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Introduction

Man has been connected with soils in Algeria since he became a farmer several thousands of years ago. For a long time, knowledge on soil has been especially related to its fertility, irrigation and drainage, liming of acid soils and extension of agriculture to new lands.

The Russian soil scientist Dranitsyne (1915) was among the first researchers who started a scientific study on soils in Algeria. He was one of those who identified, at the beginning of the past century, the red soils, the solonchaks, the rendzinas, the waterlogged soils and, on mountain areas, the podzols. His classification of Algerian soils is still much close to the present one.

C.F Marbut (1923), the American naturalist and soil scientist, follower of Dokuchaev ideas on soil formation, showed the extension of chestnut soils in Algeria. In 1948 Z.Y Chokalskaya, made a synthesis of the knowledge of that time on the soils of Africa in general, and of Algeria in particular. In her monograph, she describes 3 major types of soils: chestnut soils, mountain forest soils (brown and light brown) and brown-red soils. She highlights also the presence of podzols, of saline and alluvial soils.

In the 40's De Villars, studied in detail the soils of Algeria. He was mainly concerned with the pedogenesis of the Grande Kabylie soils and the formation of Vertisols.

One should appreciate the great contribution of I.P Guerassimoc for the study of soils of Algeria. In

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1949, he distinguished the brown forest and maquis soils as a peculiar genetic type. He classified most of chestnut soils of Marbut among the brown and grey-brown soils. In his opinion, calcareous brown soils prevail in the north of the high plateau whereas the grey-brown soils with calcareous crust in the south. He also identified the grey-black soils - or the *touares*.

The scientific study of Algerian soils has developed greatly only after the setting up of the *Bureau des Etudes Scientifiques* on May 15, 1961. J.H. Durand made an important research work on the soils of Algeria and their classification. He distinguished 25 main types of soils and subdivided them into 2 groups: zonal and azonal. Durand recognised the great importance of red soils and classified them separately by subdividing into terra rossa, carbonate red soils, yellow red soils and rubified red soils. He was among the first pedologists to identify podzolic soils developped on non-calcareous permeable rocks and on impermeable silico-aluminate rocks. He established also a map of Algerian soils at the scale 1:500,000 and a map of red soils and crusts.

Scale of studies

Pedological studies were made at different (medium and large) scales. The medium scale studies (1:100,000, and 1:50,000) are generally those that allow determining large units of soils and their major morphological characters. They are generally accompanied by a complete study of natural factors of soil pedogenesis (geomorphology, vegetation, and climate), with specific emphasis on favourable or limiting factors of land management. These types of soil surveys allow establishing soil suitability maps for different crops and provide information in view of land and water development projects. They are very important for any regional management plan (development of the steppe areas, setting up of irrigated schemes, etc).

A large-scale soil map (1:20,000, 1:10,000) often follows the medium scale soil mapping. These types of soil surveys provide useful information for the

suitability of soils for different crops and focus mainly on the following characteristics: texture, structure, soil depth, presence of crust or crusting, salinity, waterlogging, etc. These soil data are used for land and water development projects.

In Algeria, about 5,400,000 ha were studied at scale 1:100,000 and only 38,366 ha at scale 1:10,000. More than one million hectares were surveyed at 1:50,000 scale and 557,358 hectares at the scale of 1:20,000. The Oranic, the Chéliff-Mina and Algiers are the most important surfaces studied at the large and medium scale (1:20,000, 1:50,000). The other regions (Soummanm, Chot-Chergui, Zahrez-Sersou, Hodna and others) are essentially mapped at scale 1:100,000. Within these regions there are areas surveyed at the scale of 1:50,000 and 1:20,000, however they cover quite smaller surfaces (less than 100,000 ha). Out of the 13 regions that constitute Algeria, only in 6 regions some small surface areas were studied at scale 1:10,000. Hydraulic planning of these areas was the main reason for such detailed surveys.

