

Fertility of agricultural soils in the area of Jorf Lasfar (El Jadida-Morocco)

K. Moustarhfer¹, N. Saber¹, H. Mohcine¹, C. Marrakchi²

¹Laboratory of geology of old chain, Department of Geology, Faculty of Sciences Ben M'sik, University Hassan II of Casablanca, Morocco.

²Laboratory of applied geology, geomatics and environment, Department of Geology, Faculty of Sciences Ben M'sik, University Hassan II of Casablanca, Morocco.

Abstract— *The Jorf Lasfar area has known for some decades a remarkable change in lands use. In fact, the installation of the port of Jorf Lasfar, the phosphate complex and an industrial area allowed the invasion of agricultural soils and influenced their fertility. The present work aims to assess the soil fertility through some physico-chemical parameters such as (pH, OM, CaCO₃, Total Nitrogen, phosphorus and potassium); the soil samples were carried out according two horizons [0-2.5cm] and [2.5-10cm] in fifty-three points during two agricultural years 2014 and 2015. The main results indicate that the pH ranges from 7.32 to 8.7; the organic matter content is often higher than 3%. Nutritive elements (Total Nitrogen, phosphorus and potassium) record values that respectively vary from 0.001 to 0.31%, 100.15 to 261.62ppm and 102.36 to 672.17ppm. The high rate of phosphorus is probably due to the excessive use of fertilizers or to the nearby phosphate processing plant.*

Keywords— *Soils fertility, pH, Organic Matter, Nutrients elements, Jorf Lasfar.*

I. INTRODUCTION

Under a Mediterranean climate, Morocco experiences climatic variations which generally translated by inter and intra annual irregular rainfall. Morocco is now the cereals importer while in the beginning of the last century was exporter.

Doukkala region by the quality of its agricultural lands was a suitable area for the production of cereals in a non-irrigated environment but over time we notice a decline in the productivity despite the efforts at widespread mechanization, the use of selected seeds and the recommendations of fertilization [1,2,3] In the area of Jorf Lasfar (coastal Doukkala), lands which are destined for cereal crop experience nowadays a remarkable urban and industrial invasion which influenced in a negative way the cereal yields.

In fact, with climatic constraints added to bad agricultural practices in which the soil fertility is affected by intensive work that caused by the destabilization of the cycles of

principle nutrients (nitrogen, phosphorus and potassium). These essential elements of the development of the plant that are present in the soil [4] allow attributing a fertilising power. However, these mineral elements present in insufficient quantities will influence the optimal crop growth, where the necessity for a rational and reasoned use of agricultural inputs in these elements. The fertilizing potential mainly depends on soil properties and their interactions [5]. [6] In fact, according to these authors, the maintain of the fertilizing potential of a soil is determined by a combination of several parameters, knowing, its structure and texture, the presence of the OM and the dynamics and the availability of minerals from which the main objective of this work is the evaluation of the fertility of agricultural soils of Jorf Lasfar area through the fertilizer nutrients pH, OM, Total Nitrogen, Phosphorus and Potassium.

II. MATERIALS AND METHODS

2.1. Description of the study area:

The study area is part of the Doukkala plain that belongs to the Western Meseta. It is located about 24 km from the Southwest of El Jadida city and about 110 km from Casablanca city. It extends over a length of 22 Km and a width of 15 km, an area of 300 Km². It is bordered to the Northeast by Moulay Abdallah, to the South-West by Sidi Abed and to the North and to the West by the Atlantic Ocean (Fig. 1). The area is characterized by an important demography (850000 habitants, census of 2004). The economic activities are mainly industrials (phosphates, thermal power, metallurgy...) and secondarily agricultural (market gardening, cereal ...).

The climate of the region is semi-arid Mediterranean, characterized by a fresh and humid winter and a hot and dry summer. The annual average temperature is 17.7°C, with a maximum of 21°C and a minimum of 14°C. The annual average rainfall is about 389 mm, the rainiest months are November, December and January, from 68 to 75 mm and the less rainy months are June, July, August and September (Meteorology station of El Jadida). The dominant winds are often oriented South-West to

Northeast. The Jorf Lasfar site is part of the Moroccan Western Meseta (specifically coastal Meseta) characterized by tabular regim of Mesozoic and Cenozoic deposits that overcome angular unconformity the formations of Paleozoic basement affected by the Hercynian orogeny [7].

The study area is characterized by Cenomanian age deposits consist calcareous sandstone rich in shells prints, with the alternation of argillaceous limestone and marl benches. The whole is topped by conglomerates that passelocally to yellow or red sands of Plio-quaternary. The Pliocene and the Quaternary are associated and make large superimposed dunes.

