IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 14, Issue 5 Ser. I (May 2021), PP 44-49
www.iosrjournals.org

Effect of Increasing Rates of Sunflower Residues on the Evolution of Soil Mineral N In A Laboratory Incubation Study.

ZoubidaLAGHRARI[1],Abderrahim LAHRACH[2], Kaoutar HAMRIRI [2],
[1]*Département de Biologie,Université Moulay Ismail, Faculté des Sciences BP 4010, Beni M'hamed, Meknès, Maroc*
[2]*Laboratory of Functional Ecology and Environmental Engineering, Faculty of Science and Technology of Fez,University of Sidi Mohamed Ben Abdellah, B.P. 2202 - Route d´Imouzzer*
FEZ - MOROCCO.
Correspondence to: Zoubida LAGHRARI

Abstract: *An aerobic soil incubation test was carried out in the laboratory to study the N immobilization-mineralization process when increasing rates of sunflower residues were incorporated into the soil at 0, 0.15, 0.5 and 1g of residues per 50g of soil. The soil obtained from a plot where sunflower has been cultivated was incubated at 32°C for 3 months. For all residues rates, nitrogen was rapidly immobilized in the first four days of incubation, then it was rapidly liberated into the soil. However, the amount of nitrogen remineralized decreased with increasing rate of residues incorporated. In terms of incubation period, the rate of N immobilized by residues relative to the control was 22, 18, 47 and 70% for R1, R2, R3 and R4, respectively.*

Keywords: *Aerobic incubation, immobilization, mineralization, mineral nitrogen, residues rate, sunflower residues.*

Date of Submission: 30-04-2021 Date of Acceptance: 14-05-2021

I. Introduction

Crop residue is one of the most important sustainable and ecologically sound alternative for meeting the nutrient requirement of crops(Babu et al., 2014). In addition to their roleas the primary source of soil organic matter (Havlin et al., 1990; Larson et al., 1972; Uhlen, 1991; Zibilske, 1987), they have a significant positive impact on improving soil physical, chemical and biological soil properties(Gupta et al., 1987; Parr & Papendick, 1978; Sarkar et al., 2020). Moreover, incorporation of crop residues can also nourish rhizosphere biota as well as reduce farm inputs and greenhouse gases emissions (Malhi & Lemke, 2007; P. Sharma et al., 2011)responsible of climate changes.

In last years, sunflower crop has covered large areas in Meknes region (North of Morocco). It was introduced principally in biennial rotation with wheat. Sunflower is an oilseed crop which produce huge amount of crop residue. This amount of residues is neither used as feed for livestock nor suitable for fuel due to low energy value per unit mass(Babu et al., 2014). However, soil incorporation of its residues may be pertinent for replenishing the depleted soil fertility and improving production since they are nutrients rich residues (K. L. Sharma et al., 2007).

Nevertheless, the addition to the soil of an organic compound with a high C/N results in a biological immobilization of mineral nitrogen in the soil (Christensen, 1986; Jansson & Persson, 1982; S. J. Smith & Sharpley, 1990). As decomposition progresses, the initially immobilized mineral nitrogen remineralizes. This process is called Nitrogen Immobilization-Remineralization (Jansson & Persson, 1982; Kumar & Goh, 1999). It is depending on rate of residues applied to soil(Reinertsen et al., 1984; Sorensen, 1981; Zibilske, 1987). The aim of the present work is to study the immobilization and remineralization of nitrogen in the soil in the presence of increasing rates of sunflower residues known as low N content.

II. Material and Methods:

A soil laboratory aerobic incubation test was carried out to study the evolution of soil mineral N in the presence of increasing rates of sunflower residues. Soil was sampled in autumn from a field where sunflower was cultivated. Soil initial mineral N was 8.1 mg/kg, Nitrate-N was 6.3 mg/kg.

Soil sieved at 2 mm was uniformly mixed with sunflower residues. Residues contained different parts of the plant: stems, leaves, flower heads and roots. They were ground at 1.5 mm, their %N was 0.54. The doses of residues added to the soil were R_0 = 0; R_1 = 0.15; R_2 = 0.25; R_3= 0.5 and R_4 = 1 g per flask containing 50 g of soil.The 0.15g dose per 50 g of soil corresponds approximately to 500g/m² (5 t/ha), which is the average rate of residues returned to the soil by sunflower under field conditions.

