Research article

Monitoring and distribution of nitrogen and phosphorus in agricultural soil in semiarid climate (Siliana. Northern Tunisia)

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Abstract

Nitrogen (N) and phosphorus (P) are the two most important nutrients in the soil, they have a very necessary role in agricultural soils. These two nutrients are essential for increasing agricultural yield. However, their application needs to be carefully evaluated to avoid the risk of contamination and degradation of soil quality. This study was carried out to understand the dynamics and the distribution of N and P in agricultural soil in northern Tunisia. The systematic application of N and P fertilizers to agricultural soils has become an integral part of agriculture. The choice of these two elements was guided by a double concern: one economic, because the study of the distribution of nitrogen and phosphorus, in this study site, makes it possible to reason the chemical fertilization by consequently, saving expensive fertilizer units, and the other environmental, such as taking into account the fertilizers provided by the different soil compartments makes it possible to avoid losses by lixiviation which can impact the quality of water and soil.

This study was aimed to understand the distribution of N and P in depth (0-60cm) and its role in in the cropland of the North Tunisia. Sixteen soil profiles were sampled each year for the period 2015, 2016 and 2017. Our study suggested that N and P, in the different soil profiles studied, are substantially homogeneous laterally, and the high N and P contents are recorded in the surface horizons (Ap) with a decrease in depth. These findings confirm that the soil is undergoing slight degradation. Moreover, it is time to properly manage agricultural practices and the rates of fertilizer added to the soil.

Key words: Distribution, Monitoring, Nitrogen, Phosphorus, Soil, Siliana-Tunisia.

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1. Introduction

Among the multiple and complex problems caused by the use of nitrogen and phosphorus in agriculture, the dynamics of these two important elements N and P (Annabi et al., 2013, Blanchart and Plassard, 2014) in the soil constitute an economic and environmental problem to solve. Economically, the knowledge of the distribution of nitrogen and phosphorus in the various compartments of the soil, makes it possible to reason the fertilization. Environmentally, the quantitative study of these elements avoids losses by leaching which can contaminate groundwater or even join the hydrographic network. In recent years, the need for this type of study has increased, especially in this domain, for many reasons, such as: energy saving (cost of nitrogen and phosphate unit), risk of nitrogen pollution, especially of water tables and soil degradation (Decroux, 1991). To protect soils and aquifers and also save energy by avoiding a drop in the agricultural yield (Sharma et al., 2017), a seasonal pursuit (summer / winter) concerning the evolution of nitrogen and phosphorus and an understanding of its behavior under physicochemical conditions and various climatic conditions is mandatory. The objective of this work is to study, at the local scale of an agricultural plain in Elgantra-Siliana (study site), the distribution of nitrogen and phosphorus in the different vertical and lateral horizons in this soil, of northern Tunisia, which exist in a semi-arid climatic environment, and to characterize it on this basis.

2. Material and methods

2.1. Study area

The experiment was performed in a 06-10 ha, located at the southern limit of the region of Siliana (Fig. 1), at the level of the Tunisian Central-Northern Atlas, (Khayati ,1996), At this site, the average temperature is 24 °C, the climate is medium semi-arid, a mild winter variant of the Mediterranean bioclimate (Bouajila, 2009), the slope of the land is <1%, and the soil is often Vertic with a clay-like texture (Fig. 2), the two irrigation methods, for which the perimeter was designed, are drip and sprinkling, are only practiced on 20% of the cultivable area. The study site characterized by a rotation of cereal crops, the irrigation method for which the perimeter was designed is sprinkling.

The soil samples were taken during key periods of the year (Mauchet., 1991), during 05 successive seasons during the period summer 2015 - winter 2016 - summer 2016 - winter 2017 - summer 2017. In this study, we chose to work according to a sampling plan of 16 profiles, equidistant, as the area is a rectangular plain, on the depth 0-60 cm which corresponds to the Ap cultural horizon. The first 20 cm are mixed by plowing. For more precision concerning the useful root depth for cereals, the dominant crops in the region, we have therefore chosen the sampling: 0-20cm, 20-40 cm and 40-60 cm. Two types of sampling were carried out, one for physicochemical analysis where the samples are dried and sieved at 2 mm and the other for morphological analysis where certain precautions must be observed such as the conservation of the samples taken in a cooler (Viaux and Lesire, 1981).