2.1. Sampling of soils and analysis techniques:

A sampling of 53 samples was carried out during two crop years. They have been realized by using an auger on two horizons [0-2.5cm] and [2.5-10cm]. These sampling concerned plots destined for non-irrigated cereal crops (Fig. 1). After a drying in open air for at least 5 days, grinding by using an agate mortar and then sieving through a sieve of 2 mm, we have carried out the following analysis:

The determination of the texture was carried out by the Robinson pipette method at the Agronomy and Veterinary Institute of Rabat. The dosage of nutrients elements TN, P₂O₅ and K₂O were performed at the National Institute of Agricultural Research of Settat (soil fertility and plant nutrition laboratory) and at the Analysis Center at the Department of Geology (Faculty of Sciences Ben M'sik). They focus on the analysis of organic matter by [8], which consists of a cold oxidation of the organic fraction of carbon by potassium dichromate; the pH analysis by the glass electrode in a solution ½ soil / water by the method of [9]; the measurements of calcium carbonates were determined by volumetry according to Bernard's method described by [10]; the electric conductivity was measured by the method of [11]; the phosphore analysis was carried out by the method of [12] wherein the extraction is carried out by sodium hydrogen carbonate to pH = 8.5. This method is based on the formation and reduction of a complex by ortho phosphoric acid and molybdic acid (sky blue coloration); the potassium and the total nitrogen were measured respectively by the method of [13] and [14].

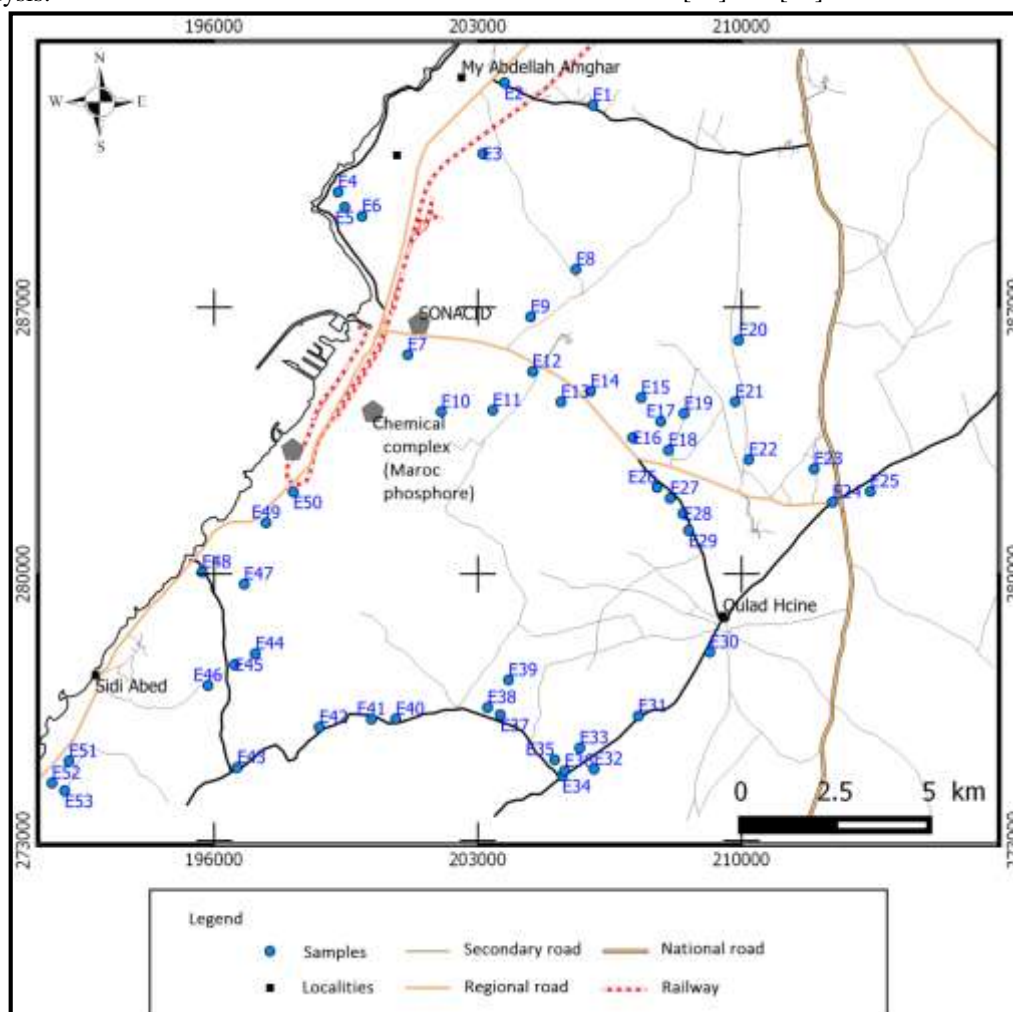


Fig. 1: Location of the sampling points

2.3. Treatment and data analysis:

The statistical analysis was used in order to detect the significant correlations between the different parameters with XLSTAT 2015 software. The spatial variations of the physicochemical parameters of soils are determined based on the geographic information system (GIS).

II. RESULTS AND DISCUSSION

3.1. Physico-chemical characterization:

The textural analysis of the soils studied revealed that the majority of the analyzed agricultural soils are classified among the limono-sandy-clay soils to sandy-clay with a percentage of clay that hardly exceeds 35% and a percentage of sand to approximately 51% (Fig. 2).