Soil Classification

Soils were studied and classified in Algeria according to the soil classification system used by A.N.R.H., which is based on the French classification. The system is adapted however to the conditions of Algeria and reflects the experience acquired by several soils scientists who worked in Algeria and in North Africa. The major classification units are the class, the sub-class, the group and the sub- group. They are used in generalised studies and for small-scale maps.

Ch Killian., G. Aubert, J. Buolaine., J. Bricheteau , G. Gaucher and P. Dutil were some of the French pedologists who contributed the most to the study of soils before the independence of the country.

Ch. Killian studied especially the red soils. G. Aubert studied calcareous crust soils and salt-affected soils. He prepared also an agro-pedological map at scale 1:20,000 and the map of saline soils of Relizane plain.

J. Boulaine made several research studies on Algerian soils. The most important of them is his impressive monograph: "Study of Chelif plain soils". He also studied the soil forming factors of Relizane plain and Oued Rhiou soils.

G.Gaucher also studied the soils of the plains of Relizane and Oued Rhiou, as well as those of the Sig region. Other pedologists to be mentioned are J. Brichteau who made a draft study of the soils of Tlemcen-Ternni region and P. Dutil who was one of the rare pedologists who dealt with the soils of Aurès and Sahara.

It is to be noticed that during the colonial period, only the large agricultural plains with a high presence of Europeans in the north of the country were pedologically studied. The other regions were simply ignored.

Since the attainment of independence, the institution that succeeded the Service of Scientific Studies - the present *Agence Nationale des Ressources Hydrauliques* (ANRH) - started setting up a detailed inventory for soil resources. Important pedological studies were made between 1963 and 1986. They were carried out by both Algerian pedologists and foreign specialists invited within the framework of co-operation.

These pedological studies have practically covered all the northern plains. In the high plateaux and Saharian Atlas, relatively important surfaces were surveyed and mapped. In the Sahara, soil studies were carried out essentially in the oases and around the wells and the water points.

The total mapped surface area exceeds 7 million hectares. The surface of inventoried soils reaches 6.5 million hectares, of which 1,347,000 hectares are suitable for irrigation and 1,060,000 ha are covered with saline soils.

The lower levels of soil classification include the family, the series, the type and the phase. They allow a more detailed description of the soils and are used in the medium and large-scale mapping

The main classes of soils identified in the pedological studies are:

- Class of row mineral soils
- Class of poorly evolved soils
- Class of calci-magnesic soils
- Class of vertisols
- Class of iso-humic soils
- Class of iron sesquioxide soils
- Class of waterlogged soils
- Class of salt-affected soils

Soil-crop suitability and land capability classes

In all agro-pedological studies performed in Algeria, specific reports that show crop suitability for different types of soils accompany the soil maps. . Crop suitability maps (under dry and/or irrigated farming) are established for groups of crops: cereals and fodder, vegetables, industrial and shrub crops.

The main properties of soils considered for establishing crop suitability maps are: depth, texture, coarse elements, structure, pH, the presence or absence of crust or crusting, active calcium carbonates, waterlogging, and salinity.

Soils are also classified by category according to their suitability for irrigation. They are considered to be suitable on the basis of their chemical, physical and physico-chemical properties (geomorphology, topography, climate, etc), without taking into account water availability (if water is available or not). Five classes are distinguished.

Class 1

This class includes deep soils, of medium to fine texture, well structured and well drained. Topography is regular and slope is irrelevant. These soils

have priority for agricultural development since they do not present major problems or constraints for the cultivation of crops. They are suitable for all the crops grown in Algeria.

Class 2

The soils of this class are generally deep or moderately deep, of medium to fine texture and well structured up to an average soil depth. There may be an impermeable layer (50-60 cm depth) that may cause the formation of a perched water table after introducing irrigation. Topography is regular or slightly undulated with low slopes.

These soils are suitable for major crops, however they posses some restrictions for some of them. They are more specifically favourable to industrial crops. Some minor land management interventions are necessary (stone removal or surface land levelling).

