A LOOK AT SOIL SCIENCE — HISTORICAL DEVELOPMENT AND RECENT ADVANCES

PAUL STEPHANUS FOUCHÉ
B.Sc., D.Sc. Agric. (PRET)

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Mr. Vice-chancellor, members of the senate, honoured guests, ladies and gentlemen -

Seeing that the Department of Soil Science is newly established at this University the object of my address will be, firstly, to introduce the discipline of Soil Science by looking at some historical developments and secondly, to give a short review of recent advances in Soil Science. I shall also propose some guide lines for future developments in Soil Science at this University.

Throughout the ages man has been dependent on soils and to a certain extent good soils have been dependent on man and the use he makes of them. One can see the soil as a natural body which covers the earth and which supplies nutrients, air, water and mechanical support to plants.

In all ages the growth of plants has always interested man. Man enjoys and uses plants because of their beauty and ability to supply fiber and food for himself and his animals. The wuality of soils and plants grown on them often determined man's standart of living. Great civilizations have almost invariably had soils as one of their chief natural resources. But soil destruction or mismanagement was associated with the downfall of some of the same civilizations which good soils had helped to build. In the Euphrates in Tigris valleys of the ancient civilizations the eleaborate irrigation and drainage systems were not maintained. This resulted in the accumulation of harmfull salts and once productive soils became barren and useless. The proud cities which had occupied selected sites in the valleys disintegrated and people migrated elsewhere.

But where did the basic knowledge of Soil Science start?

Farming began about 10 000 BC in the South west of Asia where the soil encourage the growth of wild wheat and barley, and the fore-runners of domestic sheep and goats. The best soils were mainly chosen in fertile valleys. But some races such as the Danubians who lived in central Europe chose the forest soils. They took advantage of the accumulated fertility of the centuries which was stored in the humus on the floor of great oak forests of central Europe. When they arrived in about 5 000 BC in the forests areas these people felled the smaller trees and stripped the bark of larger ones to kill them. A few seasons later when the piles of timber had dried properly, they were set on fire. The ash of these trees, supplied with the humus of the soil, a crude form of fertilization. These people also chose the best drained and most fertile soil, namely, the Loess which originated as windblown dust from the surface of North Europe ice sheets. But eventually lacking the knowledge of fertilization they exhausted the soils reserves and had to move on after 10 to 15 years. However, the Danubian farmers did not move on aimlessly but used some half a dozen sites in rotation making the earth fit for cultivation with the slash-burn technique. After 50 to 60 years they would move back to the first site now covered afresh by Oak trees and undergrowth. The fertility on this site would be partly restored and the trees would be young enough to be felled more easily than the Oaks in the primeval forest. As they spread further westward across central Europe, the

Danubian farmers started to plant and keep more stock and their villages included large fenced enclosures.

Meanwhile other groups of people also ventured across the Mediterranean in primitive sailing vessels. By 4 000 BC there were groups of farmers in Italy, Sicily, Malta and North Africa while others reached Southern France, Eastern Spain and Portugal. About 3 500 BC, farmers from northern France crossed to the British Isles. The first Britons looked for well drained soils which was easy to clear so they settled along the gravel terraces in the river valleys or on chalk and limestone soils of the upland country.

At this time the tools for farming the soil were still primitive and consisted of picks and shovels which were made from wood and flintstone. The first farmers used digging sticks to cultivate the soil but later when the land became more open with fewer tree stumps left, it was necessary to develop a method to dig the soil more thoroughly. An "Ard" was then developed which was a very simple plough, drawn first by human beings and later by oxen.

At this time the great dynasties of Mesopotamia and Egypt started to flourish with their farming based mainly on soil irrigation. The first Egyptians descended at about 5 000 BC from the uplands into the Nile valley. They learnt to sow grain on the banks of the Nile in the silty soil which followed the summer floods. These soils were quite fertile although floods during the rainy seasons were disasterous. The Nile river would sometimes rise too high, causing floods and sometimes, not high enough, for the deposit of the fertile silt. Famine thus resulted. Because of this, the early farmers banded together to build dykes for controlling the floods and also sheds for storing grain in lean years when crops failed. It is also interesting to note that the Egyptians used mud from the Nile river as interior scaffolding for building their temples. The height of the mud was raised as the walls and pillars grew, so that sometimes the whole interior of the building would be filled with mud by the time the roof was laid. Then as the mud floor was gradually lowered, the carving and painting of the temple walls and pillars could be carried out by labourers working from the top downwards.

