only on leisure, but also on the development of science and agronomy. The structure, also known as "Acclimation Garden", was meant to acclimate plant species brought from the West Indies, especially tea, which Taunay (2001) was very fond of, as stated in the first Brazilian agricultural treatise, published in 1839. In this particular setting, botany was considered a science, and agriculture ("the art of growing"), on the other hand, was considered a component of botanical taxonomy. The role of climate and soils in crops adaptation only became apparent when chemistry was linked to agronomy. As a result, species identification and variety selection (plant science) became part of botany, and agricultural chemistry and fertility (edaphology) became part of agronomy. Despite being separate areas, both sciences were complementary to each other. This interaction became apparent with efforts to grow tea, and with the introduction of botany and agriculture science in the Academy for Physicians and Surgeons in 1814. Friar Leandro do Sacramento was the first chairman of the Agriculture Course established by king John VI in 1812 (Bediaga, 2007).

As the government subsequently lost interest in the identification and selection of exotic species, economic development, with a focus on agriculture, became a priority, leading to the creation of the Agriculture School in the Botanical Gardens of Rio de Janeiro in 1833. Similarly, the creation of new imperial schools and institutes were an attempt to respond to the crisis in the slavery agribusiness model and international advances in agronomy and soil science.

In Europe, the knowledge base relative to agricultural chemistry, soil properties and plant physiology were advancing greatly. Liebig showed the relevance of nutrients and the importance of fertilizer application; Beijerink's experiments showed the effect of nitrogen supply on leguminosae; lime was being used to diminish soil acidity. All of these, among other innovations, illustrated how science and research had the potential to change productivity patterns.

In Brazil, the economy was still the same as during colonization, including a strong reliance on slave labor, and was administered by coffee aristocrats and owners of sugar cane farms. The end of slave trade, soil degradation and lack of fertility, and the decline of international trade forced the oligarchy to demand an action from the court. Inspired by the success of agronomy in Europe, spurred in particular by the creation of Experimental Stations, king Pedro II founded in 1859 the Imperial Agriculture Institutes of Bahia, and a year later other Imperial Institutes in Rio de Janeiro, Pernambuco, Sergipe, and Rio Grande

do Sul. The objective of these research institutes was to test machines and instruments used in cropping practices, and to evaluate more efficient models for soil management (Resende, 2009).

However, only the institutes in Bahia and Rio de Janeiro were built. Heavily influenced by the rural aristocracy, the Institute of Bahia presented a project for the creation of an agriculture school in the Province of Bahia (Brasil, 1860). The Imperial Agricultural School of Bahia was opened in 1877 in São Bento das Lages, and was the first to graduate agronomists in Brazil, in 1880. The curriculum included courses in chemistry and mineralogy in the second year, and also had agricultural chemistry in the third year. In Rio de Janeiro, the Imperial Institute encompassed a Botanical Garden and an Experimental Farm, focused on research and teaching. The pedagogical approach adopted consisted of linking theoretical knowledge with field practice, and research concentrated on the interaction between plants, soil, and climate, in order to maximize crop production (Bediaga, 2010). The experiments were carried out in the farm, where there was a chemistry laboratory for analysis of soils, plants and roots. Nicolau Joaquim Moreira, a physician, naturalist, and head of the Institute, published "Manual de Chimica Agrícola", in 1871, shortly after the publication of Charles F. Hatt's "Geology and Physical Geography of Brazil" (Moreira, 1871).

At that juncture, agronomy started to interact with other sciences, such as chemistry, plant physiology and entomology. Botany, on the other hand, focused on taxonomy. However, these two disciplines still sought scientific *status*, which they earned later, thanks to support and recognition granted by the state and society. This led to the following area of knowledge: agronomy, agricultural chemistry, agricultural meteorology, and forestry, followed by veterinary medicine and animal science (Domingues, 1995).

Twenty years after the creation of the two Imperial Institutes, the empire decided to create two more stations, one in Campinas (1887) and another in Barbacena (1888). The plans for the Imperial Agronomic Station of Barbacena included laboratories for the analysis of soils, fertilizer, water, seeds, and agricultural products, as well as a school of agronomy in the Province of Minas Gerais (Brasil, 1888). The Barbacena station remained a paper creation only, but the Campinas station project was completed by the government of the state of São Paulo. Campinas was a reasonable choice not because it had soil degradation issues, but because of the region's fast development. From the onset, one of the most discussed topics at the Campinas station was whether one should maintain the teaching and research models used in the imperial institutes. Franz Josef Wilhelm Dafert, from Austria, was the first in charge of the station and was opposed to the teaching activities, influenced in this sense by the German model of experimental stations. The teaching issue emerged again when the government ordered the Agronomic Institute of São Paulo to build a school in a farm (São João da Montanha) located in Piracicaba, which was donated by Luiz Vicente de Souza Queiroz. Although Dafert nominated his immediate subordinate, Ernest Lehmann, to administer the farm, the institute did not immediately provide any resources for the creation of the school, so it only happened in 1900, as the Practical Agriculture School of Piracicaba. Dafert focused his attention to research, and was especially interested in gathering knowledge about the nutrients that plants obtained from soils, and the intense fertilization of lands. He also coordinated basic research activities in soil chemistry, and supported the use of fertilizers (Imperial..., 2010).