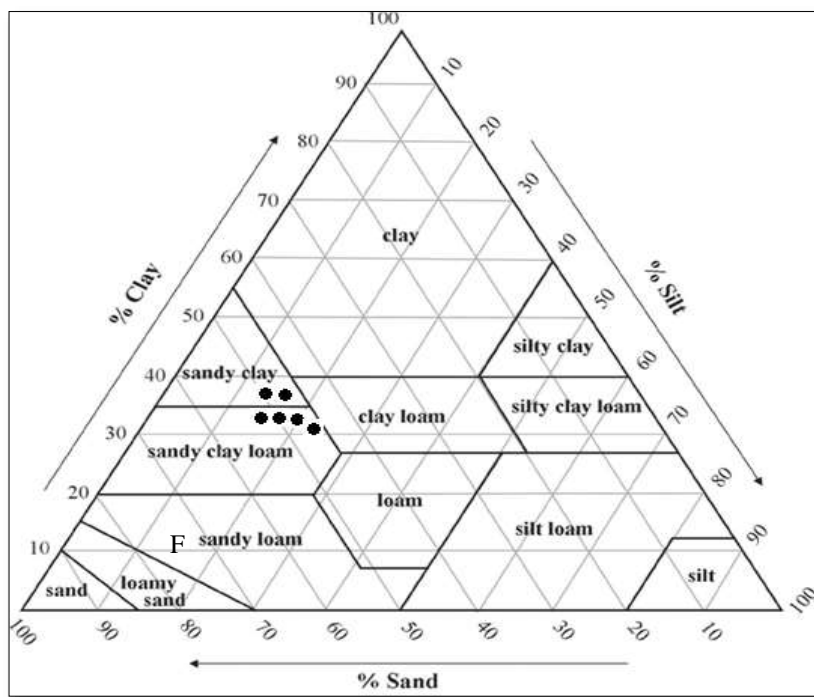


Fig. 2: Particle size classification of soil samples

The tables 1 and 2 present the descriptive statistics of the results of physico-chemical parameters of two horizons [0-2.5cm] and [2.5-10cm].

The pH values show that the majority of soils are moderately alkaline to basic tendency. They vary from 7.32 to 8.52 with a mode around 8.12 for the horizon of the surface and they range from 7.48 to 8.70 with an average of 8.24 for the horizon of depth. The rate of the organic matter is significantly higher in the horizon [2.5-10cm] even in the surface horizon. The contents recorded at this last range from 0.46 to 5.87%, unlike those registered in depth ranging from 0.77 to 6.49%. The CaCO₃ values don't show any significant differences between these two horizons, according to the distribution of limestone rate of the international standard NF ISO 10693 [15], the soils of this region are few to moderately limestone.

The electrical conductivity of the soils sampled do not reveal any significant differences between the two

horizons, it varies respectively from 0.1 to 0.74 mS/cm, (average = 0.24) and from 0.05 to 1.36 mS/cm (average = 0.21) in surface than depth. These values are lower than the agricultural standards cited by [16].

The phosphorus concentrations are variable and range between 104.31 and 261.62ppm for the horizon [0-2.5cm] and between 100.15 and 199.99ppm for the horizon [2.5-10cm]. Following the standards [17], the agricultural soils of the site studied present high phosphorus levels as compared to normal soils and they are higher in surface than depth. The potassium contents are higher in surface (60.1 to 672.17ppm) as those in deep (58.9 to 461.15ppm), according to the classification of [17], the analyzed soils manifest high levels to very high in potassium.

The analyzes revealed very low nitrogen contents, which are of the order of 0.08% in surface and 0.06% in depth. Noting that there was no significant difference between the two horizons [0-2.5cm] and [2.5-10cm].

Table.1: Descriptive statistics of physic-chemical parameters to the horizon surface [0-2.5cm]

	pH	TOM (%)	CaCO ₃ * (%)	EC* (mS/cm)	P ₂ O ₅ (ppm)	K ₂ O (ppm)	TN* (%)
Maximum	8,52	5,87	32,11	0,74	261,62	672,17	0,31
Minimum	7,32	0,46	0,19	0,1	104,31	60,1	0,001
Mean	8,12	2,96	5,24	0,24	177,33	285,61	0,087
Td. deviation	0,21	1,39	7,47	0,13	29,11	145,57	0,077

Table.2: Descriptive statistics of physic-chemical parameters to the horizon of depth [2.5-10cm]

* TOM = Total Organic Matter; EC = Electrical Conductivities; TN = Total Nitrogen.

	pH	TOM (%)	CaCO ₃ * (%)	EC* (mS/cm)	P ₂ O ₅ (ppm)	K ₂ O (ppm)	TN* (%)
Maximum	8,7	6,49	33,94	1,36	199,99	461,15	0,23
Minimum	7,48	0,77	0,16	0,05	100,15	58,9	0,002
Mean	8,24	3,04	5,19	0,21	152,21	189,94	0,06
Td. deviation	0,26	1,41	7,26	0,2	24,64	100,99	0,045

3.2. Spatial variation of physico-chemical parameters:

The spatial distribution maps of different parameters of the two horizons [0-2.5cm] and [2.5-10cm] are reported in the figures (3 to 9).

- **pH:**

According to the pH distribution maps (Fig. 3a and 3b), the pH of the soils studied shows significant spatial variation. It is generally a homogeneous alkaline trend throughout the study area, and those for the two horizons [0-2.5cm] and [2.5-10cm].

The Alkaline trend of these soils may be associated with the chemical composition of the original material (limestone) that plays a role in the valuation of nutrients elements in the rhizosphere. It can also be due to the close relationship between annual rainfall and pH: more the rain is important more the soil is acidic. Remembering that the study area is characterized by a semi-arid climate with low rainfall which would explain in part the pH values found. High pH values were already reported in soils with high content of carbonates [18, 19, 20, and 21].

