E3S Web of Conferences **489**, 08001 (2024) https://doi.org/10.1051/e3sconf/202448908001
GIRE3D 2023

Impact of Nitrogen Fertilization on Soil Nitrate Concentrations in an Onion Field in the Saiss Basin

Chaimae. NESSAH[1,2], Abdellah. EL HMAIDI[3], Abdelhakim. LAHJOUJ [3,1] , El mâti. EL FALEH[2], Karima. BOUHAFA[1]*

[1]Soil, Plant, and Water Laboratory, National Institute of Agronomic Research, km 10, Road Haj Kaddour, P O Box 578 VN, Meknes, Morocco.
[2]Department of Geology Faculty of Sciences, Moulay Ismail, University, P O Box 11202, Zitoune,Meknes, Morocco.
[3]Laboratory of Geo-engineering and Environment, Department of Geology, Faculty of Sciences, Moulay Ismail University, P O Box 11202, Zitoune, Meknes, Morocco.

Abstract. High nitrogen (N) fertilizer rates can result in excessive nitrate (NO_3^-N) in soils and groundwater. The Saiss basin is an agricultural area in Morocco, where substantial increases in nonpoint source pollution from excessive N fertilization is commonly observed. The purpose of this study was to determine the short-term effect of N fertilizer application rates on soil NO_3^-N and soil water contents (SWC) in an onion (*Allium cepa L.*) field over two consecutive years (2021 and 2022). The field experiment was conducted in a randomized complete block design. Six N rates, namely 0, 90, 135, 180, 225, and 270 Kg N/ha were considered in drip-irrigated onion crops. Soil samples were collected from five consecutive soil layers, namely 0-20, 20-40, 40-60, 60-80, and 80-100 cm, and analyzed for NO_3^-N contents and SWC. SWC were lower before irrigation and increased significantly after irrigation for both seasons. There was no significant effect of N rates on SWC. Soil NO3-N decreased significantly with time. In the first season, lowest NO3-N levels was observed after harvest for all N rates. Visually, a marked accumulation of nitrate in soil was observed in the three highest N rates after harvest. Statistically, N rates did not show significant effect on soil NO3-N (p>0,05) in 2021 and 2022. This finding may be explained by the predominance of the denitrification process at Douyet station.

1 Introduction

In Morocco, the application of fertilizers has been intensified to increase the yields of vegetables and other crop species. However, this application was not based on clear norms, considering the specificity of agricultural areas. The excessive application of N fertilizers can increase greatly the contamination risk of groundwater by nitrate (Elmidaoui et al., 2001;

* Corresponding author: nessah.chaimae@gmail.com

Laftouhi et al., 2003; Tagma et al., 2009; Lgourna et al., 2014; Mountassir et al., 2021).
Nitrate accumulation is influenced by several factors, including N rates, irrigating rates, and soil proprieties (Chen et al., 2016; Zhou et al., 2016; Gao et al., 2019; Fan et al., 2014; Liu et al., 2019; Hebbar et al., 2004).
In Morocco, the Saiss basin is a major agricultural area. It is confronted with soil nitrate (NO_3-N) accumulation and leaching problem (Sadkaoui et al., 2013; Lahjouj et al., 2021). The onion (*Allium cepa L.*) cropping is one of the important agricultural production systems in the area. It requires excessive N fertilizer inputs and high irrigation rates to achieve optimal yields. Therefore, cultivated soils with onion are highly susceptible to NO_3^-N leaching (Halvorson et al., 2002). However, few studies have assessed the effects of N rates application on NO_3^-N dynamics in the Saiss Basin. Lahjouj et al. (2021) have assessed the impacts of N fertilizer rates on SWC, NO_3^-N contents, and yield in a wheat field.
To address these knowledge gaps, this study was designed to assess the short-term effects of N fertilizer in an irrigated onion field:
- The vertical and temporal distribution of SWC and NO_3^-N contents in the soil profile (0-100 cm) in an onion field during two-year growing seasons (2021 and 2022);