Fig. 1. Geographical position of Siliana.



Fig. 2. Soil map of the study area $(\overleftrightarrow{})$.

2.2. Analytical techniques

Soil samples were air-dried, well mixed and sieved to pass a 2-mm screen for the measurements. Physicochemical analysis of soil samples was determined according to the standard method published by Richards (1954) and Jackson (1958). The granulometry (Robinson. 1922), X-Ray Diffraction (XRD) (Chamley, 1971), soil pH (AFNOR, 2005), and the electrical conductivity EC (AFNOR, 1995c), organic matter (OM) in the soil was quantified by the modified Walkley-Black method (Yeomans and Bremner, 1998) and total nitrogen and mineral nitrogen was determined by digestion with sulfuric acid and Kjeldahl distillation (Bremner, 1996), phosphorus was determined colorimetrically in all extracts using ammonium molybdate ascorbic (Olsen et al., 1954, Bowman and Cole, 1978).

2.3. Statistical analysis

Data analysis was performed using SPSS version 23.0 for Windows (SPSS, Inc. Chicago, IL, USA). Means and standard deviations (SD) were calculated after verifying the normality of distributions using the Kolmogorov-Smirnov procedure. For mineral clues, the data were analyzed using a two-factors ANOVA (5×3). The within-subjects factor is time (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017) with the between-subjects factor being Layers (H1, H2 and H3). Greenhouse-Geisser corrections were used when the assumption of sphericity (Mauchly's test) was violated. To help protect against type II errors, an estimate of power and

effect size were presented using ω and $\eta 2p$, respectively. Bonferroni-adjusted pairwise post hoc comparisons were performed when appropriate. Significance for all the statistical tests was accepted at p<0.05.

3. Results and discussion

3.1. Monitoring of nitrogen, phosphorus and physicochemical properties

a) Morphological properties of the soil

The studied soil profile, showed a homogeneous color of the horizons. This is due to the depth of penetration of the vertic movements and the presence of the clayey material in depth in the form of shiny faceted plaques well individualized with good porosity of fissure origin. These movements follow the seasonal rhythm of moistening and drying which results in a very large cracking on the surface.

The structure is lumpy on the surface disturbed by plowing. The texture is clayey-silty and the distribution of the particle size fractions is heterogeneous from horizon to another. As shown in (Tab. 1), soil pH in the study area are around 7.47 in the 0-20 cm; these values are rather basic resulting from more or less high carbonate contents (Brahim and Ibrahim, 2018; Wang et al., 2015). The total lime content is high along the profile and reaches a maximum of 32% in the deepest horizon. The active limestone does not exceed 9% along the profile. The electric conductivity was increased from the surface to the depth due to the influence of the fluctuation of the surface water table. However, organic matter showed a decreasing trend with soil depth, due to the amendments (Pallo et al., 2009).

Table 1. Analytical characteristics of the studied soil profile

Depth (cm)	Particle size (%)			pН	EC	CaCO ₃ T	CaCO ₃ A	OM
	Clay	Silt	Sand		(µs/cm)	(%)	(%)	(%)
0-20	46	39	15	7.47	302	25	8.79	2.53
20-40	51	38	11	7.66	293	28	8.49	1.72
40-60	55	36	9	7.79	319	32	8.87	1.91

b) Potential of hydrogen (pH)