Before incubation, flasks were added with fertilizer in the form of (NH4)2SO_4, P_2O_5 and KCI at the respective doses 5 mg of N (100 N mg/g of soil), 1.5 mg of Pet 2 mg of K per vial.The soil was incubated in a culture chamber at 32°C and 90% humidity. The soil water was 60% of the field capacity, it was adjusted by weighing every four days. In total, the number of vials was 135. The experimentwas completely randomizeddesign with 3 repetitions. The incubation period was 3 months. During this period, samples were taken on the 2nd; 4; 7; 15; 30; 45; 60; 75 and the 90th day of incubation. In each date, 3 flasks of each treatment were sacrificed for analysis. The soil was oven dried at 40°C, nitrate and ammoniacal nitrogen were analyzed by the method of Deverda(Keeney & Nelson, 1982).

An analysis of variance (ANOVA) was performed according to the completely randomized design with 3 repetitions, at significance level of 5%.

III. Results

Evolution of total mineral Nitrogen

Evolution of total soil mineral nitrogen during the 90 days of incubation was characterized by a fast disappearance of mineral nitrogen in the start of incubation (figure 1). This phase was immediately followed by a rapid nitrogen remineralization. The later phase showed irregular fluctuations, but the general appearance tended towards a stable evolution of mineral nitrogen in the soil. At each sampling date, the analysis of variance showed a highly significant effect of the dose factor of sunflower residues incorporated into the soil. In general, as the amount of residue increased the mineral nitrogen decreased.For all residue treatments, the drop in the level of mineral nitrogen was observed from the 2nd day of incubation, and was maximal on the 4th day. Indeed, the disappearance of mineral nitrogen from the initial level was 74.68%, 86%, 93%, 99%, and 98%. Between the 15th and the 45th day of incubation, the level of total mineral nitrogen remained almost stable. In the control treatment, remineralization continued until day 30. The period between the 45th and the 60th day saw further nitrogen remineralization in the R_1 and R_2 treatments, which remained less than that of the first week of incubation. This remineralization was observed until the 60th day in the R_3 and R_4 and R_0 control treatments. From the 75th day, the evolution of mineral nitrogen was almost stable.

After three months of incubation, the mineral nitrogen was higherin the control treatment, at the same level in R_1 and R_2, and notably lower in R_3 and R_4 comparing to the initial soil mineral N.

