Sodic Vertisols in Central Sudan

P. BURINGH

Agricultural University, Wageningen, Netherlands

Large flat areas in Central Sudan are characterized by the occurrence of Vertisols [3, 4], that have been investigated by British (GREEN, JEWITT), Dutch (BLOKHUIS and OCHTMAN [2], German (FINCK [5], PETERS [9]) and Sudanese (RAI) soil scientists. The Gezira and Managil irrigation schemes, in which cotton is the main crop, are well known in this region [5, 6, 11]. Soils of various potential agricultural project areas in Central Sudan, being mainly Vertisols, have been investigated by some consulting firms (Huntings, Ilaco) and by an FAO-Special Fund Group in co-operation with Sudanese soil specialists. I had the opportunity to work for some months with the latter group, mainly studying salinity and alkalinity problems. It was found that in various places sodic Vertisols with a very high ESP (40 to 80%) do occur. The pH of these soils often is above 8.5, but sometimes lower. These soils are non-saline. In the field there are no differences in soil morphology between the sodic Vertisols and the normal Vertisols nearby. There is no argillation and no natric horizon in the sodic Vertisols. In areas, where land is cultivated, cotton (and sometimes wheat) is growing well, and no significant differences in crop growth can be observed. In non-cultivated land no clear differences in natural vegetation occur. The sodic Vertisols can only be detected when samples are analysed in the laboratory.

The Vertisols in Central Sudan are approximately 10,000 years old. They were deposited by the Blue Nile; the material coming from volcanic regions in Ethiopia. The soils can be classified as Chromusterts and Pellusterts [12] occurring in the tropics. The overhead climate is semi-arid and tropical with warm to hot, extremely dry winters and a warm summer (June, July, August) with a very wet tropical climate (rainfall over 100 mm per month). The pedoclimate therefore is characterized by a long warm and dry "dead season" and a short, warm and wet "active season".

During the dead season surface mulching and cracking are the main processes of soil formation, whereas during the active season with a very humid tropical pedoclimate the clays swell, the soils churn and various chemical and biological processes are active. The normal process of soil formation in nearly non-Vertisols is ferrallitization, a common process in the humid tropical regions. This starts with sodic hydrolysis of weatherable minerals, then the leaching of bases and silica followed by the formation of kandoid clays. A similar process is supposed to go on in Vertisols during the active season. However, this process cannot proceed in the normal way, because of the very slow permeability of the surface soils and the impermeability of the lower part of the subsoil. Bases and silica cannot be leached, kandoid clays cannot be formed, and moreover the process of churning gradually brings material from the upper subsoil to the surface. In the surface layer (20 to 30 cm), in which mulching and churning is rather intensive, some leaching is possible. In the subsoil one may expect to find colloidal silica, dehydrated silica gels, various amorphous compounds and bases; probably partly combined with silica. The most soluble compounds gradually may be transported to and accumulated in the lower part of the solum as is the case with soluble salts and gypsum.

An important part of the parent material of the Central Sudan clay soils consists of sodium granite and sodium felspar originating from the volcanic region of Central Ethopia. During the hydrolysis of this material in the active season an appreciable part of the bases will consist of sodium, combined with the non-leached products in the soil system, forming various compounds with colloidal silica and finally with dehydrated silica gels.

The ESP as measured in a soil sample in the laboratory according to the standard method probably does not only indicate the adsorbed sodium of the exchange complex, but also the sodium of various other compounds in the soil systems. The real ESP of the soil may be expected to be much lower, maybe even lower than 10 or 15%, than the calculated ESP. Crops grow well and there is no argillation and no natric horizon. PETERS [9], who studied the alkalinity problem of some Gezira soils, mentioned thin skins of dehydrated silica on micro-aggregates in the subsoil. Similar observations could be made in all high ESP soils, that were studied during the last weeks of my stay in the Sudan after the above hypothesis was developed.

There is often even a slight silica cementation at a depth of 60 or 70 cm, even in some Orthids of the Northern Province.

The precipitation and the length of the active season in Central Sudan increases from Khartoum to the south. There are more spots with sodic Vertisols in the southern part than in the northern part of the Central Sudan clay plain. It also was observed that the ESP, as measured in soil samples, increases with increasing soil depth and that soils with somewhat better internal drainage (Chromusterts) have lower ESP values than soils with very poor internal drainage (Pellusterts).