2 Materials and methods

The study area is located in the Saïss basin. The onion (*Allium cepa L.*) field experiments were conducted the Douyet experimental station under drip irrigation system. The study was conducted through two consecutive growing seasons (2021 and 2022). The same design was adopted for the two years. Six N application rates were arranged in a randomized complete block design with three blocks. The N application rates were 0 (N0), 90 (N1), 135 (N2), 180 (N3), 225 (N4), and 270 (N5) kg/ha.
Onion sowing was carried out in 8 April 2021 and 14 April 2022. The crop was harvested on 4 August 2021 and 28 July 2022. Before onion sowing, one soil sampling point was randomly selected, then soil samples were collected to determine soil properties.
Soil sampling was carried out 4 times from March to August and from March to July, respectively in 2021 and 2022. Indeed, soil samples were collected from five consecutive soil layers (0-20, 20-40, 40-60, 60-80, and 80-100 cm) and analyzed for nitrate concentration and SWC.
Analysis of variance (ANOVA) was performed using R (Version 4.11) software environment (Gentleman et al., 1996). The One-way ANOVA test for the soil parameters (NO_3-N and water contents) was performed separately for each year. The significance level of the test has been set at 5%.

3 Results and discussion

3.1 Soil water content (SWC)

The observed SWC are shown in Figure 1 and Figure 2, respectively, over the two onion-growing seasons (2021 and 2022). In the first season, the obtained results showed similar SWC patterns over the growing seasons under all treatment scenarios. At 0-20cm, SWC were lowest before irrigation and increase significantly after irrigation. After harvest, SWC decrease in the soil profile. In the second season, SWC were lowest before sowing from 20 to 100cm. After irrigation, SWC increased slightly at all soil horizons. For both seasons, SWC decreased slightly with depth. N rates did not show significant effect on SWC.

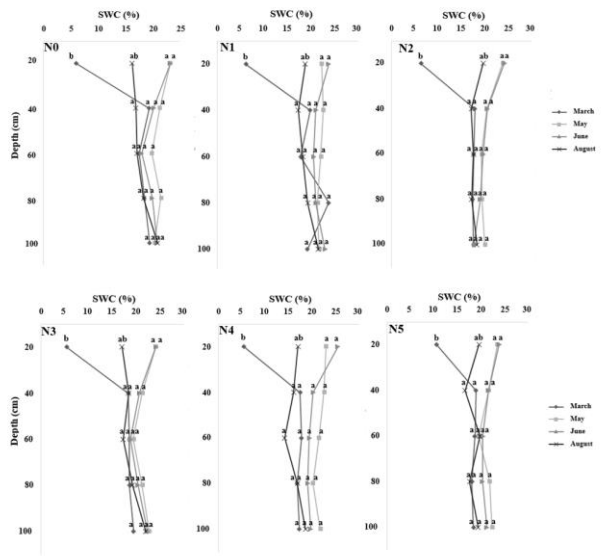

Figure 1. Soil water concentration (SWC) at different soil depths as affected by nitrogen fertilization application rates (2021); Mean values in each N rate for same depth in different time followed by the same letter are not significantly different at the 0.05 level.

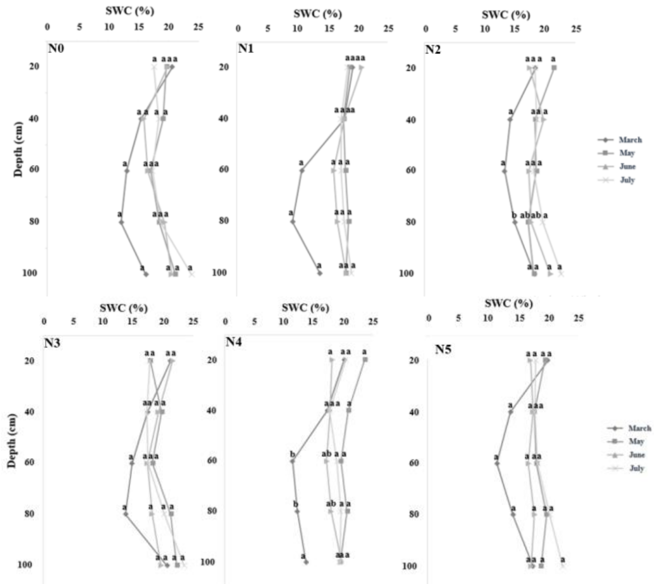

Figure 2. Soil water concentration (SWC) at different soil depths as affected by nitrogen fertilization application rates (2022); Mean values in each N rate for same depth in different time followed by the same letter are not significantly different at the 0.05 level.