There is a significant difference between the 05 seasons of pH monitoring (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017), F = 337.98, p <0.001, $\eta 2p = 0.88$ and significant differences between the 03 horizons (i.e. H1, H2 and H3), F = 45.82, p <0.001, $\eta 2p = 0.67$ (Tab. 2). There is no clear interaction between time and horizons, F = 5.13, p <0.001, $\eta 2p = 0.19$. Bonferroni's post hoc statistical

test indicated that at p <0.05. The pH was significantly higher during the winter compared to the pH during the summer, because in the winter, H+ ions are less concentrated in the soil solution due to the higher humidity. In summer, the production of organic acids due to the high biological activity in this season and the lower water content in the soil lowers the pH (Allani et al., 2020). Also, the highest significant pH value was in H1 (Fig. 3). pH varies slightly over time and with soil layers. In summer, pH is low compared to winter, and gradually decrease with depth, this slight decrease can be explained by; the levels of organic matter, the seasonal rotation and the application of fertilizers, and according to (Schroder, 2014) the application of nitrogenous fertilizers not favors alkalization of the soil.



Fig. 3. Evolution of pH in the soil \pm SD determined during summer 2015, winter 2016, summer 2016, winter 2017, and summer 2017. (pH = potential of hydrogen; H1 = horizon 1 (0-20cm); H2 = horizon 2 (20-40cm) and H3 = horizon 3 (40-60cm)).

c) Electrical conductivity (EC)

Following the electrical conductivity (EC), there is no significant difference between the 5 seasons (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017), F = 17.95, p < 0.001, $\eta 2p = 0.29$ and there are clear differences between the layers (H1, H2 and H3), F = 73.21, p < 0.001, $\eta 2p = 0.29$. Monitoring of this interaction indicated that in H1 and H2 (EC) were higher (p <0.001) during the summer than the winter noting summer 2016 (Tab. 2 and Fig. 4). Electrical conductivity (EC) shows a decreasing distribution for the three horizons, and since there was no significant difference, as a function of time, between the five monitoring seasons, we can explain it by the effect of hydromorphy which tends to standardize the salinity and therefore to reduce its variability, and these results are also signed by (Yegul et al., 2011). So the seasonal evolution of the EC of the soil profiles depends on the depths and the vertical distribution of the soil texture. There are probably other factors involved in this interaction, mainly, in H1 and H2, as the release of exchangeable bases by the adsorbent complex to the soil solution essentially relating to the most hydrated cations Na⁺ and K⁺. Hartsock et al. (2000) and Yegul et al. (2011) found that soil electrical conductivity was positively related to soil Ca²⁺ and Mg²⁺ and soil moisture content. Strong correlations were founded between EC and Cl⁻, HCO³⁻, SO4²⁻, K⁺ and Na⁺ (Yegul et al., 2011).



Fig. 4. Evolution of soil EC (μs / cm) ± SD determined during summer 2015, winter 2016, summer 2016, winter 2017, summer 2017.
(EC = electrical conductivity; H1 = horizon 1 (0-20cm); H2 = horizon 2 (20-40cm) and H3 = horizon 3 (40-60cm)).

d) Organic matter (OM)

For the organic matter (OM) contents, there is an important difference between the 05 seasons (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017), F = 221.86, p < 0.001, $\eta 2p = 0.83$ and on note significant differences between the 03 layers (H1, H2 and H3), F = 1323.93, p <0.001, $\eta 2p = 1.00$. By comparing the OM contents in the three layers we notice that they are higher on the surface and decrease with depth, due to the fact that the OM is biodegraded, which prevents its accumulation in depth (Bosmans and Paenhuys, 1980). Also there was an expressive interaction between the seasons and the horizons, F =75.76, p = <0.001, $\eta 2p = 0.71$. Bonferroni's post hoc statistical test indicated that at p <0.05; in H1 and H2 organic matter (OM) contents were higher (p <0.001), and during winter seasons OM contents were higher compared to summer seasons, this is explained by the important role of humidity and the gradual decomposition of crop residues (Mlih et al. 2019), and of plants, animals and other biological organisms living in the soil (mites, fungi, microfauna, microflora, etc.) (Tab.2 and Fig. 5).