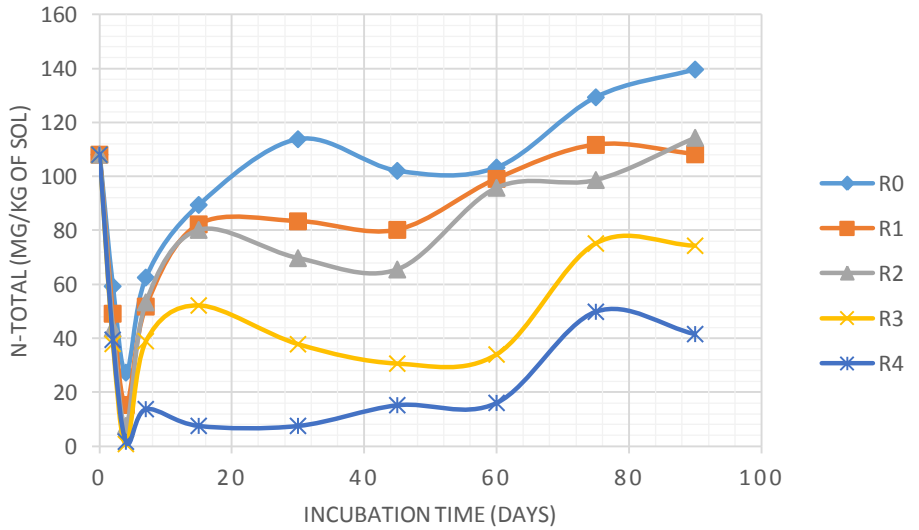

Figure 1: *Evolution of total Nitrogen during incubation period*

Evolution of ammoniacal Nitrogen

During the entire incubation period, the variation of ammoniacal nitrogen was not affected by the doses of residues brought to the soil, except on the 7th day when NH_4-N was reduced by the addition of increasing doses of residues (figure 2). In fact, on the 2nd day, 93% and 95% of initial NH_4-N disappeared in the control and R_1 treatments respectively, and of the order of 99% in the R_2, R_3 and R_4 treatments. On the 7th day of incubation, remineralization peaks of NH_4-N appeared and their importance decreased with increasing rates of residues.These peaks of NH_4-N reappearance coincided with the remineralization phase of total soil mineral nitrogen. On the 15th day, the NH_4-N disappeared again, and remained at the same level until the end of incubation, with no difference in residue doses.

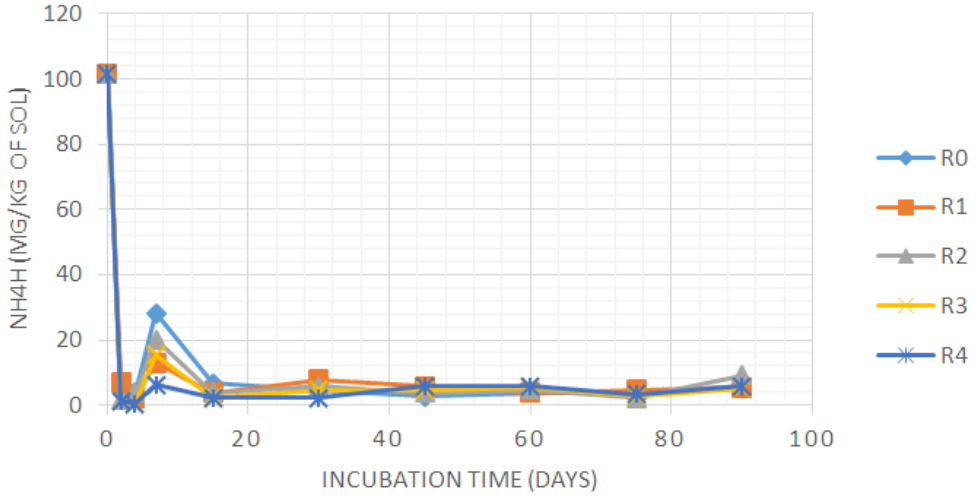

Figure 2: *Evolutionof ammoniacal Nitrogen during incubation period*

Evolution of nitric nitrogen in the soil

Analysis of variance revealed a highly significant effect of increasing dose levels of sunflower residue on soil NO_3-N at all sampling dates; the increase of residues rate resulted in a decrease in nitrate nitrogen in the soil (figure 3). This drop was not significant between R_1 to R_2.

Due to the very low NH_4-N content of the soil recorded throughout the incubation period, NO_3-N showed variations similar to those of total mineral nitrogen. The only difference between NO_3-N and total mineral nitrogen was observed in the first two days of incubation. This is because total mineral nitrogen has decreased, while NO_3-N has increased. On the 4th day, an appreciable amount of the nitrified nitrogen had disappeared again. With the exception of the R_4 treatment, the period between the 4th and 15th day was characterized by a significant reappearance of NO_3-N. During the remainder of the incubation period, the evolution of NO_3-N was identical to that of total mineral nitrogen.