3.2 Soil nitrate concentrations

The effect of N fertilizer rates on NO_3^-N distribution in the 0-100 cm soil profile are shown in Figure 3 and Figure 4, respectively, for 2021 and 2022. Initial soil NO3–N levels on March

were highest in all N treatments for both seasons. This may come from previous N application (Xiao-Zong, et al., 2009).
In the first year, an increase on soil NO3-N was observed visually on May for all N rates except the control plot. This response to N is similar to the accumulation patterns reported by (Guillard, et al., 1995). For the second season, there was no increase in soil NO3-N on May. Visually, lowest soil NO3-N were observed after harvest for all N treatments in the first season. However, a slight increase on soil NO3-N accumulation was visually observed after harvest for the highest N rates 180, 225 and 270kgN/ha. The soil NO3-N content at all the sampling depths was least in the control plot. The short-term monitoring of temporal variation of soil NO3-N showed that the levels decrease significantly with time and depth for both seasons. This may be explained by the slower drainage due to the fine texture of soil the slower drainage and/or the N uptake by the crop. According to Halvorson et al. (2002), the N uptake by onion cropping increased as the growing season progressed in a silty clay soil. The one-way ANOVA result show that N rates did not show significant effect soil NO3-N (p>0,05) in 2021 and 2022. This result can be caused by the denitrification which is the main N-loss pathway of N fertilizer at Douyet (Lahjouj, et al., 2023). The predominance of this process might be due to the fine soil texture which reduce water percolation and the high initial NO3-N contents.

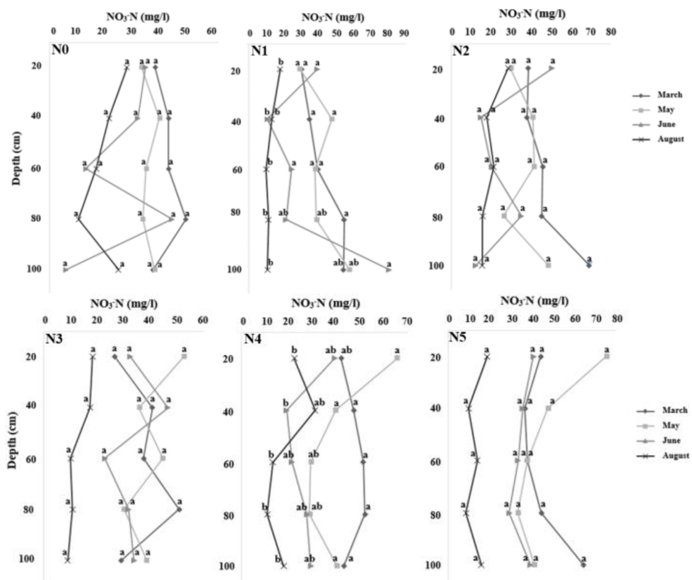

Figure 3. Soil nitrate concentration at different soil depths as affected by nitrogen fertilization application rates (2021); Mean values in each N rate for same depth in different time followed by the same letter are not significantly different at the 0.05 level.

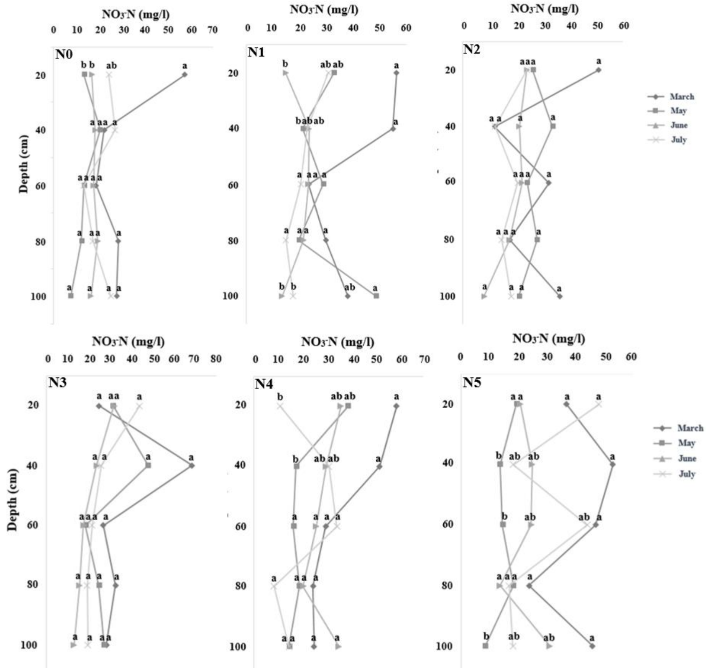

Figure 4. Soil nitrate concentration at different soil depths as affected by nitrogen fertilization application rates (2022); Mean values in each N rate for same depth in different time followed by the same letter are not significantly different at the 0.05 level.