- **Organic Matter:**

The figure 4 (a and b) shows the spatial distribution of the organic matter in the study area. From this figure, the North zone and the South-West zone are characterized by high contents of organic matter exceeding 3%. However, the Northeast zone and Southeast manifest low contents of OM do not exceed 3%. These results show that the studied soils are fairly rich in organic matter and they are comparable with those found by [22] in the Jorf Lasfar region where the organic matter ranges from 1.9 to 6.54%. These high rates can be related to the role which the type of cereal rotation acts as [23] proposed, where they indicate that the rotation (wheat-wheat) allows a high rate in OM.

- **Calcium carbonates:**

From the figure 5 (a and b), the samples showing the highest contents of calcium carbonates are those located in the North-West and in the South-West of Jorf Lasfar. In fact, the spatial distribution of these concentrations presents a remarkable variability, registered rates at Sebt Ouald Douib are of the order of 1.19 and 0.91% in surface and depth respectively, while those recorded in North-East of Sidi Abed are of the order of 28.8 and 29.08%, as well as those revealed in the North-West of Moulay Abdellah attain 32.11 and 33.94%.

This variability is mainly due to the proximity of the mother rock and sampled horizon where the lithological nature of the rock (limestone Cenomanian) is responsible for high contents of CaCO₃ found. The relative similarity between the horizons [0-2.5cm] and [2.5-10cm] is due, especially to the precipitation of carbonates and to their insolubility in the soil [24]. This can be eventually added to tillage and the crops grown that make soils homogeneous.

- **Electrical Conductivities**

From the figure 6 (a and b), the distribution of the electrical conductivity do not show any remarkable spatial variation across the study site. The East zone and the Southeast zone show the lowest values compared from North to South-West. These results allow to suggest that the soils of the region are not affected by the problem of salinization despite the significant variation of the overall mineralization of groundwater that are not widely used in the irrigation of these soils [22].

- **Phosphorus (P₂O₅):**

The spatial distribution of phosphorus (P₂O₅) of the studied the site presents significant variations in the recorded concentrations (Fig. 7a and 7b). The agricultural

soils of the study area show high contents of P_2O_5 and they are higher in surface than in depth.

The highest concentrations are located in South-West of the industrial area where the P_2O_5 values could reach 261.62ppm and 199.99ppm respectively at surface and at depth. However, the phosphorus contents increase while going away from the phosphate chemical complex, toward South-West (toward Sidi Abed) and decrease toward the North and Northeast. This seems to indicate a probable influence whether to the clearances dust coming from the plant of Morocco Phosphorus III and IV. Knowing that according to climatological studies winds mainly flow from the phosphate industries to Sidi Al Abed. Whether to the massive amount of phosphorus present in the soil that will be probably linked to the richness of mother rock [25] or the excessive use of phosphate fertilizers in these agricultural fields. We can conclude that the most affected sectors match those located in South-West of the phosphate industry complex.

• **Potassium (K_2O):**

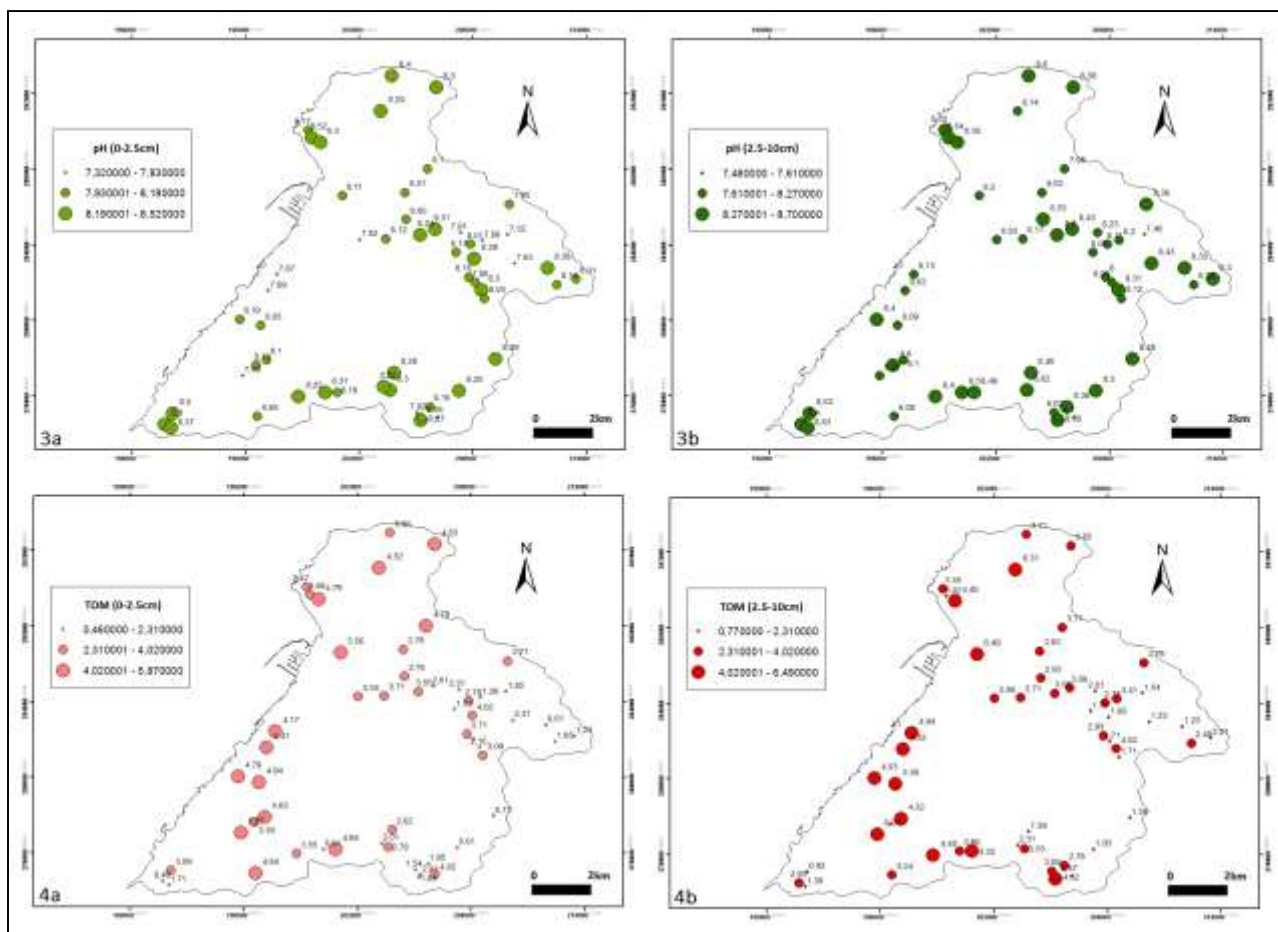
The figure 8 (a and b) show the spatial distribution of the potassium contents of the two horizons. The potassium concentrations are higher in the superficial samples than