Class 3

This class includes deep or moderately deep soils of medium, fine or very fine texture. Soils are generally well structured down to a given depth and then can exhibit salinity or waterlogging problems once the presence of the watertable reaches approximately 1-meter depth. Topography is regular or moderately undulated and slope can be as high as 5 percent.

These soils should be used for rotational crops. Major reclamation problems are drainage and desalination to be corrected before implementing irrigation projects.

Class 4

The soils of this class have a high variability in soil depth. They are coarse to fine textured and posses poor structure properties. The presence of inclusions within these classes can be also high. Often soils could be salty or waterlogged with the

presence of the watertable at shallow depth. Topography is regular or undulated and the slope can reach up to 10 percent.

This zone is often pedologically heterogeneous, with limited suitability for irrigation, therefore, they should not be included in major land reclamation projects that require drainage, desalinisation, and land levelling improvements for instance. Alternatively, dry farming is more recommended. Crop suitability of these soils is often limited to some cereal, fodder and vegetable crops.

Class 5

This category includes soils that cannot be irrigated for different reasons: urban area, oueds beds, swamps, high steep slope, mountain or uneven area, very high salinity and waterlogging problems, presence of crusts (calcareous or gypseous) at shallow depth, etc.

Major land reclamation works to be carried out for this class are land levelling, stone removal, desalination, drainage, deep ploughing, and establishment of wind breaks.

The development of agriculture in Algeria depends largely on irrigation. However, in defining the most suitable areas for irrigation, soil information and agro-pedological studies are more than necessary. The following are some descriptions for the most important hydrological regions of the country (Régions de Planification Hydraulique R.P.H.).

R.P.H. 1 – Orania

Orania is one of the most pedologically surveyed regions in Algeria. The agro-pedological studies made in this region cover a surface area of 350,000 ha. Soils suitable for irrigation cover 178,374 ha and salt-affected soils cover 44,537 ha.

Pedological studies cover almost all large plains and agricultural valleys of Orania: Valleys of

Tafina Isser (about 10,000 ha at scale 1:20,000), Telagh (40,000 ha at scale 1:50,000), Saida (14,000 ha at scale 1:20,000), Habra (20,000 ha at scale 1:20,000), Sig (10,600 ha at scale 1:50,000) Oran-Arzew (11,600 ha at scale 1:10,000) and plateaux of Abdellys (8,000 ha at scale 1:50,000) and of Mostaganem (26,000 ha at 1:50,000).

R.P.H. 2 Chelief - Mina

Agro-pedological studies in this region comprise 3 main morphological units: Chéliff valley, Mina plain and the coastal plains. They cover a total area of 176,268 ha, of which 96,850 are suited for irrigation and 41,268 ha are salt-affected soils. Most of the studies were carried out at scale 1:20,000 (140,598 ha). Some other 30,000 hectares were mapped at scale 1:100,000 (geo-morphological study of Achaacha plateau) and only 10,700 hectares were surveyed at 150,000 scale (Deurdeur plain, El Attaf and Moyen Chéliff).

The most important morphological unit is certainly Chéliff valley that includes the upper, middle and low Chéliff plains covering 85,000 ha approximately, of which 60,000 hectares consist of irrigated soils.

In Mina plain and its extensions (Sebka Ben Ziane and Guerouaou), soils suitable for irrigation cover an area of 32,392 ha. Coastal plains of Ténès-Cherchell are not very extended. Total surface area of soils suitable for irrigation is less than 3,000 ha.

R.P.H. 3 – Algiers region

In Algiers region, the total area covered by soil surveys is about 313,046 ha, of which 191,358 ha are suitable for irrigation. The main morphological units studied in this region are Mitidja plain, Algiers Sahel, Aribs-Béni-Slimane plain, the valleys of Isser and Sebaou oueds and Ouzera region (Medea).

The studies were mainly made at scale 1:50,000 (305,323 ha) while at scale 1:20,000, were surveyed 89,300 ha and at scale 1:10,000, only 16,183 ha.