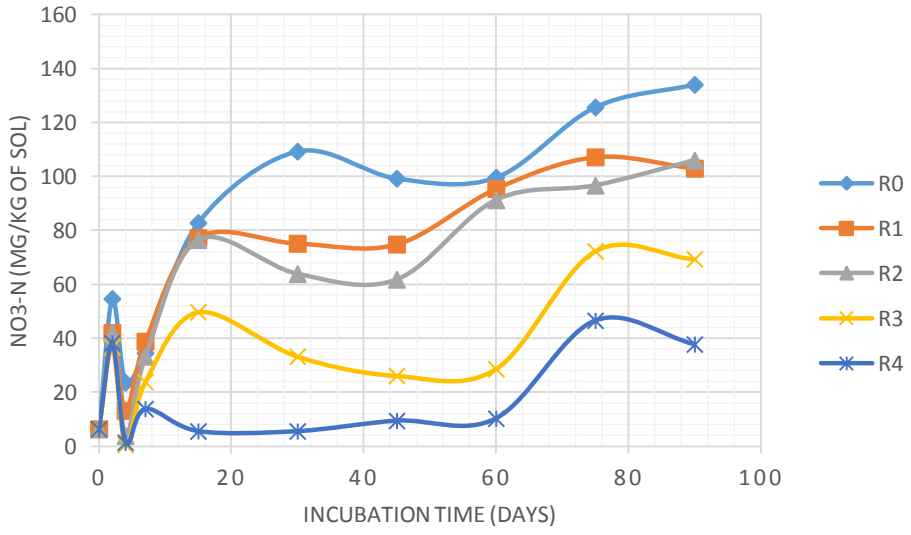

Figure 3: *Evolutionof nitric nitrogen during incubation period*

IV. Discussion

The initial nitrogen was mostly in the form of NH_4-N. It was added to soil as fertilizer in the form of $(NH_4)_2SO_4$ at a dose of 100 mg/kg of soil. In all residues treatments, therapid disappearance of NH_4-N at the start of incubation indicates an intense microbial activity.Nitrification and immobilization are the most important biological processes that must have caused the consumption of NH_4-N. Concerning NO_3-N, its content increased. This increase would be due to a nitrification of NH_4-N brought to the soil. From the second day of incubation, the NO_3-N then dropped. Thus, the nitrogen nitrified in the first two days was immediately immobilized. Immobilization was therefore the predominant process during the first four days of incubation, where both NH_4-N and NO_3-N were used by microorganisms.

Several studies havereported that nitrogen is rapidly immobilized during the first days of incubation.Hdoudouch (1994) detected NH_4-N immobilization from the first 7 days of incubation in the presence of sunflower residues. In the presence of wheat straw,Jawson & Elliott (1986) found that mineral nitrogen was immobilized within the first 12 days of incubation. Following the addition of wheat straw into soils, rapid decrease of nitrate content in soil and increase of microbial biomass C and N occurred within the first week from onset of the experiment was noted by Shindo & Nishio (2005). In our experiment, the rapid consumption of nitrogen at the start of incubation can be explained by an intense proliferation of microbial biomass in the presence of sunflower residues. The significant immobilization of nitrogen in the control treatment would be explained by an activation of the microorganisms following the rewetting of the soil(De Bruin et al., 1989; Van Veen et al., 1985), and also by the presence in the soil of remaining sunflower residues from the previous season.

Once immobilized, nitrogen mineralization started since the fourth day of incubation. This phase of intense mineralization would correspond to the decomposition of the microbial biomass which immobilized nitrogen at the start of incubation. In all treatments, mineralized nitrogen was predominantly in the form of NO_3-N. Nevertheless, a brief peak of NH_4-N was recorded; it coincided with the phase of net mineralization. A similar result was found by(Ladd & Paul, 1973) in a soil supplemented with glucose and by Hdoudouch (1994) in the presence of sunflower residues. This appearance of NH_4-N would be due to the ammonification of certain decomposition products from the first generation of microorganisms, which proliferated in the first days of incubation. The period succeeding therapid immobilization and mineralization phase was characterized by slower evolution of mineral nitrogen. This phase would correspond to the proliferation of microbial populations which use the relatively less available carbon from sunflower residues. In the same hand,Cochran et al. (1988) suggested the existence of two pools of microbial biomass which degrade wheat residues; an initial population that uses the readily available carbon from residues, and another pool of microbial biomass that simultaneously uses the less available carbon from residues and the nitrogen remineralized from the first population.

According toReichel et al. (2018), high organic carbon amendments (HCA) consist of very different quantities and qualities of fast, moderately, and slowly degradable organic sub-fractions.In fast fraction, which is usually decomposed whiting a few days, immobilization can be expected to increase with increasing size and C:N ratio (Plante & Parton, 2007). Sugars, amino acids, and nucleic acids are the main constituents of this fraction (Mueller et al., 1998). It represents a substrate of a rapid growth of fermentative microorganisms(Kuzyakov & Blagodatskaya, 2015). After dead of this first microbial biomass generation, C and N released serve as additional substrates for microbes that grow more slowly on morecomplex organic compounds(Fontaine et al., 2004).