Parallel to the Egyptians another community began to develop between the Tigris and Euphrates where a broad fertile valley lay and which has the claim of the birthplace of civilization. Here in Mesopotamia the Sumerians, as the Egyptians, farmed on the fertile silt brought down by the rivers during flood times. Dams and canals had to be dug to conserve and carry water used for irrigation. Crop production and cattle breeding remained the main sources of their prosperity and cities started to rise and flourish on the riverside plains. In the time of the Babylonians knowledge of soil irrigation was quite advanced. Clues of this are found in the hanging gardens which were accounted by the Greeks as one of the seven wonders of the world. These gardens existed on a massive arched structure with thick layers of soil on the roof. Water which was pumped from shafts beneath, irrigated the gardens above.

But written scientific knowledge of the soil in these times still remained limited and it is not until the Roman and Greek civilizations that more knowledge was reported. In the year 1240 AD a senator, Petrus Crestentius, collected Roman literature on Agriculture and condensed it into one volume. This book remained popular and was regularly revised giving rise to the standard European teatises of the 16th and 17th centuries. In this book the Roman writers describe a reasonably elaborate system of farming which involved leguminous plants and the use of ashes of sulphur as soil amendments. These evidences suggest that by the time of the early Roman civilization in 100-100 BC, many of the practical principles governing modern agriculture, including soil management, had been discovered and put to use by farmers.

The cultural practices were passed from generation to generation even though farmers were ignorant as to why the practices were necessary. When in the 17th and 18th century intellectual activity was again revived, the stage was set for the application of science to the improvement of agricultural systems including those involving soils. In the 15th century speculation already existed as to the need for nutrients in the soil for plantgrowth. Pallissy of France makes a statement in 1563 that by burning plants on the soil one puts back those salts extracted by the plants from the soil. This was the first scientific statement which formed the base of plant and soil fertility.

From the 17th to the middle 20th century the primary occupation of the soil scientist has been to increase the production of crop plants. Van Helmont (1577-1644), a Flemmish chemist conducted in the beginning of the 17th century the first scientific experiment in soil fertility in which he regarded water as the sole nutrient of plants. He grew a willow tree in 90 kg of soil receiving only rainwater over a period of 5 years. After 5 years the tree showed a weight increase of 75 kg while the weight of the 90 kg of soil decreased with about 60 gram. Van Helmont concluded that this increase of 75 kg of dry matter came primarily from the water since the soil lost no weight at all while producing the tree. Woodward, an English researcher, later on found in 1699 that muddy water produced more plantgrowth than rain water and came to the conclusion that the "fine" soil was the principle of growth. Jethro Tull, an Oxford researcher in 1731, demonstrated the source of plant-nutrition as follows: "It is agreed that all the following materials contribute in some manner to increase the growth of plants, but it is disputed which of them is that very essence of increase, namely, nitre, water, air, fire and the soil".

During 1840 the eminent German chemist, Julius von Liebig, reported findings that crop yields were directly related to the content of minerals in the manures applied to the soil. Liebig's famous report published as "Chemistry in its application to Agriculture and Physiology" in 1840 came like a thunderbolt upon the world of science and opened numerous other investigations. Much of Liebig's findings were confirmed by other English researchers although two erros were pointed out. These were, that the atmosphere was not the main source of nitrogen to plants but in this case the soil, and secondly, salts cannot be fused, prior to application to the soil, but must be applied in an available form for optimum uptake by plants. Further investigations led to the development of acid treated phosphate or superphosphate which is still the main commercial source of phosphorous.