4 Conclusion and perspectives

The work carried out in this framework has brought out some important points. SWC levels were approximately similar in the two years since the two experiments were carried out in Douyet. However, the difference was observed vertically. Before sowing, nitrate contents were high in soil which is reinforced by the many years of agricultural use. Regarding the short-term monitoring of soil NO3-N, a temporally and vertically decrease of levels was observed in the two years. This result was probably related to the fine texture of soil. The effect of N rates is not statistically significant on soil NO3-N for both seasons. Therefore, soil NO3-N were not directly proportional to N rates applied in soil. It appears that it is difficult to predict and control the path of nitrogen in soil since N fertilization is not the only one source of free nitrate found in soil profile. As a solution, N-labeled fertilizers are suggested to be used in future long-term studies.

References

1. A. Elmidaoui, F. Elhannouni, M. M. Sahli, L. Chay, H. Elabbassi, M. Hafsi, D. Largeteau. *Desalination, 136 (1)*, 325-332 (2001)
2. N.-E. Laftouhi, M. Vanclooster, M. Jalal, O. Witam, M. Aboufirassi, M. Bahir, E. Persoons. Comptes Rendus Geosciences, 335 (3), 307-317 (2003)
3. T. Tagma, Y. Hsissou, L. Bouchaou, L.Bouragba, S. Boutaleb. Afr. J. Environ. Sci. Technol. 3 (10), 301-309 (2009)
4. Z. Lgourna, N. R. Warner, L. Bouchaou, S. Boutaleb, T. Tagma, M. Hssaissoune, A. Vegnosh. Mor. J. Chem, 2(5), 447-451(2014).

5. O. E. Mountassir, D. Ouazar, M. Bahir, A. Chehbouni, P. M. Carreira. Arab. J. Geosci, 14(321) (2021)
6. Z. Chen, T. Tian, L. Gao, Y. Tian. *Environ. Sci. Pollut. Res. 23*, 13076–13087 (2016)
7. J. Zhou, B. Gu, W. Schlesinger, X. Ju. Sci. Rep. 6, 25088 (2016)
8. J. Gao, Y. Lu, Z. Chen, L. Wang, J. Zhou. Land. Degrad. Dev, 30, 2150-2161 (2019)
9. Z. Fan, S. Lin, X. Zhang, Z. Jiang, K. Yang, D. Jian, C. Yongzhi, L. Junliang. C. Qing, J. Wang. Agric. Water Manag, 144, 11-19 (2014)
10. Z. Liu, P. Ma, B. Zhai, J. Zhou. *CATENA, 181*, 104080 (2019)
11. S. Hebbar, B. Ramachandrappa, H. Nanjappa, M. Pranhakar. Eur. J. of Agron, 21, 117-127 (2004)
12. N. Sadkaoui, S. Boukrim, A. Bourak, F. Lakhili, L. Mesrar, L. Chaouni, B. Akdim. Present environment and sustainale development, 7, 1 (2013)
13. A. Lahjouj. Groundwater vulnerability to nitrates : statistical, parametric and numerical modeling approaches (case of Saiss plain). 246 (2021)
14. A. D. Halvorson, R. F. Follett, M. E. Bartolo, F. C. Schweissing. J. *Agron*. 94, 442–449 (2002).
15. A. Lahjouj, A. El Hmaidi, M. Boufala, K. Bouhafa. Soil Sci. Annu. 74(1), 161944 (2023)
16. R. Gentleman, R. Ihaka. R: A Language for Data Analysis and Graphics. J. Comput. Graphi. Stat. (1996)
17. S. Xiao-Zong, Z. Chang-Xing, W. Xiao-Lan, L. Ji. Comptes rendus biologies. 332 (2009)
18. K. Guillard, G. F. Griffin, D. W. Allinson, W. R. Yamartino, M. MoosaRafey, S. W. Pietrzyk. J.Agron, 87, 199-207 (1995)
19. J. C. Díaz-Pérez, J. Purvis, T. Paulk. J. *Am. Soc. Hortic. 128*, 144–149 (2003)
20. S. Nasreen, M. M. Haque, M. A. Hossain, A. T Farid. *Bangladesh j. agric. res. 32*(3), 413–420 (2007)