Organic matter (OM) contents vary from 3.44% to 0.86% during the summer periods and from 4.25% to

0.81% during the winter periods, on the 03 horizons, these values show weakly organic soils (Okomo, 2011). Soil organic matter content plays a major role in maintaining soil quality and influences several soil properties, especially those related to physical conditions (Clapp et al., 2007). So the low levels of organic matter (OM) in this soil can lead to an increased risk of soil erosion, degradation of water quality, decrease in biomass and agronomic productivity (Jacinthe et al., 2002).

Organic matter (OM), generally, was more concentrated in the surface horizon (0-20 cm). However, in winter, there is an opposite effect where the concentration tends to increase with depth. The measured OM contents at the surface horizons are related to the clay texture and fresh organic matter, and to the important role of humidity and temperature. Noting the example of (Feller et al., 1991) showed that high organic matter contents of surface horizons are related to soil texture and increase with clay content.



Fig. 5. Evolution of OM content (%) in the soil ± SD determined during summer 2015, winter 2016, summer 2016, winter 2017, summer 2017.

(OM = organic matter; H1 = horizon 1 (0-20cm); H2 = horizon 2 (20-40cm) and H3 = horizon 3 (40-60cm)).

e) Total nitrogen (TN)

The total nitrogen (TN), there is a marked difference between the 05 monitoring seasons (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017), F = 253.59, p <0.001 and $\eta 2p$ = 0.85, and significant differences between the 03 horizons (H1, H2 and H3), F = 359.83, p <0.001 and $\eta 2p$ = 0.94. But there is no clear interaction between the five times and the three soil layers, F = 3.99, P = 0.002 and $\eta 2p$ = 0.15. Bonferroni's post hoc statistical test indicated that at p <0.05; in H1 and H2 total nitrogen (TN) was higher during the winter seasons than the summer seasons. Total nitrogen (TN) was higher in H1 and lower in H3 (Tab. 2, Fig. 6), this variation in total nitrogen content (TN) probably explained by the significant use of nitrogen fertilizers (100 -200 kg / haSODAL) in this agricultural soil (Rigby et al., 2016). Generally, the total nitrogen contents decrease slightly but remain high with depth, this is the result of the application of fertilizers and manures in quantities exceeding those used by the crops (Jeng and Singh, 1995).

total nitrogen (TN) in the soil consists in identifying the variation in nitrogen content at the scale of our plot which is based on several precise and limited parameters, including the monitoring results taking into account time factor account, sampling methodology, dimensions spatiotemporal (Ildiko, 2001) and agricultural activities. Total nitrogen contents, throughout the years (2015-2016-2017), increase during the winter seasons following nitrogen fertilizer applications and they decrease in summer.



Fig. 6. Evolution of TN (%) contents in the soil ± SD determined during summer 2015, winter 2016, summer 2016, winter 2017, summer 2017.

(Nt = total nitrogen; H1 = horizon 1 (0-20cm); H2 = horizon 2 (20-40cm) and H3 = horizon 3 (40-60cm)).

<u>f) Ammonium (NH4)</u>

Ammonium (NH₄) showed a clear difference between the 05 sampling periods (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017), F = 308.45, p <0.001 and η 2p = 0.87, and significant differences between the horizons (H1, H2 and H3), F = 3.96, p = 0.026 and η 2p = 0.15 (Tab. 5). But there is no important interaction between the five seasons and the three horizons, F = 0.79, p = 0.610 and η 2p = 0.03. Bonferroni's post hoc statistical test indicated that at p <0.05; in H1 and H2 the ammonium (NH₄) contents were higher (p = 0.026) during the winter than the summer seasons.

Ammonium (NH₄) was higher in H1 and lower in H3 (Fig. 7), these variations are explained by the nitrogen mineralization process which related to the activity of the different decomposing microorganisms of the soil organic matter (Schipper et al. 2004; Price et al., 2015).