During the entire incubation period of our experiment, the amount of mineralized nitrogen decreased with the rate of sunflower residues added. Nitrogen immobilization in the presence of low residues N has been reported in most studies(Aulakh et al., 1991; J. H. Smith & Douglas, 1970; S. J. Smith & Sharpley, 1990), this is explained by consumption of soil nitrogen by microorganisms to degrade residues (Alexander, 1978; Bartholomew, 1965). Therefore, increasing residues rates in the soil would increase the nitrogen demand of microorganisms which would cause more immobilization. Similar results were reported by Sorensen (1981), Zibilske (1987) and Reinersten et al. (1984).

On the other hand, the high quantity of residues in the soil seems to slow down the processes of nitrogen transformation. Indeed, we noticed that the mineralization of NO_3-N observed on the 45^{th} day for the R_1 and R_2 doses was only observed on the 60^{th} day for the R_3 and R_4 treatments.

During the last days of incubation, mineralization was the prevalent process. However, referring to the control, an appreciable amount of nitrogen was immobilized in the treatments supplemented with sunflower residues. At the end of the incubation period (90^{th} day), the amounts of immobilized nitrogen were 31.4, 24.58, 65.32, 98.07 mg/kg of soil for the treatments R_1, R_2, R_3 and R_4 respectively. The decrease of remineralized N, with the increase of residues doses, could result from a high rate of N immobilization and/or an incorporation of the nitrogen immobilized in stable organic forms. Indeed, several authors have shown that in the presence of crop residues, an appreciable quantity of the nitrogen of the immobilized fertilizer is stabilized in the soil(Azam, Mulvaney, et al., 1989; Azam, Stevenson, et al., 1989; He et al., 1988; Sorensen, 1981).

In the term of the incubation period mineral N of the control treatment was clearly higher than the initial mineral N by a difference of 30 mg N/kg soil suggesting a priming effect due to the activation of soil microorganisms further the addition of inorganic N (Jenkinson et al., 1985; Kuzyakov, 2010).

V. Conclusion

The incorporation of sunflower residues in the soil inducted a fast immobilization of mineral nitrogen. The nitrogen immobilized was rapidly remineralized. The quantities ofremineralized N decreased with the dose of residues. In the R_1 treatment (the equivalent of 5t of residues/ha) and R_2 (the equivalent of 8t of residues/ha) the amounts of nitrogen mineralized were little different. Their impact on mineral soil nitrogen was low compared to treatments R_3 (equivalent to 16t of residues/ha) and R_4 (equivalent to 32t of residues/ha), which could cause nitrogen deficiency in soil, especially if the period of immobilization coincides with the plant's high nitrogen demands. However, for practical recommendations, this work would be experiencedin the greenhouse and in the field conditions in the presence of the plant to study the synchronism between remminalization and plant needs.

References

[1]. Alexander, M. (1978). Introduction to Soil Microbiology. *Soil Science*, *125*(5), 331.

[2]. Aulakh, M. S., Walters, D. T., Doran, J. W., Francis, D. D., & Mosier, A. R. (1991). Crop residue type and placement effects on denitrification and mineralization. *Soil Science Society of America Journal*, *55*(4), 1020‐ 1025.

[3]. Azam, F., Mulvaney, R. L., & Stevenson, F. J. (1989). Transformation of 15 N-labelled leguminous plant material in three contrasting soils. *Biology and fertility of soils*, *8*(1), 54‐ 60.

[4]. Azam, F., Stevenson, F. J., & Mulvaney, R. L. (1989). Chemical extraction of newly immobilized 15N and native soil N as influenced by substrate addition rate and soil treatments. *Soil Biology and Biochemistry*, *21*(5), 715‐ 722.

[5]. Babu, S., Rana, D. S., Yadav, G. S., Singh, R., & Yadav, S. K. (2014). A review on recycling of sunflower residue for sustaining soil health. *International Journal of Agronomy*, *2014*.

[6]. Bartholomew, W. V. (1965). Mineralization and immobilization of nitrogen in the decomposition of plant and animal residues. *Soil nitrogen*, *10*, 285‐ 306.