Apart from this, the Institute also had in 1890 an analytical section for research on soils, plants, organic and inorganic fertilizers, among other areas. During the 1927 reformation, after a period of intense work on coffee, the institute had several attributions, specifically to study: a) several types of soils, and their economic value in the region, b) the use of *Rhizobium leguminosarum* on legume culture, and c) the influence of bacteria on soils and fertilizers, in order to evaluate the relevance of microorganisms to soil fertility and to the decomposition of mineral and organic fertilizers. In 1935, decree Nº. 7.312 reorganized the institute, thus creating the soil section (Imperial..., 2010). This section subsequently provided the first soil surveys in Brazilian history, and in 1941 published a detailed description of the characteristics of 22 types or classes of soil from the State of São Paulo (Moniz, 1981), establishing the beginning of Pedology in Brazil.

In most teaching institutes, the fields of study related to soil science were actually part of broader disciplines. However, the term "soil" was already part of the curriculum of the Taquaryense Agromony School since 1885 (decree Nº 2.028). Specific soil-related disciplines appeared during the first and last stages of the curriculum, as is the case in current agronomy courses. Soil mineralogy and geology were offered in the first year, and courses of soil physics, soil chemistry, soil mechanics, soil liming, and organic fertilization were offered in the last year of the Agronomy program (Escola…, 2010).

An important event at the beginning of the Republic was the creation of the Chemistry Institute in Rio de Janeiro, in 1918, from which would later emanate the Embrapa-Soils, still located in the same original building. Among the initial objectives of the Chemistry Institute, the certification of fertilizers, insecticides, and antifungal drugs are particularly relevant. In 1934, the institute became subordinated to the National Department of Plant Production, changing its name to Agricultural Chemistry Institute and establishing the Section of Soil Chemistry, Mineralogy and Genesis of Soils, under the administration of Fernando Ramos (Faria, 1997).

In 1943, the institute became part of the National Service of Agronomic Research, which had several sections, including a Soil section and an Agriculture Analysis section, headed successively by Luis Osvaldo de Carvalho (1945-1946) and Leandro Vettori (1946-1953). The Soil section became famous, as the Soil Comission and was responsible for soil surveys all around the country and for the elaboration of the Brazilian Soil Maps. To produce these maps, many activities were carried out, including the development of Graduate Programs in Pedology during the 1960s. The interactive soil map of Brazil was published by IBGE in 2003 after half a century of studies (http://mapas.ibge.gov.br/solos/viewer.htm). From the Soil Comission emerged the Pedology and Soil Fertility section, which later became the Pedology Research Center (Embrapa, 1974-1975), the National Service of Soil Survey and Conservation (Embrapa, 1975-1993), and eventually the current Embrapa-Soils (http://www.cnps.embrapa.br/sibcs/index.html). This research center was supported by a number of meetings and field trips for soil correlation and classification (RCCS), organized by the Brazilian Soil Science Society, and it published in 1999 the Brazilian Soil Classification System (SiBCS), with the participation of professors (37) and researchers (34). The last update of the SiBCS, in 2005, defined all 13 soil orders found in Brazil.

From an institutional perspective, the creation of the Brazilian Soil Science Society in 1947 was one of the most significant chapters in the history of soil science in Brazil. This creation is linked to the Fourth Interamerican Conference of Agriculture, in Caracas (1945), when the need of an Interamerican Society of Soil Science was recognized. Participants of the 2nd Pan American Congress of Mining and Geology, held in 1946 in Petropolis, again emphasized the need for a specific venue to gather soil science researchers. The idea was widely discussed in February 1947 at the Fifth Brazilian Congress of Chemistry, in Porto Alegre, where participants scheduled a new meeting for the creation of the Brazilian Soil Science Society. This foundational meeting took place in October 1947, in the conference hall of the Agricultural Chemistry Institute of Rio de Janeiro. By the end of this meeting, the General Assembly had approved the creation of the SBCS. Dr. Alvaro Barcellos Fagundes, a former doctoral student of Professor Selman Waksman, was the first president, and the SBCS was housed in the Agricultural Chemistry Institute until 1975, when the head office moved to the Agronomic Institute of Campinas, where the executive department was created. At the same time, the SBCS launched the Brazilian Journal of Soil Science (1977) and the SBCS Bulletin (1976). In 1997, the head office was moved to its present location in the Department of Soils of the Federal University of Viçosa.