The production and storage of mineral nitrogen in the soil are largely influenced by the climatic and pedoclimatic conditions, also depend on the physical and chemical characteristics of the soil. The highest amounts of ammonium nitrogen noted at the superficial horizon H1 compared to the deeper horizons, justified by the microbial biomass and its renewal rate, in the first 20 centimeters, depended to the presence of water in the soil (Janice et al., 2005).

In addition to humidity, temperature is also one of the most important environmental factors that affect the mineralization and transformation of nitrogen, it deeply affects the biological changes of the soil. Therefore, the seasonal influence on biological changes is often explained by the effect of temperature (Li et al., 2012). Throughout the experimental period, the seasonal distribution of ammonium contents gradually decreases, but they remain higher than nitric nitrogen. Ammonium (NH₄) increase during the 2016 and 2017 winter seasons, explained by the soil character and the moisture content, Moreover, this soil has a high water retention capacity related to their richness in clay minerals. The semi-arid climate certainly has an important role as several studies have shown that nitrogen mineralization related to humidity and rainy seasons (Pansu et al., 2013).



Fig. 7. Evolution of NH4 contents (mg.kg-1) in the soil \pm SD determined during summer 2015, winter 2016, summer 2016, winter 2017, summer 2017. (NH₄ = ammonium; H1 = horizon 1 (0-20cm); H2 = horizon 2 (20-

g) Nitrate (NO_3)

40cm) and H3 = horizon 3 (40-60cm)).

A pronounced difference is noted between the 05 sampling periods (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017), F = 151,778.56, p <0.001 and $\eta 2p = 1.00$, and significant differences between the three horizons (H1, H2 and H3), F = 470.50, p <0.001 and $\eta 2p = 0.95$ (Tab. 2). There is not a significant interaction between the seasons and the horizons, F = 2.04, p = 0.044 and $\eta 2p = 0.08$. Bonferroni's post hoc statistical test indicated that at p

<0.05; in H1 and H2 the nitrate (NO₃) contents were higher during the winter of 2016 and 2017 than the summer seasons. Throughout the study period, nitrate (NO₃) contents were higher in H1, and lower in H3 (Fig. 8), these variations related to the contents of ammonium nitrogen, which increases in winter and decreases in summer, under the significant effect of water, depending on the season and the depth of the soil, because these contents gradually decrease towards depth, so the vertical and horizontal distribution of nitrates is in an exponential relationship with the ammonium contents (Price et al., 2015; Halilat, 2004). During the winter seasons, nitrates are absorbed by roots (Calvet, 1990) limiting their migration at depth and reducing their presence in the deepest horizon. following the seasonal monitoring of NO₃, we noted higher levels in winter than in summer, coinciding with fertilization. Thus, the presence of the total organic carbon available associated with the rewetting of the soil would stimulate nitrification (Coppens et al., 2006).



Fig. 8. Evolution of NO3 contents (mg.kg-1) in the soil ± SD determined during summer 2015, winter 2016, summer 2016, winter 2017, summer 2017.
(NO₃ = Nitrate; H1 = horizon 1 (0-20cm); H2 = horizon 2 (20-40cm)

h) Phosphorus (P₂O₅)

and H3 = horizon 3 (40-60 cm)).

There is an important difference between the 05 seasons (summer 2015, winter 2016, summer 2016, winter 2017 and summer 2017), F = 858.15, p < 0.001, $\eta 2p = 0.95$, and a significant difference between the 03 horizons (H1, H2 and H3), F = 1630.99, p < 0.001, $\eta 2p = 1.00$, in P₂O₅. There is also a significant interaction between seasons and layers, F = 136.41, p < 0.001, $\eta 2p = 0.86$. Monitoring this interaction indicated that in all horizons (i.e. H1, H2 and H3) the amounts of phosphorus (P₂O₅) were higher during the summer seasons than the winter seasons (Tab. 2, Fig. 9), this result is often associated with a high dose of phosphate fertilizer precipitate on the surface (Coale et al., 2002).