[7]. Christensen, B. T. (1986). Barley straw decomposition under field conditions : Effect of placement and initial nitrogen content on weight loss and nitrogen dynamics. *Soil Biology and Biochemistry*, *18*(5), 523‐ 529.

[8]. De Bruin, B., De Vries, F. P., Van Broekhoven, L. W., Vertregt, N., & Van de Geijn, S. C. (1989). Net nitrogen mineralization, nitrification and CO 2 production in alternating moisture conditions in an unfertilized low-humus sandy soil from the Sahel. *Plant and soil*, *113*(1), 69‐ 78.

[9]. Fontaine, S., Bardoux, G., Abbadie, L., & Mariotti, A. (2004). Carbon input to soil may decrease soil carbon content. *Ecology letters*, *7*(4), 314‐ 320.

[10]. Gupta, S. C., Schneider, E. C., Larson, W. E., & Hadas, A. (1987). Influence of corn residue on compression and compaction behavior of soils. *Soil Science Society of America Journal*, *51*(1), 207‐ 212.

[11]. Havlin, J. L., Kissel, D. E., Maddux, L. D., Claassen, M. M., & Long, J. H. (1990). Crop rotation and tillage effects on soil organic carbon and nitrogen. *Soil Science Society of America Journal*, *54*(2), 448‐ 452.

[12]. He, X. T., Stevenson, F. J., Mulvaney, R. L., & Kelley, K. R. (1988). Incorporation of newly immobilized 15N into stable organic forms in soil. *Soil Biology and Biochemistry*, *20*(1), 75‐ 81.

[13]. Jansson, S. L., & Persson, J. (1982). Mineralization and immobilization of soil nitrogen. *Nitrogen in agricultural soils*, *22*, 229‐ 252.

[14]. Jawson, M. D., & Elliott, L. F. (1986). Carbon and nitrogen transformations during wheat straw and root decomposition. *Soil Biology and Biochemistry*, *18*(1), 15‐ 22.

[15]. Jenkinson, D. S., Fox, R. H., & Rayner, J. H. (1985). Interactions between fertilizer nitrogen and soil nitrogen—The so-called 'priming'effect. *Journal of soil Science*, *36*(3), 425‐ 444.

[16]. Keeney, D. R., & Nelson, D. W. (1982). Total Nitrogen. In *Methods of Soil Analysis* Part 2 (2nd edition), Chemical and microbiological properties, agronomy monograph No 9 (p. 711‐ 733).

[17]. Kumar, K., & Goh, K. M. (1999). Crop residues and management practices : Effects on soil quality, soil nitrogen dynamics, crop yield, and nitrogen recovery. *Advances in agronomy*, *68*, 197‐ 319.

[18]. Kuzyakov, Y. (2010). Priming effects : Interactions between living and dead organic matter. *Soil Biology and Biochemistry*, *42*(9), 1363‐ 1371.

[19]. Kuzyakov, Y., & Blagodatskaya, E. (2015). Microbial hotspots and hot moments in soil : Concept & review. *Soil Biology and Biochemistry*, *83*, 184‐ 199.

[20]. Ladd, J. N., & Paul, E. A. (1973). Changes in enzymic activity and distribution of acid-soluble, amino acid-nitrogen in soil during nitrogen immobilization and mineralization. *Soil Biology and Biochemistry*, *5*(6), 825‐ 840.

[21]. Larson, W., Clapp, C. E., Pierre, W. H., & Morachan, Y. B. (1972). Effects of Increasing Amounts of Organic Residues on Continuous Corn : II. Organic Carbon, Nitrogen, Phosphorus, and Sulfur 1. *Agronomy Journal*, *64*(2), 204‐ 209.

[22]. Malhi, S. S., & Lemke, R. (2007). Tillage, crop residue and N fertilizer effects on crop yield, nutrient uptake, soil quality and nitrous oxide gas emissions in a second 4-yr rotation cycle. *Soil and Tillage Research*, *96*(1‐ 2), 269‐ 283.