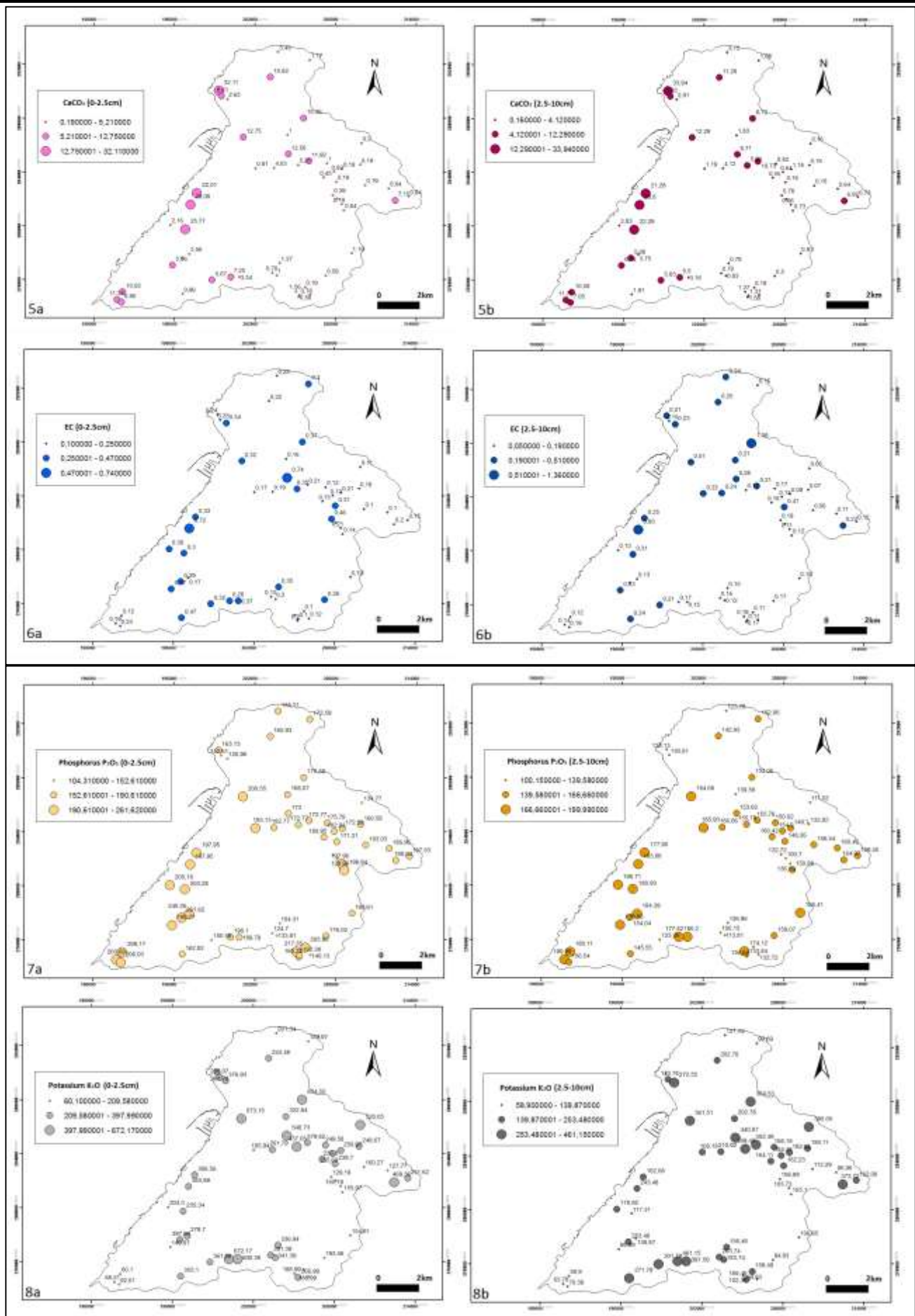
in depth samples. The distribution of these concentrations shows some variability throughout the study area. The potassium values are higher in the Northeast and South-West parts. These concentrations reflect the richness of these soils in this element ($> 100ppm$).