After Liebig, Way discovered in 1856 that nitrates are formed in soils from ammonia containing fertilizers. This was later on proved to be a biological process in the soil by nitro bacteria, called nitrification. In 1860 researchers in the USA also began to show an interest in soil and King of Eisconsin studied the movement and storage of water in soils in relation to root penetration and plantgrowth.

But Liebig's concepts still thoroughly dominated the thinking of soil scientists during the late 19th and early 20th centuries. Furthermore, except for some field testing of crop response much of the research was done in the laboratory and greenhouse. Inadequate attention was given to the variable characteristics of the soil found in the field. In Russia during 1870, Dokuchaev came to the conclusion that soils were natural bodies which had horizontal layers that could be associated with climate, vegetation and underlying soil material.

At this stage Soil Science was already devided in three divisions namely Soil Fertility, Soil Physics and Soil Classification. Following the studies of Wollny in England and Berthelot in France it was found that the soil contained micro-organisms which played a major role in the mineralization of plantfood, especially from organic matter. Thus another division of Soil Science was born namely Soil Microbiology. Van Bemmelen showed that the soil had colloidal properties on which cation exchange of the ions took place and this gave birth to Soil chemistry as an additional division of Soil Sciences.

At the beginning of the 20th century Soil Science was established as a science and this called for more coordination between researchers of this field. In 1924 the International Society of Soil Science was established at a conference in Rome. This led to the forming of six International commissions namely:

Soil Physics
Soil Chemistry
Soil classification
Soil microbiology
Soil Cartography

and the International Soil Science Journal.

From thereon it was decided to hold International conferences every third year. Later on more commissions were added which included Soil fertility, plant nutrition and Soil mineralogy.

Coming nearer to the South African scene a Soil Science Society was established in Southern Africa in 1953 with a membership of 29 Soil

Scientists. Most of the members at that stage were qualified in higher degrees of Soil Science at Universities of Europe or North America. Research programmes in academic departments of Soil Science started to gain momentum and in time a steady flow of graduates and post graduates in Soil Science resulted. Statistics for 1978 showed that since 1953, 173 B.Sc Agric degrees with Soil Science as major subject have been granted in the four established faculties of Agriculture. In addition 40 B.Sc Agric (Hons), 99 M.Sc Agric and 38 PhD and D.Sc degrees in Soil Science were awarded. Today these graduates, many with additional qualifications and experience overseas, constitute the core of Soil teaching staff at our Universities and colleges of Agriculture. Beside these there are also those who play a role in numerous government departments, Research experiment stations, regional constitutions, control boards, private industries such as fertilizer companies, the sugar and citrus industry etc.

With this steady flow of highly qualified Soil Scientists advances in Soil Science naturally took place. When looking at the different divisions of Soil Science one can divide these advances in different categories.

The first being:

Soil Fertility, Plant Nutrition and Soil Chemistry

Since 1955, fertilizer consumption in SOuth Africa has increased from 100 000 ton to 750 000 tone of plantnutrients used annually. The nutrients being mainly N, P + K. As the total crop area did not increase correspondingly one can conclude that this is evidence of more intensive use of fertilizer. Since 1959 the use of Nitrogen fertilizer increased to 450 000 ton, Potassium fertilizer to 150 000 ton and Phosphorous fertilizer to 190 000 ton. These increases were brought about by more intensive farming to produce maximum yields on the soil available. Records show that the yield of a crop such as maize increased from a average of 3 ton/ha to 7 ton/ha in high potential areas the past 20 years.

To this situation the South African Soil Scientists also responded. Elaborate studies by universities and institutions were undertaken in which Soil acidity, Lime requirement, the uptake of nutrients by plants under acid and alkaline soil conditions, diagnostic soil and plant analysis and methods to provide a basis for fertilizer recommendations were some of the most important. When looking at the titles of theses and dissertations one can see that 60 titles dealt with soil fertility and plantnutritional problems.

The Fertilizer Society of South Africa also started to coordinate 15 Soil analysis laboratories in South Africa in which Soil testing methods have been standardized and calibrated against field responses.