However, the creation of soil science postgraduate schools in the 1960s is what really propelled the Brazilian Soil Science to its current level. The first two courses were created in São Paulo (ESALQ-1964) and Rio Grande do Sul (UFRGS-1965). There are currently 15 master and doctoral degree courses over the country. The knowledge generated in postgraduate programs has allowed Brazilian agriculture to reach high standards of efficiency, income and competition, as well as to become recognized as the most promising tropical agriculture in the world. The following chapter describes the main contributions of Brazilian Soil Science.

BRAZILIAN SOIL SCIENCE

In the early 19th century, Taunay (2001) referred to agronomy as an "inheritor" of botany. Likewise, soil science could be considered an outgrowth of agronomy. As agronomy became dissociated from botany, it established itself as scientific discipline by merging with chemistry. In the process, along with the Imperial Research Institutes, it led to the launching of soil science in Brazil in the middle of the 19th century. At first, the discipline of soil science shared the same focus on fertilizers as its counterpart in Europe, seeking ways to restore soil fertility. By the 20th century, it focused on pedology, aiming to survey our renewable resources and to evaluate soils for agricultural use. Nowadays, soil science has broadened its scope, and has several distinct, established sub areas, while remaining the basis for much of the knowledge used in the primary sector of Brazil's economy. The greatest contribution of Brazilian Soil Science on the world scale was the development of the technology that enabled Brazil to develop the largest and most competitive tropical agriculture, and afforded sustainable expansion of agricultural lands. Examples of activities and successes include the viability of Cerrado biome for agricultural purposes, adaptation of genotypes to abiotic stress, nitrogen fixation on grass, technological support for direct seeding, the Brazilian Soil Classification System , control of soil degradation, management of cover crops and forests, and analysis and recommendation of nutrients for local crops, among others (Siqueira et al., 2005).

Soil Science evolved due to advanced theorization of its subdisciplines, specially soil genesis, soil physics, soil chemistry, and soil microbiology, although it also became a very fragmented science, making it harder for knowledge integration and application. It currently faces changes in its core, related to a needed focus on multidisciplinary and pragmatic solutions, and to an expansion from Agricultural Science to Environmental Science, Ecology, Natural Resources and Sociology. It has to use multiple bodies of knowledge in order to deal with the current transdisciplinary challenges (Ceretta et al., 2008).

The evolution of soil science in Brazil was determined by Soil Science Departments, graduate

programs, research and technology transfer institutes, and the Brazilian Soil Science Society. Since the first soil department was created in 1928 in Viçosa, many others followed, and judging by how expansion has occurred so far, new departments are still likely to emerge in the future. Although 64 % of the 25 departments are located in the south and southeast regions, there has been a marked expansion elsewhere as well, since five departments were created in the span of 15 years in the north and central-west regions (Table 1). At present, there are 333 professors who work directly in Soil Science, and are active in teaching in both undergraduate and graduate programs. Brazil has about 300 degree programs that are directly associated with Soil Departments, offering an average of about 1.9 to 4.3 soil courses to more than 40 000 students every year (Table 2).

Soil Science graduate programs in Brazil have been in existence for almost fifty years, and have played key roles in the intense transformations in soil science and agriculture. The training of generations of students and the knowledge produced in departments of soil science stimulated proper uses of soils and water, and could be considered at least partly responsible for the enviable economic position Brazil is enjoying at the moment (Ceretta et al., 2008). Nowadays, the 15 graduate programs are gathered in the south, southeast and northeast regions (Table 3), indicating the urgent need of programs in the north and central-west regions, where deforestation and agricultural production are more intense and demand more attention from soil science research.

Having produced already more than 4 000 theses and dissertations, the existing graduate programs are still expanding. For example, three master and two doctoral programs were created in the last five years. All 15 soil science graduate programs are in public institutions, at either the federal or state levels, and have a total of 235 faculty members. Graduate programs in soil science have provided one of the greatest returns on investment in research carried out in Brazil. This contribution is very likely to increase along with the impact of soil and water on the production of food, fiber, fuel, and environmental quality (Ceretta et al., 2008).

Besides the scientific and technological knowledge developed, Soil Science Graduate Programs are also responsible for more than 95 % of the soil-related publications in scientific journals, produced by public education institutions from the south and southeast regions (Prado, 2008). The author also reported that many of these scientific publications focus on Soil Fertility and Plant Nutrition, with publications in basic areas, such as Soil Genesis and Morphology, Pedology, and Soil Science Teaching lacking somewhat. Brazil has nowadays 387 research groups that work directly in Soil Science, and 534 groups working indirectly with soils, as shown in the National Directory of Research Groups website (http://dgp.cnpq.br/buscaoperacional/). In the last 10 years research has been driven towards environmental areas, focusing on soil management and conservation, biology, soil pollution, and environmental welfare.