Another important problem is that the old clay plains in Central Sudan are characterized by smectoide clays, whereas the young alluvial Blue Nile soils and the Nile delta soils in Egypt mainly consist of illite clays. According to BLOKHUIS, OCHTMAN and PETERS [2] the clay of the Plains is a pseudo-chlorite transitional montmorillonite-illite clay. One may expect that the original sediment in Central Sudan was an illite clay, that has been transformed into a montmorillonite clay due to alkaline conditions, the tropical type of soil formation during the active season, and the lack of leaching. As I was not in a position to carry out the necessary laboratory analysis in the Sudan, or to bring some soil samples to the soil laboratories in Wageningen I cannot prove that the hypothesis mentioned above is correct. However, it is strange that extremely high ESP values are obtained, that the soils do not show sodic characteristics and that plant growth is almost normal. It is evident that the present methods of soil analysis leading to the calculation of the ESP are not suited to these "sodic" Vertisols. It is well known that various methods give rather different results [VAN ALPHEN (1)]. However, even with a very big mistake in analysis, the ESP-values of such "sodic"

Vertisols will still be very high. This shows that a method of soil analysis, developed for soils of temperate regions, cannot be used for analysing tropical soils.

My conclusion is, that the "sodic" Vertisols of Central Sudan probably are not sodic at all and that the problems of these soils can only be solved by intensive research and the development of a new and better method for determining ESP. It is suggested that more detailed observations be made on soil peels and thin sections and that the mineralogical composition be studied in connection with soil genesis. Such investigations will reveal typical characteristics of semi-arid tropical Vertisols. I am also convinced that the results will be important for the classification of all soils, which at present belong to the order of Vertisols, because the basis of the present system of classification of these soils is rather weak.

In the past some soil scientists e.g. SCHOKALSKAJA [10] have classified similar soils as mentioned here as solonetz or solonetzic soils. KERPEN, GEWEHR and SCHARPENSEEL [7], however claim that this is not correct for the Central Sudan Vertisols. On the other hand KOVDA [8] believes that various dark coloured steppe and meadow soils (so-called Vertisols) are in fact soda-saline soils. I do not believe that this is true for these typical soils. It is even doubtful — as I stated before — that the sodic Vertisols in Central Sudan are real sodic soils.

References

[1] ALPHEN, J. G. VAN: Some notes on the reclamations of sodic soils. Annual report I.I.L.C. Wageningen. 28—36. 1966.

[2] BLOKHUIS, W. A., OCHTMAN, L. H. J. & PETERS, K. H.: Vertisols in the Gezira and Khashm el Gibra clay plains, Sudan. Trans. 8th Int. Congr. Soil Science. Bucharest. **5**. 591—603. 1964.

[3] D'HOORE, J. L.: La carte des sols d'Afrique au 1 : 5.000.000. Lagos. 1964.

[4] DUDAL, R.: Dark clay soils of tropical and subtropical regions, F.A.O. Rome. p. 20. 1965.

[5] FINCK, A.: Tropische Böden. Springer. Hamburg—Berlin. 1963.

[6] GAITSKELL, A.: Gezira, a story of development of the Sudan. London. 1959.

[7] KERPEN, W., GEWEHR, H. & SCHARPENSEEL, H. W.: Zur Kenntnis der ariden Irrigationsböden des Sudan. Pedologie, (Gent) **10**. 303—323. 1960.

[8] KOVDA, V. A.: Alkaline soda-saline soils. Symposium on sodic soils. Budapest. 1964. Agrokémia és Talajtan. Suppl. **14**. 15—48. 1965.

[9] PETERS, K. H.: An aspect of soil fertility problem in the Gezira. Research Colloquium. Wad Medani (unpublished). 1965.

[10] SCHOKALSKAJA, S. JU.: Die Böden Afrikas. Akad. Verl. Berlin. 1953.

[11] TOTHILL, J. D.: Agriculture in the Sudan. London. 1948.

[12] U. S. Soil Survey Staff: Soil classification system and supplement. Washington. 1960. 1967.