One of the problems that was thoroughly studies was soil acidity. At the University of Pretoria 5 graduates did their post degree studies on the uptake of nutritional elements by cross growing on acid soils. At the same time extensive studies on this subject were also made at other universities such as Natal. This all provided a better concept of the problems of crops growing in acid soils such as the Transvaal summer rainfall area and lead to better farming practices and higher crop yeilds. The second division of advance was in *Soil Physics*.

Of the 30 relevant studies at Universities which led to higher degrees in Soil Physics during the period 1953 to 1978, more than the half were concerned with soil-water relationships, irrigation and drainage. Salinity studies, soil structure, compaction and factors affecting root penetration together, accounted for the balance.

Pionering work was done at Pretoria with lysimeter studies while the concept of leaching requirement in the use of brackish water for irrigation, was also undertaken. In the citrus and fruit industries extensive work was also done on irrigation methods and the use of tensiometers, evaporation pans and other soil moisture measuring equipment for predicting irrigation needs.

Studies on soil erosion have also been made and a recent survey showed that crop production has been seriously affected on 12% of our arable land while a further 41% is in danger of moderate damage. Mathematical models of the hydro salt flow systems in the catchment and irrigation areas of the Fish and Sundays river scheme were also formulated by the Research Institute for Soils and irrigation.

The third division of advance took place in *Pedology and Soil classification*.

A first attempt to classify South African Soils was made by Van der Merwe (1914) in his book Soil groups and sub-groups of South Africa. Although having shortcomings this system of classifying South African soils was a worthy beginning. In 1969 the next classification of soils was made by Van der Eyk, Macvicar and De Villiers under the title of "Soils of the Tugela Basin".

After wide ranging pedogenetic studies and surveying of the country by nine co-operaters, the Research Institute for Soils and Irrigation brought out a handbook for Soil classification in 1977 called a Binomial system for S.A.

At the different universities approximately 30 higher degrees were earned for studies in this field which covered soil genesis, soil survey and clay mineralogy.

I have briefly pointed out some major advances in South African Soil Science but the question that now remains is what about the future.

It is natural that in a young developing country such as South Africa with all its nations, the production of food with its fertility aspects should receive priority. The exponential population growth in the world cause tremendous problems in practically all branches of society. There is already a serious shortafe of food in many countries and many peoples greatest fear is hunger. South Africa faces the same problems as the rest of the world

namely a rapid population growth and limited agricultural resources. Fortunately the volume of food production in South Africa kept up with the population growth. Today South Africa is classified under a few countries that exports food which is a remarkable achievement in view of the fact that only 3,3% of the total available agricultural land has a high production potential. But food is becoming of increasing strategic importance in the world and it is essential for SOuth Africa to increase production systematically in order not to become dependant on other countries.

Rising cost of farming is one of the main problems in the agricultural world today. There is still no fool proof scintifically based method by which fertilizer recommendations can be forecast. Taken into consideration the rising cost of fertilizers and the threatening energy cris, there is enough motivation for the soil scientist, also at this university to take another look into the whole matter of soil fertility and plant nutrition, especially in the developing national states.

It is generally know that the South African water supplies are limited and a further need for study to increase the efficiency in the use of irrigation water must be undertaken. At the moment there is still a shortage of Soil physicists to undertake such studies and it is also hoped that the University of the North will contribute its part, in the training of these people.

The quality of the soil is of interest to all agriculturists and non agriculturists. Soil scientists cannot restrict themselves to agriculture alone. They must also play an important role in the planning and development of the environment. Together with civil engineers, ecologists and urban and regional planners, they must make sure that our environment is utilized to the best advantage.

I have attempted to highlight some of the main developments in Soil Science. At the moment SOuth Africa is facing a critical shortage of skilled man-power and this also includes Soil Scientists. It is therefore hoped that the Department of Soil Science at the University of the North will also fulfill its role in supplying this need especially to develop the agricultural potential of the national states in Southern Africa.

Mr. Vice-chancellor, I hereby accept the chair of Soil Science and pledge to serve the University of the North to the best of my ability.

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