Certain institutes engaged in research, technology transfer and other related to soil activities gained notoriety along with time, such as several Embrapa centres, Research State Foundations, Technology Transfer Institutions, Mining Companies, Institutes of Research and Statistics, private corporations and consultants. Currently, there are 65 Agricultural Research Centers, federal and state, most of them involving a team of soil scientists. Even among these institutes, Embrapa-Soils is still particularly relevant, as its origin is linked to the Chemistry Institute and it has 35 years of existence. The institute goals are the development of research solutions, development and innovation in understanding soils and their interaction with the environment, and sustainability of tropical agriculture. Some of the most important activities developed include the ecological-economic zoning, the Brazilian Soil Classification System, soil surveys, proper use of fertilizers, among others.

The Brazilian Society of Soil Science is responsible for congregating professionals and instituitions in order to promote and develop Soil Science in Brazil. Therefore, it is organized in four Divisions (Soil in Space and Time, Soil Properties and Process, Soil Use and Management, Soil-Environment-Society), 14 Comissions (Soil Genesis and Morphology; Soil Survey and Classification; Pedometry; Soil Biology; Soil Physics; Soil Mineralogy; Soil Chemistry; Soil Fertility and Plant Nutrition; Management and Conservation of Soil and Water; Planning and Use of the Land; Pollution, Soil Remediation and Restoration of Degraded Lands; Education and Public Perception of Soils; Soil and Food Safety; History, Epistemology and Sociology of Soil Science), and eight regional units throughout the Brazilian territory, known as State or Regional Nuclei (Figure 1).

In the 2nd article of the SBCS creation statutes, the main objectives of the society are stated as follows: (a) to promote and improve association between partners and exchange of knowledge between those involved in research, education, disclosure or technical activities for a better use of soil and water in Brazil; (b) disseminate the knowledge on scientific methods and applied technologies for use, treatment and conservation of soil and water; (c) adapt and standardize nomenclature, methods of soil analysis, and quality control; (d) contribute to the organization of the Brazilian System of Soils Classification and soil surveys; (f) support the development of Soil Science-specialized libraries, museums, and databases in Soil Science.

In order to achieve these goals, SBCS has been promoting several special events and periodical meetings for exchange of knowledge among members, and disclosure of Soil Science studies. The graphic in figure 2 displays all 32 editions of the Brazilian Congress of Soil Science, showing the number of

Table 1. Main characteristics of the Soil Science and related departments in Brazil

Department	Founded	Local	Institution	Faculty	Number of Soil disciplines (level)	Website
South Region						
Soil	1969	Porto Alegre (RS)	UFRGS	16	10 (Undergraduate); 28 (Graduate)	www6.ufrgs.br/agronomia/novo/index.php?p=principal.php
Rural Engineering and Soil	1969	Florianópolis (SC)	UFSC	11	7 (Undergraduate); 3 (Graduate)	www.enr.cca.ufsc.br/
Soil	1969	Pelotas (RS)	UFPel	11	8 (Undergraduate); 15 (Graduate)	www.ufpel.tche.br/faem/solos/
Soil	1970	Santa Maria (RS)	UFSM	14	11 (Undergraduate); 18 (Graduate)	w3.ufsm.br/solos/
Soils and Natural Resources	1980	Lages (SC)	UDESC	13	17 (Undergraduate); 26 (Graduate)	www2.cav.udesc.br/main.php
Soils and Agriculture Engineering	1985	Curitiba (PR)	UFPR	21	12 (Undergraduate); 22 (Graduate)	www.dsea.ufpr.br/
Soil Science and Agric. Engineering	1992	Ponta Grossa (PR)	UEPG	10	5 (Undergraduate); 6 (Graduate)	www.uepg.br/uepg_departamentos/desolo/
Southwest Region						
Soil	1928	Viçosa (MG)	UFV	25	18 (Undergraduate); 23 (Graduate)	www.dps.ufv.br/
Soil Science	1970	Piracicaba (SP)	ESALQ	21	7 (Undergraduate); 16 (Graduate)	www.solos.esalq.usp.br/
Soil Science	1976	Botucatu (SP)	UNESP	8	23 (Undergraduate); 6 (Graduate)	www.fca.unesp.br/instituicao/departamentos
Soils and Fertilizres	1976	Jaboticabal (SP)	UNESP	11	10 (Undergraduate); 12 (Graduate)	www.fcav.unesp.br/departamentos/solos/index.php
Phytopathology, Rural Eng. And Soil	1993	Ilha Solteira (SP)	UNESP	22	13 (Undergraduate); 8 (Graduate)	www.agr.feis.unesp.br/defers/
Soil Science	1973	Lavras (MG)	UFLA	19	6 (Undergraduate); 21 (Graduate)	www.dcs.ufla.br/
Soil	1974	Seropédica (RJ)	UFRRJ	16	8 (Undergraduate); 33 (Graduate)	www.ufrrj.br/institutos/ia/ds/dsprinci.htm
Soil	1991	Campos (RJ)	UENF	9	6 (Undergraduate); 15 (Graduate)	www.uenf.br/Uenf/Pages/CCTA/Lsol/
Soil	1986	Uberlândia (MG)	UFU	7	8 (Undergraduate); 7 (Graduate)	www.iciag.ufu.br/index.php?id=105
Northwest Region						
Soil Science	1982	Fortaleza (CE)	UFC	12	18 (Undergraduate); 14 (Graduate)	www.solos.ufc.br/
Rural Engineering and Soil	1979	Areias (PB)	UFPB	15	4 (Undergraduate); 20 (Graduate)	www.cca.ufpb.br/Gestao/dser.HTM
Soil and Water Science	1967	Cruz das Almas (BA)	UFRB	14	10 (Undergraduate): 22 (Graduate)	www.ufrb.edu.br/ccaab
Agriculture Engineering and Soil	1967	Teresina (PI)	UFPI	10	4 (Undergraduate); 5 (Graduate)	www.ufpi.br/page.php?pai=86&id=17
Agronomy - Soils	1912	Recife (PE)	UFRPE	15	16 (Undergraduate); 31 (Graduate)	www.ufrpe.br/departamento_ver.php?idConteudo=2
Soils, Water and Energy	1975	Rio Largo (AL)	UFAL	10	5 (Undergraduate); 6 (Graduate)	www.ceca.ufal.br/
North Region						
Soils and Agriculture Engineering	1995	Boa Vista (RR)	UFRR	5	8 (Undergraduate); 4 (Graduate)	www.ufrr.br/institucional/unidades-academicas/cca
Rural Engineering and Soil	1988	Manaus (AM)	UFAM	5	16 (Undergraduate); 6 (Graduate)	http://portal.ufam.edu.br/index.php/unidades-academicas/20-fca
Middle-Western Region						
Soils and Rural Engineering	1992	Cuiabá (MT)	UFMT	11	15 (Undergraduate) ; 6 (Graduate)	http://cpd1.ufmt.br/famev2008/
				333		