The P_2O_5 contents were higher in the H1 horizon (0-20cm), because, in general, the phosphorus is not leached, or a little bit in depth, but can be diluted by the deep work of the soil. Also, phosphorus compartments generally accumulate in the surface horizon of the soil. The variations in the contents of phosphorus (P_2O_5) depend on the pH of the soil, so this phosphorus form decrease with increasing pH because it is fixed by limestones in a neutral environment (Parent et al., 2003).

Phosphorus (P_2O_5) is less available in winter than in summer. Reactions such as precipitation, adsorption and microbial immobilization are slower at low temperature, which illustrates the decrease in P_2O_5 amounts during winter periods.

The results show a significant seasonal variation. Indeed, during winter (2016 and 2017) soil temperatures are relatively low, pH relatively high (8.69 at P1-H1), phosphorus decreases compared to summer seasons, because this element is assimilated by the roots. It is also related to its adsorption on limestones in neutral and alkaline environment (Parent et al., 2007).

In recent research, several studies show that soil texture is the most important factor to consider in the relationship between phosphorus and seasonal contrast. In fact, clayey and silty soils have a buffering capacity conferred by iron oxyhydroxides and aluminum. The environmental risk of (P_2O_5) should be assessed according to the texture and the pedologic classification of the soil (Ben Hassine, 2002).





 $(P_2O_5 = phosphorus; H1 = horizon 1 (0-20cm); H2 = horizon 2 (20-40cm) and H3 = horizon 3 (40-60cm)).$