[23]. Mueller, T., Jensen, L. S., Nielsen, N. E., & Magid, J. (1998). Turnover of carbon and nitrogen in a sandy loam soil following incorporation of chopped maize plants, barley straw and blue grass in the field. *Soil Biology and Biochemistry*, *30*(5), 561‐ 571. https://doi.org/10.1016/S0038-0717(97)00178-8

[24]. Parr, J. F., & Papendick, R. I. (1978). Factors affecting the decomposition of crop residues by microorganisms. *Crop residue management systems*, *31*, 101‐ 129.

[25]. Plante, A. F., & Parton, W. J. (2007). The dynamics of soil organic matter and nutrient cycling. In *Soil microbiology, ecology and biochemistry* (p. 433‐ 467). Elsevier.

[26]. Reichel, R., Wei, J., Islam, M. S., Schmid, C., Wissel, H., Schröder, P., Schloter, M., & Brüggemann, N. (2018). Potential of wheat straw, spruce sawdust, and lignin as high organic carbon soil amendments to improve agricultural nitrogen retention capacity : An incubation study. *Frontiers in plant science*, *9*, 900.

[27]. Reinertsen, S. A., Elliott, L. F., Cochran, V. L., & Campbell, G. S. (1984). Role of available carbon and nitrogen in determining the rate of wheat straw decomposition. *Soil Biology and Biochemistry*, *16*(5), 459‐ 464.
[28]. Sarkar, S., Skalicky, M., Hossain, A., Brestic, M., Saha, S., Garai, S., Ray, K., & Brahmachari, K. (2020). Management of Crop Residues for Improving Input Use Efficiency and Agricultural Sustainability. *Sustainability*, *12*(23), 9808.
[29]. Sharma, K. L., Srinivas, K., Mandal, U. K., Ramakrishna, Y. S., Vittal, K. P. R., Das, S. K., Martin, D., Grace, J. K., & Balloli, S. S. (2007). Kinetics of Decomposition of Un‐ conventional Farm‐ Based Crop Residues and Their Composting and Quality Monitoring. *Communications in Soil Science and Plant Analysis*, *38*(17‐ 18), 2423‐ 2444. https://doi.org/10.1080/00103620701588791
[30]. Sharma, P., Abrol, V., & Sharma, R. K. (2011). Impact of tillage and mulch management on economics, energy requirement and crop performance in maize–wheat rotation in rainfed subhumid inceptisols, India. *European journal of agronomy*, *34*(1), 46‐ 51.
[31]. Shindo, H., & Nishio, T. (2005). Immobilization and remineralization of N following addition of wheat straw into soil : Determination of gross N transformation rates by 15N-ammonium isotope dilution technique. *Soil Biology and Biochemistry*, *37*(3), 425‐ 432.
[32]. Smith, J. H., & Douglas, C. L. (1970). Influence of silica and nitrogen contents and straw application rate on decomposition of gaines wheat straw in soil. *Soil Science*, *109*(6), 341‐ 344.
[33]. Smith, S. J., & Sharpley, A. N. (1990). Soil nitrogen mineralization in the presence of surface and incorporated crop residues. *Agronomy Journal*, *82*(1), 112‐ 116.
[34]. Sorensen, L. H. (1981). Carbon-nitrogen relationships during the humification of cellulose in soils containing different amounts of clay. *Soil Biology and Biochemistry*, *13*(4), 313‐ 321.
[35]. Uhlen, G. (1991). Long-term effects of fertilizers, manure, straw and crop rotation on total-N and total-C in soil. *Acta Agriculturae Scandinavica*, *41*(2), 119‐ 127.
[36]. Van Veen, J. A., Ladd, J. N., & Amato, M. (1985). Turnover of carbon and nitrogen through the microbial biomass in a sandy loam and a clay soil incubated with [14C (U)] glucose and [15N](NH4) 2SO4 under different moisture regimes. *Soil Biology and Biochemistry*, *17*(6), 747‐ 756.
[37]. Zibilske, L. M. (1987). Dynamics of nitrogen and carbon in soil during papermill sludge decomposition1. *Soil Science*, *143*(1), 26‐ 33.

Zoubida LAGHRARI, et. al. " Effect of Increasing Rates of Sunflower Residues on the Evolution of Soil Mineral N In A Laboratory Incubation Study." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 14(5), 2021, pp. 44-49.