Table 2. Characteristics of undergraduate programs related to Soil Science in Brazil

Undergraduate programs	Number of programs	Number of students	Number of soil courses[1]	Hours of soil courses[1]
Bachelor in Science (BSc)				
- Agronomy	149	22 543	4.33	271
- Animal Science	89	11 267	2.04	166
- Foresty	47	5 809	2.56	204
- Agriculture Engineering	20	2 452	2.33	187
Bachelor in Education (BS in Ed)				
- Agriculture	14	1 491	1.89	138
TOTAL	**299**	**43 562**		

[1] Randomly sampled in 10 % of the programs. Source: http://emec.mec.gov.br/.

Table 3. Characteristics of graduate programs in Soil Science in Brazil

Graduate programs	Beginning		Instituition	Professors	Students		Concluded		Post Doc	Website
	MSc	PhD			MSc	PhD	MSc	PhD		
Soils and Plant Nutrition	1964	1970	ESALQ-USP	19	34	50	514	530	5	www.esalq.usp.br/pg/11140.htm
Soil Science	1965	1987	UFRGS	18	28	49	325	107	12	www6.ufrgs.br/agronomia/novo/index.php?
Soil S cience	1970	1970	UFSM	14	46	38	189	32	3	w3.ufsm.br/ppgcs/
Soil Science	1970	1982	UFRRJ	19	40	51	308	139	2	www.ia.ufrrj.br/cpacs/index.php
Soils and Plant Nutrition	1976	1994	UFLA	13	26	46	311	112	6	www.dcs.ufla.br/pgsolos/
Soils and Plant Nutrit ion	1976	-	UFC	15	41	-	194	-	0	www.solos.ufc.br/
Soils and Plant Nutrition	1977	1982	UFV	20	38	61	382	191	7	www.possolos.ufv.br/
Soil Science	1977	2003	UFRPE	15	23	28	161	22	4	www.pgs.ufrpe.br/
Soil and Water Management	1977	-	UFPA	18	32	-	156	-	5	www.cca.ufpb.br/pgmsa/index.html
Soil Science	1978	-	UFPR	18	36	-	269	-	3	www.pgcisolo.agrarias.ufpr.br/
Soil Science	1996	2005	UNESP	19	45	54	100	8	0	www.fcav.unesp.br/cienciadosolo/
Soil Management	1997	2008	UDESC	15	32	28	161	-	1	http://manejodosolo.cav.udesc.br/
Soil Science	2008	-	UFERSA	15	21	-	-	-	0	www2.ufersa.edu.br/posgraduacao/solos/
Soils and Plant Nutrition	2009	-	FUFPI	14	21	-	-	-	1	www.ufpi.br/bomjesus/snp/coord.html
Soils and Ecosystem Quality	2009	-	UFRB	15		-	-	-	0	http://www.ufrb.edu.br/pgsolos/
TOTAL				**235**	**471**	**405**	**3 070**	**1 141**	**49**	

Source: www.capes.gov.br/avaliacao/cursos-recomendados-e-reconhecidos.