The largest study is the one of Mitidja that covers 128,470 ha. It was mapped at scale of 1:50,000 and subsequently repeated at 1:20,000 scale for some small areas (East, West and Centre). The studies of Algiers, Sahel and of Aribs-Béni-Slimane plain cover each a surface of more than 40,000 ha and were surveyed at scale 1:50,000.

R.P.H. 4 –Soummam

The most important study in this region is the one carried out in 1965 by ENERGOPROJECT. It was made at 1:100,000 scale and cover 921,600 hectares, corresponding to the whole watershed of oued Soummam. A part of the watershed (250,000 ha) – the high Sétifiennes plains – was the subject of a geomorphological study at scale 1:100,000. Other parts of the watershed were equally covered by pedological studies at 1:50,000 (El Asnam plain – 4,000 ha, Soumam valley, 23,000 ha, Aïn Zada plain – 32,000, Ftaissa plain – 10,000 ha), and at 1:20,000 scale (low Soummam – 2,000 ha, Tilesdit plain – 4,000 ha) and at 1/10,000 (middle Soummam – 9,000 ha). In total, in this region 32,432 ha irrigable lands were inventoried, from which 10,442 ha are covered with salt-affected soils.

R.P.H. 5 – Constantine

A total area of 139,285 ha of soils was mapped in the Constantine region, of which, 90,166 ha are found suitable for irrigation and 4,782 ha are salt-affected soils. The studies made at 1:100,000 scale amount to a total surface of 83,885 ha (Teleghma plains – 6,640 ha, Merouana – 7,665 ha, Batna – Touffana – 58,680 ha and the watershed of Rhumel -11,000 ha). Only two studies were made at scale 1:50,000 (Bir Chouhada plains – 8,000 ha and Batna El Mahder – 9,200 ha) and at scale 1:10,000 was surveyed the Ain Djasse plain with about 9,300 ha. The remaining part, 8 studies amounting to a total of 28,900 ha, were studied at scale 1:20,000.

R.P.H. 6 Annaba

In this region, 93,873 ha of soils were mapped at different scales, which allowed assessing about 57,327 ha of lands as suitable for irrigation and 11,737 ha of as salt-affected soils. The most important studies are those of Kébir Ouest – Fetzara plains (46,000 ha at scale 1:100,000), West Annaba (6,700 ha at scale 1:50,000), East Annaba (15,000 ha at scale 1:50,000 and 6,000 ha at 1:20,000 scale), low Seybouse (6,500 ha at scale 1:50,000) and Bounamoussa (19,100 ha at 1:50,000 scale) and 5 additional studies of different surfaces at 1:20,000 scale.

R.P.H. 7 – Chott Chergui

This region is mainly pastoral while agriculture is poorly developed and dominated by cereal crops. One important soil survey was made at scale 1:100,000, for the areas of El Biodh (205,820 ha) and of Arbaouets (274,250 ha), which are to be developed for integrated pastoral management. One agro-pedological study at scale 1:50,000 was made for the Synclinal of El Bayadh (85,000 ha) and another one at scale of 1:20,000 for the Ain Skhouna scheme (7,000 ha). These studies allowed identifying 6,982 ha of soils suitable for irrigation and 47,498 ha of saline soils.

R.P.H. 8 Zahrez - Sersou

This region of high plateaux in the north where cereal growing prevails and pastoralism in the south, was studied at different scales that in total cover over 824, 941 hectares. Pedological studies were made at scale 1:100,000 on large areas (Touil and Nahr Ouassel Oueds – 71,000 ha, Sersou plateau – 400,000 ha, Aïn Oussera plain – 50,000 ha, Zahrez-Gharbi basin – 256,000 ha and Maalba-Tisselouine plain – 35,600 ha). The other studies made at scale 1:50,000 cover less than 10,000 ha and those at scale 1:20,000 cover and even less than 1,000 ha.