Moreover, these values are comparable to those obtained by [22]. Therefore, we can consider the potash status of cultivated land steady over the past 10 years. The richness of these potassium soils may be could be related to the use of potash fertilizers. In fact, the crops grown receive lots of fertilizers, including potash fertilizers.

• **Total nitrogen:**

The spatial distribution of total nitrogen of the region shows that there are no significant differences in the values recorded throughout the area (Fig. 9a and 9b). At the two horizons [0-2.5 cm] and [2.5-10 cm] the total nitrogen values vary respectively from 0.005 to 0.31 and from 0.002 to 0.23%, which shows that there is no significant variation between the two horizons. According to [26], the decrease in the quantity of N mineralizable can probably be linked to an increase in pH which promotes the mineralization of the organic matter and this by stimulation of the biological activity.





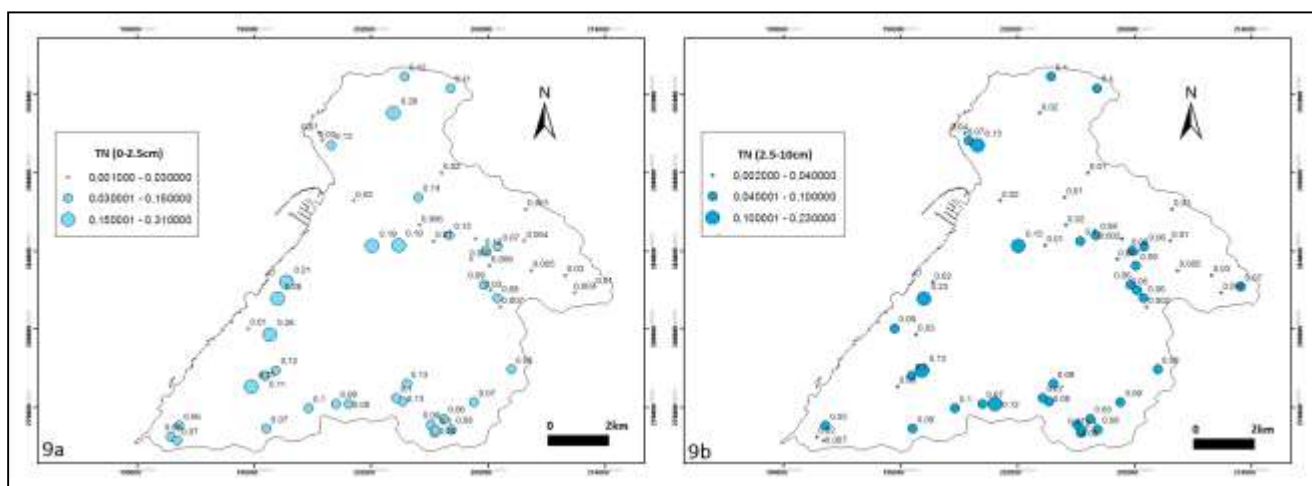


Fig. 3 to 9: Spatial distribution maps of different parameters of the two horizons [0-2.5cm] and [2.5-10cm]

3.3. Statistical analyzes of physico-chemical parameters:

- **Principal Component Analysis (PCA)**

To identify the relationships that may exist between soil parameters, seven variables were used for principal component analysis (PCA). Soil parameters refer to the results of physicochemical analyzes (pH, total organic matter, calcium carbonate, electrical conductivity, total nitrogen, potassium and phosphorus) of the two horizons [0-2.5cm] and [2.5-10cm] of soils. They are used in the analysis as active or explanatory variables.

a. Correlation between parameters and soils of the superficial horizon [0-2.5cm]

The information provided by the factorial axes is shown in Table 3. These results range from 2.24 to 0.38%, whether from 32.06 to 5.49%. The F1 axis alone accounts almost the information whether 32.06% of the total inertia. The other axes (F2, F3, F4, F5, F6 and F7) provide respectively 18.42%, 14.74%, 13.21%, 9.01%, 7.04% and 5.49%. The first four factorial axes explain about 78.45% of the total variability of the different active variables.

Table.3: Participation rate of each factorial axis in the preparation of the projection plans. Fn represents the factorial axes of the ACP

Fn	F1	F2	F3	F4	F5	F6	F7
Eigenvalue	2,245	1,290	1,032	0,925	0,631	0,493	0,384
% Variability	32,066	18,423	14,748	13,216	9,015	7,043	5,490
% Cumulative	32,066	50,489	65,237	78,452	87,467	94,510	100,000

The axis 1 alone accounts for 32.06% of the total variation of the dispersion matrix of individuals and axis 2 accounts for 18.42%. The first two axes (F1 and F2) define the principal plan; they bring about 50.49% of the information. On this plan that the important of the

analysis has been established (Fig. 10). The axis 1 is characterized by OM, CaCO₃ and EC. The axis 2 is characterized by pH, K₂O and P₂O₅. This axis can be considered as the axis of soil fertility.