Figure 1. SBCS headquarter and regional nuclei, Department of Soils and Graduate Programs in Soil Science in Brazil.

participants and papers. In 2007 there were almost 2 500 participants and about 2 700 papers in 2009. Additionally, the SBCS promoted 23 editions of the Brazilian Meeting of soil Fertility and Plant Nutrition, 26 editions of the Management and Conservation of Soil and Water, and six editions of the FertBio (Brazilian Meeting of Fertility and Soil Biology). SBCS is also responsible for the Soil Correlation and Classification Meetings, an event in which pedologists discuss, among other things, how soil genesis, morphology and classification can be used in soil conservation, how it fits in the Brazilian Soil Classification System, and how the system can be improved.

Besides that, the SBCS also publishes the Brazilian Journal of Soil Science since 1977, which is internationally indexed, receiving impact factor since 2004 and being the most important Soil Science publication in Brazil. Finally, the SBCS maintains a substantial number of specialized libraries and museums as a mean for fostering knowledge on Soil Science. Currently, it has about 2 000 members, classified as official, inactive, foreign, honorary and students. In 63 years of activity, SBCS has been responsible for deep changes in the productivity of Brazilian agriculture and cattle raising, thanks to researches and studies produced by its associates in several national and international institutions.

THE FUTURE OF OUR FUTURE

Brazilian Soil Science has always focused on healthy and sustainable ways of producing food. However, the importance of soils for the society, for future generations, will be more and more complex, demanding specific solutions for every single new issue that emerges. In future decades, Soil Science will still remain topical in discussions regarding environment care and production of food and fibers. Moreover, it will have a determining role in the resolution of certain issues, such as water quality, poverty and development of renewable sources of energy.

According to various analyses of the world economy, the emerging markets known as the BRICs (Brazil, Russia, India and China) are expected to have the highest economic development in the next 40 years. Currently, these countries have a lower Gross Domestic Product (GDP) than that of their more developed counterparts. However, it is expected that the economic rise of the BRICs will allow it to overpass the economy of the current richest countries of the world, and that the BRICs will become the greatest market of the world, with more than nine billion consumers of food, water and fuel. This perspective also suggests a special role for Brazil, based on its highly competitive agriculture, huge water reserves, and renewable sources of energy (hydropower and biofuels).

In this context, Brazil is supposed to hold a strategic place in food production, since it is the only country among the others from the BRIC that can expand its agricultural space (to an area roughly five times bigger than the current one) (FAO, 2007). Research and development of soils contribute to the improvement of the Brazilian economy, which has agribusiness responsible for almost 40 % of GDP and exportations. Product exportation rises every year, due to the huge boost in production of food and biofuel. Scientific

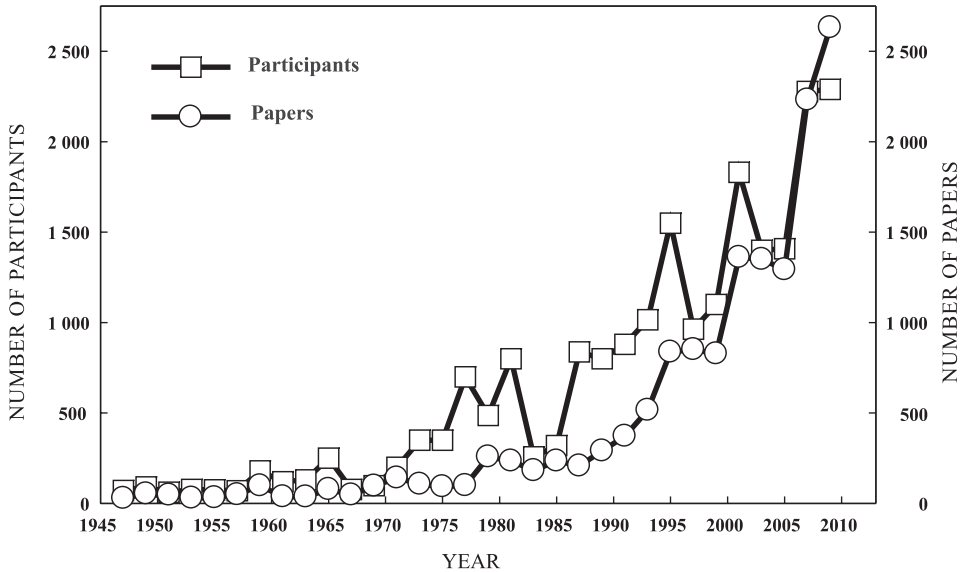

Figure 2. Number of participants and papers in 32 editions of the Brazilian Congress of Soil Science promoted by the SBCS in Brazil (Oliveira, 2007).

progress since the 60s enabled the land occupation of more than 10 M ha in Cerrado. The agricultural area increased by 24 %, while agricultural production increased by 125 % in the same period. The income generated by this productivity increase allowed the maintenance of large ecosystem conservation areas. The agrarian sector in Brazil is effective and competitive due to the wide range of weather conditions, sufficient and seasonal rain falls in most of the territory, abundant solar radiation, and constantly upgraded and advanced technology. An area of 360 Mha of land is used for agrarian activity, although not all is fit for agriculture. An area of 62 Mha is being cultivated, of which 3.6 Mha is irrigated. Additionally, about 200 Mha of land is used as pasture and 5 Mha for forest cultivation (eucalyptus and pine). Moreover, some 29.5 Mha is suitable for irrigated cultivation and 92.4 Mha potentially suitable for agriculture (ECONOMIA BR, 2010; Silva et al., 2010). In these areas, proper management and fertilization could obtain high productivity levels.