All these agro-pedological studies allowed identifying about 108,819 ha of soils suitable for irrigation and 32,625 ha of salt- affected soils.

R.P.H. 9 – Chot Hodna

The pedological maps of this semi-desert region cover more than one million hectares, 164,000 of which are classified as soils suitable for irrigation and 269,000 ha are covered by saline soils. Two important studies at scale 1:100,000 cover 910,000 ha (Hodna basin) and 83,000 ha (Bou Saad plain). Two additional pedological studies were performed at 1:50,000 scale (Ksob and Aïn Rich plain – 13,500 ha each) and five soil surveys at scale 1:20,000 covering a total area of 13,580 ha.

R.P.H. 10 – Medjerda – Mellegue

The surface of mapped soils in Medjerda-Mellegue region cover 316,423 ha, of which 127,778 ha are lands suitable for irrigation and 13,887 ha are salt-affected soils. Agro-pedological studies at scale 1:10,000 cover a total surface area of 187,200 ha (Aïn Beida plains – 40,000 ha, Gasses – 20,000 ha, Meskiana – 15,000,ha Morsott – Tebessa – 6,200 ha, and finally the high Constantine plains – 106,000 ha). At 1:50,000 scale, 95,500 ha were mapped (Aïn Hassainia and Sellaoua-Announa – 7,658 ha, Tebessa plains – 42,000 ha, Lutaud Chemora – 40,000 ha). Finally, six studies were made at scale 1:20,000 (49,460 ha in total) and only one at 1:10,000 scale (105 ha).

R.P.H. 11 – Aures – Nementcha (Chott Melhir)

The agro-pedological studies made in this region cover more than 700,000 ha, of which 173,000 ha are suitable for irrigation and 118,000 ha are saline soils.

Aurès-Nementcha region includes two large distinct areas:

Chott Melrhir area, and

Messad area,

In the Chott Melrhir area, the main studies are those of El Outaya plain (33,000 ha at 1:100,000 scale and 4,000 ha at scale of 1:20,000) of Khangat Sini Nadji (64,000 ha at scale 1:100,000) and Zeribet El Oued plains (184,000 ha at 1:100,000 scale).

In Messad area, two important studies were made at 1:100,000 scale: Mekhareg plain (18,000 ha) and Messad Aïn Ibel region (384,000 ha). In Aurès-Nementcha region, some other studies were made at 1:20,000 scale.

R.P.H. 12 – South Atlas

In this region, only two agro-pedological studies were made, i.e. in Brezina plain at scale 1:50,000 (19,110 ha) and at scale 1:20,000 (3,500 ha). They allowed identifying 9,772 hectares of soils suitable for irrigation and 7,543 ha of salt-affected soils.

R.P.H. 13 . Sahara

All the pedological studies made in Sahara are concentrated in its northern part. The total surface area of soils mapped in this region cover more than one million hectares, 110,000 of which are suitable for irrigation and 495,000 ha are salt-affected.

The pedological studies are subdivided in the West, in the Centre and in the East of the northern part of Sahara. In the west, there are studies at 1:50,000 scale for the valleys of Saoura (23,000 ha) and Zousfana (30,000 ha) oueds and at scale 1:20,000 for the Abadla plain (22,000 ha).

In central Sahara, the most important study is the one of Toua Gourara (256,000 ha at 1:100,000 scale). In eastern Sahara, there are four studies at scale 1:100,000 covering a total surface area of 670,000 ha: Rhir Souf oued (250,000 ha), Hassi Mes-

saoud zone (150,000 ha), Gassi Touil area (200,000 ha), and Aïn Amenas Area (70,000 ha). Some other pedological studies, covering small areas were made also at the scales of 1:20,000 and 1:10,000.

Conclusion

Except for the far south, important pedological studies and soil surveys were made in large surface areas throughout Algeria. However, considering the extension of the country and the prospects of agricultural development, this inventory is far from being complete. A final estimation for all the lands of Algeria suitable for dry or irrigated farming is a must for the near future.

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