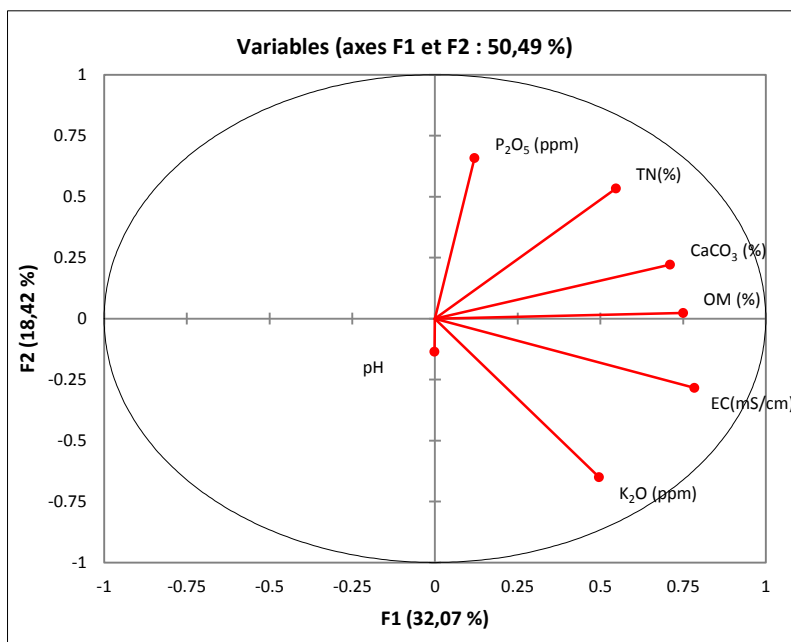


Fig. 10: Principal component analysis between superficial soil parameters on the principal plan (plan 1 - 2) of Jorf Lasfar

b. Correlation between parameters and soils of the depth horizon [2.5-10cm]

The figure 11 shows the results of the PCA of seven variables. The first two axes present respectively 29.29 and 16.89% of the information, whether a total of 46.18% of the total variability. The correlation matrix of the variables analyzed represents the correlation circle of the

variables on the principal plan (plan 1 - 2). The first four factorial axes account for 74.82% of the total variability of the different active variables. The factorial axis F1 allows distinguishing five parameters CaCO₃, OM, K₂O, P₂O₅ and EC. The factorial axis F2 allows distinguishing two parameters: pH and TN.

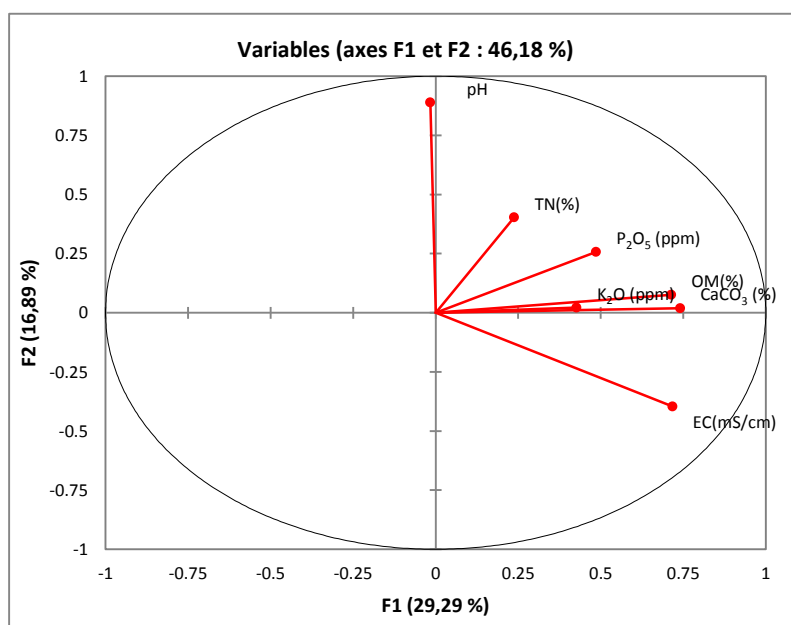


Fig. 11: Principal component analysis between depth soil parameters on the principal plan (plan 1 - 2) of Jorf Lasfar

IV. CONCLUSION

The objective of this work was the evaluation the fertility of agricultural soils in the Jorf Lasfar area through fertilizer elements: pH, OM, Total Nitrogen, phosphorus and potassium.

The results obtained from the analysis of the various samples taken from the different points of the study area allowed demonstrating:

The soils with limono-sandy-clayey to sandy-clayey texture with a moderately alkaline pH. The majority of the soils of the region are characterized by high levels of organic matter overcome largely 3%. The electrical conductivity remains below the agricultural standards which range of 4mS/cm, the CaCO₃ rates of these soils allowed to classify them among the soils that are moderately rich in limestones. The evaluation of the phosphorus and potassium soil contents shows that they have a richness of these elements in the whole study area studied.