The most important agricultural products in Brazil are soybean, corn, coffee, sugarcane, wheat, beans, cotton, sorghum, and fruits. Forest cultivation products such as pine and eucalyptus are equally important, as well as livestock products such as cattle, pork and chicken meat (ECONOMIA BR, 2010). The agribusiness accounts for 33 % of the GDP, 42 % of exportations, and 37 % of employment rates (Silva et al., 2010). Brazil exports more than 150 agricultural products; soybean, meat, sugar, coffee, corn, orange, and tobacco account for 50 % of the total. Brazil is the main producer and exporter of sugar, ethanol, coffee, orange juice, tobacco, chicken and cattle meat, ranks second as producer and exporter of soybean (grain, bran and oil) and third as corn and fruit producer and exporter. Brazil is also an important producer and exporter of cotton, leather and hides (Silva et al., 2010). The eucalyptus plantations cover an area of around 4 Mha, and are 10 times more productive than other market leaders. The trees are used for cellulose, for coal in the metallurgy industry, or for wood and furniture production (ECONOMIA BR, 2010).

According to Siqueira et al. (2005) Soil Science did not make much progress in certain aspects, which should be a research priority, such as: (a) fertilizer technology and alternative sources of nutrients; (b) biological control and organic producing; (c) indicators of quality and sustainability; (d) legal rules for waste (solid and liquid) cycling in soil; (e) soil organic matter and carbon sequestration; (f) critical concentration of micronutrients and metals; (g) inventorying the soil biodiversity; (h) use of water, salinization and irrigation-fertilization; (i) bioremediation and its derivatives as phytoremediation; (j) ecological-economic zoning and environmental impact in ecosystem; (k) ecosystem dynamics and nutrient cycling; e (l) value for environmental soil and ecosystem services.

During the 31th edition of the biannual meeting of the SBCS, after 60 glorious years, the Brazilian Soil Science Society carried out an evaluation of all the challenges related to rising demands of food, water, and energy, as the population keeps growing, not always in harmony with the environment. During the lecture "Challenges of Brazilian Soil Science", Cogo (2007) listed a number of important issues that soil scientists and the SBCS will face in the future. According to him, Brazilian Soil Science must elaborate more concrete goals in order to keep managing soil resources and to improve its public relations. Also, he suggested to rank priorities for soil research, elaborate soil degradation maps, apply research results in agricultural and industrial production, relocate human resources on graduate programs according to regional inequalities, elaborate and apply a solid legislation regarding the management, use and conservation of soil and water, and, finally, instruct citizens, society and government about the importance of soil, as it is an essential, complex and fragile natural resource.

LITERATURE CITED

BAVEYE, P.; JACOBSON, A.R.; ALLAIRE, S.E.; TANDARICH, J.P. & BRYANT, R.B. Whither goes Soil Science in the United States and Canada? Soil Sci., 171:501-518, 2006.

BAVEYE, P.; CAMARGO, F.A.O. & POSS, R. The discipline of Soil Science is not doing too badly under different skies. Soil Sci., 175:313-314, 2010.

BEDIAGA, B. Conciliar o útil ao agradável e fazer ciência: Jardim Botânico do Rio de janeiro – 1808 a 1860. Hist. Ci. Saúde Mang., 14:1131-1157, 2007.

BEDIAGA, B. O. Jardim Botânico do Rio de Janeiro e as Ciências Agrárias. Ci. Cult., 62:28-32, 2010.

BRASIL. Ministério da Agricultura. Relatório da Repartição dos Negócios da Agricultura, Commercio e Obras Públicas apresentado à Assembléia Geral Legislativa na primeira sessão da décima primeira legislatura pelo respectivo ministro e secretário de Estado Manuel Felizardo de Souza e Mello. Rio de Janeiro, Tip. Laemmert. Available in: <http.//brazil.crl.edu/bsd/bsd/harteness/agricultural.html> Acesso em: maio de 2010. Relatório relativo ao ano de 1860.

BRASIL. Ministério da Agricultura. Relatório da Repartição dos Negócios da Agricultura, Commercio e Obras Públicas apresentado à Assembléia Geral Legislativa na quarta sessão da vigéssima primeira legislatura pelo respectivo ministro e secretário de Estado Manuel Rodrigo Augusto da Silva. Rio de Janeiro, Tip. Laemmert. Available in: <http.//brazil.crl.edu/bsd/bsd/harteness/agricultural.html> Acesso em: maio de 2010. Relatório relativo ao ano de 1888.