		Summer 2015	Winter 2016	Summer 2016	Winter 2017	Summer 2017	Mains Effects	Layer	Interaction
		n=16	n=16	n=16	n=16	n=16	Time	Layer	Time ×Layer
рН	H1	8.37±0.074 a.c	8.59±0.095a.b	7.81±0.137 a.d	8.39±0.094 a.e	7.74±0.0901 a.d	F=337.98 (p<0.001)	F=45.82 (p<0.001)	F=5.13 (p<0.001)
	H2	8.18±0.25 a.c	8.43±0.092 a.b	7.81±0.158 a.b	8.29±0.074 a.c	7.66±0.086 a.b	$\eta^2_{\rm p}=0.88$	$\eta^2_{\rm p}=0.67$	$\eta^2_{\rm p}=0.19$
	Н3	7.97±0.21 a.b	$8.32{\pm}0.075a.b$	7.80±0.186 a.b	8.21±0.066 a.b	7.51±0.095 a.b	<i>ώ</i> =1	ώ=1.00	ώ=0.99
	H1	287.75±22.67 a	288.75±25.09 f	269.23±44.16 a.b	216.68±2.96 a	275.5±11.21 f	F=17.95 (p<0.001)	F=73.21 (p<0.001)	F=17.18 (p<0.001)
EC(µs/cm)	H2	259.31±17.63 a.g	265.5±41.11	327.37±38.51 a.b	225±2.89 a.b	275±12.87 a	$\eta^2_{\rm p}=0.29$	$\eta^2_{\rm p}=0.77$	$\eta^2_{\rm p}=0.43$
	Н3	228.68±18.95 a.i	236.81±35.74	222.87±35.67 a	250±7.30 a	251.81±6.72 a	ώ=1.00	ώ=1.00	ώ=1.00
	H1	3.11±0.26 a.c	3.96±0.16 a.b	2.97±0.26 a.b	3.28±0.35 a	2.73±0.29 a.b	F=221.86 (p<0.001)	F=1323.93 (p<0.001)	F=75.76 (p=<0.001)
OM (%)	H2	1.86±0.22 a.b	3.38±0.23 a.b	1.59±0.24 a.b	2.69±0.34 a.b	1.42±0.26 a.b	$\eta^2_{\rm p} = 0.83$	$\eta^{2}_{p}=1.00$	$\eta^2_{\rm p}=0.71$
	Н3	0.93±0.08 a.j	0.97±0.09 a	0.83±0.03 a	0.84±0.09 a	0.75±0.04 a	ώ=1.00	ώ=1.00	ώ=1.00
P ₂ O ₅ (ppm)	H1	26.64±1.042 a.c	9.65±1.89 a.k	27.35±1.92 a.l	8.84±0.87 a.k	20.40±0.63 a.b	F=858.15 (p<0.001)	F=1630.99 (p<0.001)	F=136.41 (p<0.001)
	H2	23.26±1.94 a.1	6.16±1.63 a.k	24.75±2.26 a.1	5.53±0.64 a.k	15.46±0.89 a.b	$\eta^2_{\rm p} = 0.95$	$\eta^{2}_{p}=1.00$	$\eta^2_{\rm p}=0.86$
	Н3	6.42±1.80 a.m	4.35±0.36 a.k	7.25±2.79 a	4.16±0.36 a.k	6.80±0.79 a	ώ=1.00	ώ=1.00	<i>ώ</i> =1.00
TN (%)	H1	0.68±0.04 a.b	0.84±0.07 a.b	0.61±0.04 a.b	0.76±0.06a.b	0.54±0.02a.b	F=253.59 (p<0.001)	F=359.83 (p<0.001)	F=3.99 (P=0.002)
	H2	0.50±0.02 a.b	0.66±0.05 a.b	0.45±0.03 a.b	$0.58{\pm}0.05~a.b$	0.41±0.09 a.b	$\eta^2_{\ p} = 0.85$	$\eta^2_{\ p}=0.94$	$\eta_{p}^{2}=0.15$
	Н3	0.34±0.04 a.c	0.45±0.04 a.b	0.28±0.04 a.b	0.35±0.04 a	0.21±0.07 a.b	ώ=1.00	ώ=1.00	ώ=0.94
NH ₄ (mg·kg ⁻¹)	H1	15.38±0.40	23.77±4.08	12.85±0.13	21.01±0.15	10.97±0.13	F=308.45 (p<0.001)	F=3.96 (p=0.026)	F=0.79 (p=0.610)
	H2	15.16±0.43	22.80±4.46	12.62±0.13	20.71±0.11	10.82±0.15	$\eta^2_{\ p} = 0.87$	$\eta^2_{\rm p} = 0.15$	$\eta^2_{\rm p} = 0.03$
	Н3	14.80±0.36	21.26±4.98	12.33±0.06	20.47±0.06	10.51±0.08	ώ=1.00	ώ=0.68	ώ=0.361
NO ₃ (mg·kg ⁻¹)	H1	9.59±0.07 a.b	18.39±0.10 a.b	7.95±0.10 a.b	15.93±0.09 a.b	6.36±0.06 a.b	F=151778.56 (p<0.001)	F=470.50 (p<0.001)	F=2.04 (p=0.044)
	H2	9.34±0.08 a.b	18.15±0.10a.b	7.72±0.08 a.b	15.65±0.08 a.b	6.17±0.07 a.b	$\eta^2_{\ p} = 1.00$	$\eta^2_{\rm p} = 0.95$	$\eta^2_{\rm p}=0.08$
	Н3	9.08±0.09 a.b	17.93±0.11 a.b	7.44±0.08 a.b	15.33±0.07 a.b	5.93±0.14a.b	ώ=1.00	ώ=1.00	<i>ώ</i> =0.76

Table 2: The effects of seasons and layers on soil mineral composition

Data are means \pm SD; pH=...; EC=....; OM=...; P₂O₅=...; TN=...; P₂O₅=...; NH₄=....; NO₃=....; H1=...; H2=...; H2=....; H²_p= effect size; $\dot{\omega}$ = statistical power.