REFERENCES

- [1] P. Jouve, "Analyse des modèles de conduite des céréales et voies d'amélioration des rendements", Hommes, Terres, et Eau, Vol 9, No: 35, pp. 79-85, 1979.
- [2] P. Jouve, F. Papy, "Les systèmes de culture dans les zones semi-arides du Maroc occidental", RGM, NO 7, pp. 3-30, 1983.
- [3] M. Ait Hamza, "Les céréales dans le Maroc du Centre-Ouest, Méditerranée", pp. 27-32, 1988.
- [4] L. P. Delville, "Gérer la fertilité des terres dans les pays du sahel", pp. 397, 1996.
- [5] D. Soltner, "Les bases de la production végétale. Tome I : sol 18 è édition", Collection Science et Technique Agricole, pp. 467, 1990.
- [6] V. Genot, G. Colinet, L. Bock, "La fertilité des sols agricoles et forestiers en région wallonne", Rapport analytique 2006 sur l'État de l'Environnement Wallon. Gembloux, Belgique : Laboratoire de Géopédologie, Unité Sol-Écologie-Territoire, Faculté universitaire des Sciences agronomiques, 2007.
- [7] M. Fadili, "Etude hydrogéologique et géophysique de l'extension de l'intrusion marine dans le Sahel de l'Oualidia (Maroc) : analyse statistique, hydrochimie et prospection électrique", Thèse de Doctorat Es-Science, Univ. Chouaib Doukkali, pp. 15, 2014.
- [8] A. Walkley, I. A. Black, "An examination of the Degtjareff method for determining organic carbon in soils: Effect of variations in digestion conditions and of inorganic soil constituents", Soil Sci. 63, pp. 251-263, 1934.
- [9] E. O. Mc lead, "lime requirements. In : Page, A.L. et al. (Eds.), Methods of Soil Analysis, Part 2", second ed., Agronomy, vol. 9 Soil Society of America, Madison, WI, pp. 199-244, 1982.
- [10] H. Chamley, "Guide des techniques du laboratoire de Géologie Marine de Luminy", pp. 198, 1966.
- [11] J.D. Rhoades, D.L. Corwin, "Monitoring soil salinity", J. Soil and Water Cons., 39(3), pp. 173-175, 1984.
- [12] S. R. Olsen, "Estimation of available phosphorous in soils by extraction with sodium bicarbonate", Cir.U.S. Dep.Agr. 939, pp.1-19, 1954.
- [13] E. Lakanen, R. Ervio, "A comparison of eight extractions for the détermination of plant available micronutrients in soils", ActrAgr.Fenn.123, pp. 223-232, 1971.
- [14] Seal analytical, "Total Kjeldahl Nitrogen in Acid Digests", Method No. G-188-97, Rev. 6, 2008.
- [15] D. Baize, "Guide des analyses courantes en pédologie : choix, expression, présentation et interprétation", INRA Editions, Paris, 1988.
- [16] DIAEA /DRHA /SEEN, "Direction de l'irrigation et de l'aménagement de l'espace Agricole, Service des Expérimentations, des Essais et de la Normalisation -Rabat", 2008.
- [17] A. Delaunois, Y. Ferrie, M. Bouche, C. Colin and C. Rionde, "Guide pour la description et l'évaluation de la fertilité des sols", 2008.
- [18] D. Wenming, G. Zhijun, D. Jinzhou, Z. Liying, and T. Zuyi, "Sorption characteristics of zinc (II) by calcareous soil", radiotracer study.Applied Radiation and Isotopes, vol. 54, pp. 371-375, 2001.
- [19] R. Moral, A. Cortés, I. Gomez, J. Mataix-Beneyto, "Assessing changes in Cd phytoavailability to tomato in amended calcareous soils", Bioresource Technology, vol. 85, n° 1, pp. 63-68, 2002.
- [20] M. Jalali, Z. V. Khanlari, "Effect of aging process on the fractionation of heavy metals in some calcareous soils of Iran", Geoderma, vol. 143, pp. 26-40, 2008.
- [21] G. Sayyad, M. Afyuni, S. F. Mousavi, K. C. Abbaspour, B. K. Richards, R. Schulin, "Transport of Cd, Cu, Pb and Zn in a calcareous soil under wheat and safflower cultivation", a column study. Geoderma, vol. 154, pp. 311-320, 2010.
- [22] P. El Hassnaoui, "Impacts environnementaux de la zone industrielle (province d'El Jadida) : Approche pluridisciplinaire et épidémiologie", Thèse de doctorat, Univ. Chouaib Doukkala, 2011.
- [23] R. Mrabet, N. Saber, A. El-Brahli, S. Lahlou, F. Bessam, "Total, Particulate Organic Matter and Structural Stabihty of a Calcixeroll soil under different wheat rotations and tillage systems in a

- semiarid area of Morocco”, *Soil & Tillage Res.* 57, pp: 225-235, 2001.
- [24] A. Ruellan, “Individualisation et Accumulation du Calcaire dans les sols et les dépôts quaternaires du MAROC”, *Cah. O.R.S.T.O.M., sér. Pédol.*, vol. V, n°4, 1967.
- [25] P. M. V. Compos, “Contribution à l’étude des transporteurs de phosphate de la famille PHT1 chez le Peuplier (*Populustrichocarpa* Torr. & Gray) et le champignon ectomycorhizien *Laccariabicolor* (Maire) P. D. Orton”, Thèse de doctorat. *Biologie Végétale et Forestière*. Nancy (France), pp. 141, 2008.
- [26] R. L. Halstead, J. M. Lapansee, K. Irvason, “Mineralization of soil organic phosphorus with particular reference to the effect of lime”, *Can. J. Soil Sci.* 43, pp. 97-106, 1963.