CERETTA, C.A.; ANJOS, L.H.C. & SIQUEIRA, J.O. A pós-graduação em ciência do solo no Brasil: Evolução e tendências. R. Bras. Pós Graduação, 5:7-35, 2008.

COGO, N.P. Responsabilidade e competência de execução da ciência do solo brasileira - desafios da ciência do solo brasileira. In: CONGRESSO BRASILEIRO DE CIÊNCIA DO SOLO, 31., Gramado, 2007. Anais...Gramado, SBCS, 2007.

DOMINGUES, H.M.B. Ciência – Um caso de política. As relações entre as ciências naturais e a agricultura no Brasil Império. São Paulo, Universidade de São Paulo, 1995. 336p. (Tese de Doutorado)

ECONOMIA BR. Economia do Brasil.- As exportações brasileiras.- O agronegócio principais produtos. Available in: <http://www.economiabr.defasabr.com/Eco/Eco_exportação_agro_pr...> Acesso em junho, 2010.

ESCOLA de Agricultura e Viticultura de Taquari. Dicionário Histórico-Biográfico das Ciências da Saúde no Brasil (1832-1930) Casa de Oswaldo Cruz – Fiocruz. Available in:<http.//www.dichistoriasaude.coc.fiocruz.br> Acesso em: maio de 2010.

FAO and ECLAC/CEPAL. Opportunities and risks arising from the use of Bioenergy for food security in Latin America. Report. 2007.

FARIA, L.R. Uma ilha de competência: A história do Instituto de Química Agrícola na memória de seus cientistas. Hist.Ci. Saúde Mang., 3:51-74, 1997.

HARTEMINK A.E.; MCBRATNEY, A. & MINASNY, B. Trends in Soil Science education: Looking beyond the number of students, J. Soil Water Conserv., 63:76A-83A, 2008.

IMPERIAL Estação Agronômica de Campinas. Dicionário Histórico-Biográfico das Ciências da Saúde no Brasil (1832-1930) Casa de Oswaldo Cruz – Fiocruz. Available in:< http.//www.dichistoriasaude.coc.fiocruz.br> Acesso em: maio de 2010.

MONIZ, A.C. A história da Pedologia no Brasil. In: FERY, M.G. & SHOZO, M., eds. História das ciências no Brasil. São Paulo, EPU, 1981. v.3. p.73-103.

MOREIRA, N.J. Manual de chimica agricola. Rio de Janeiro, Sociedade Auxiliadora da Indústria Nacional (Brazil). Typ. Industria Nacional de Cotrim & Campos, 1871. 437p.

MOTOYAMA, S. Prelúdio para uma história: Ciência e tecnologia no Brasil. São Paulo, EDUSP, 2004. 518p.

OLIVEIRA, L.B. Sociedade Brasileira de Ciência do Solo – Um olhar sobre sua história. 2.ed. Recife, Edição do Autor, 2007. 195p.

PRADO, R.M. Diagnóstico sobre o conhecimento em Ciência do Solo no Brasil: A produção científica de periódicos de 1988 a 2007. R. Bras. Pós Graduação, 5:303-321, 2008.

RESENDE, J.O. As Origens do ensino da agronomia no Império e suas repercussões no Brasil. In: SIMPÓSIO DOS 150 ANOS DO ENSINO SUPERIOR AGRÍCOLA NO BRASIL, 2009, Cruz das Almas. Palestras. Cruz das Almas, PRPPG, 2009.

RODRIGUES, C.M. Gênese e evolução da pesquisa agropecuária no Brasil: Da instalação da corte portuguesa ao início da República. Cad. Dif. Tecnol., 4:21-38, 1987.

SCHAEFER, C.E.G.R.; SÁ e MELO MARQUES, A.F. & CAMPOS, J.C.F. Origens da pedologia do Brasil: Resenha histórica. Geonomos, 5:1-15, 1997.

SILVA, N.M.G.S.; CESÁRIO, A.V. & CAVALCANTI, I.R. Relevância do Agronegócio para Economia Brasileira Atual. Available in <www.prac.ufpb.br/anais/XEnex/iniciacao/.../ 8CCSADAMT01.pdf-> Acesso em junho, 2010.

SIQUEIRA, J.O.; LIMA, A.S.; BARBERI, A. & SILVA, C.A. Evolução da ciência do solo: A pesquisa e pós-graduação no Brasil. In: CONGRESSO BRASILEIRO DE CIÊNCIA DO SOLO, 30., Recife, 2005. Anais...Recife, SBCS, 2005.

TAUNAY, C.A. Manual do agricultor brasileiro. Re-edição de 1839. São Paulo, Cia das Letras, 2001. 328p.