^a Significantly different (p<0.05) from all other layers; ^b Significantly different (p<0.05) from all other times; ^c Significant different (p<0.05) between Winter 2016. Summer 2016 and Summer 2017; ^d Significant different (p<0.05) between H1 and H3; ^g Significant different (p<0.05) between Summer 2016. Winter 2017 and Summer 2017 and Summer 2017 ^h Significant different (p<0.05) between Summer 2017; ^j Significant different (p<0.05) between Summer 2015. Summer 2016 and Summer 2017

<u>a) Total nitrogen (TN) / Ammonium (NH₄) / Nitrate</u> (NO₃)

Figure 10 shows the variation of the average contents of TN, NH₄, NO₃ during the 05 seasons, and based on the ARC-GIS software, the maps of the lateral distribution of total nitrogen (Fig. 11), ammonium (Fig. 12) and nitrate (Fig. 13) were extrapolated, depending on the season.

We noticed a small variation with time (seasons) for all forms of nitrogen, and the contents are almost homogeneous. This slight variation is associated with the morphology of the site and with the effect of the physicochemical factors (Price et al., 2015).

Moreover, in summer 2015 the total nitrogen content; example P1: 0,52 % is higher than in summer 2017: 0,36 % (Fig. 11), the contents are decreasing from one year to another; for TN a maximum of 0.77% summer 2015 and 0.57% summer 2017 (Fig. 11), ammonium NH4 16.02 mg / kg in summer 2015 and 11.16 mg / kg summer 2017 (Fig. 12), nitric nitrogen NO3 9.71 mg / kg summer 2015 and 6.44 mg / kg in summer 2017 (Fig. 13). the quality of this soil is undergoing a slight degradation over time. This slight degradation is explained by intensive agriculture, the application of chemical fertilizers and irrigation (Brabant, 2010).



Fig. 10. Variation of the average contents of TN, NH₄, NO₃ during the 05 seasons.

b) Phosphorus (P2O5)

Figure 14 shows the variation of the average contents of P_2O_5 during the 05 seasons. The lateral distribution of P_2O_5 in function of the weather is illustrated in Figure 15. P_2O_5 contents are higher in summer and decrease in winter (Fig. 14). This phenomenon is explained by the assimilation of this element by culture, similarly, the levels are decreasing from one season to another (Fig. 14), such as the variation of phosphorus decreased from 28.10 ppm in summer 2015 to 21.35 ppm in summer 2017 (Fig. 15). The absorption of phosphoric ions and their availability depend on the nature and state of the absorbent component (Jellali et al., 2011).



Fig. 11. Lateral distribution of TN (%) in summer 2015 / 2017



Fig. 12. Lateral distribution of NH4 (mg / kg) in summer 2015 / 2017



Fig. 13. Lateral distribution of $NO_3~(mg\,/\,kg)$ in summer $2015\,/\,2017$

Generally, this availability is lower as the absorbency is high. Thus, we can oppose clays and active limestone, iron and aluminum hydroxides, which form complexes with phosphorus. Due to the richness of vertic soils in clay minerals, the phosphorus will then be retained and adsorbed. The phosphorus contents increase with the clay content and under the effect of climatic conditions and the presence of the plant part (Rigane, 2003).



Fig. 14. Variation of P₂O₅ contents during the 05 seasons

4. Conclusion

The variation in the contents of essential elements such as nitrogen, phosphorus and the physicochemical parameters of the soil are significantly related to the seasonal contrast and to the depth of the Ap cultural horizon. Laterally, the variation is very slight, it seems related to the homogenization of the studied soil. Relate to the dynamics and repair of nitrogen and phosphorus in vertebrate agricultural soil. The contents of total nitrogen, mineral nitrogen and assimilable phosphorus are recorded in the surface horizons in all the profiles studied with a slight decrease in depth. This results in a homogenization in the distribution of all forms of nitrogen and phosphorus in soils with vertic traits.

Based on seasonal monitoring, during the three years of this study (2015, 2016 and 2017), N and P levels have allowed us to deduce that our soil is undergoing a slight degradation. Thus, it is time to properly manage agricultural practices and fertilizer rates added to the soil. The factors that influence the dynamics of nitrogen and phosphorus in our study site are essentially the physicochemical properties of the soil, such as: texture, clay content, structure and soil nature.

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