Study of residual effect of N fertilizer (Total N) on the soil

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Abstract. The study of residual effect of N fertilizer on the soil is important research so far so good. This study was conducted on Brack-Ashkda agricultural project soil middle south of Libya to investigate the effects of soil depth (0-180 cm) and duration of soil use (January, April, July and October) on the presence of the level of total N as a residual effect of additions of N fertilizer to the soil. Results showed that the total N concentrations decreased with increasing soil depth (0-180 cm) and there are significant differences between them in all studied wells. Also, the results showed that the concentrations decreased with increasing duration of soil use from January until October. There are significant differences between the total N concentrations along the duration of soil use in all studied wells.

keywords: Total N, nitrogenous fertilizer, depth, duration time

1. Introduction

Soil rarely contain enough nitrogen for maximum plant growth. Because nitrogen fertilization is such an important crop production practice in semiarid and arid regions a judicious choice of the kind of nitrogen fertilizer and dosage is essential in order to obtain high yields. Residual nitrogen can accumulate to sufficiently high levels so that no response to nitrogen fertilization, even with high yielding crops, is obtained (Hagin and Shmueli 1960).

Urea dissolves readily in water, about 100 g may be dissolved in 100 g H₂O at 20°C. When applied to soils, urea hydrolysis within 2-3 days, depending on temperature, to form ammonium carbonate which is an unstable salt that decomposes by further hydrolysis into ammonia and carbon dioxide gases (Beaton 1978).

\[ \text{CO(NH}_2\text{)}_2 + 2\text{H}_2\text{O} \rightarrow (\text{NH}_4\text{)}_2\text{CO}_3 \rightarrow 2\text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} \]

From the above reaction it would appear that nitrogen applied to the soil surface as urea is likely to be lost as NH₃.

Leaching periodically removes most of the nitrate nitrogen from the profiles of permeable soils in humid regions. Soils of drier regions do not suffer leaching losses where water does not penetrate beyond the depth of the solum, but the nitrate nitrogen can be removed to a lower part of the solum (Thompson and Troeh 1978).
Some farmers apply nitrogen fertilizer in the fall for a crop to be planted the following spring. Leaching losses from such applications can be considerable if the nitrate form of nitrogen is present. The leaching hazard can be markedly reduced by applying the ammonium form of nitrogen after the topsoil temperature is below 5 °C (Thompson and Troeh 1978). Ammonia applied to the soil as a fertilizer absorbs H⁺ ions and forms NH₄⁺ ions that can be adsorbed by cation exchange. Ammonium ions from fertilizers are likewise adsorbed and thus held against loss. Mills; Barker; and Maynard (1974) showed that large losses can occur when high rates of nitrogen are applied to alkaline sandy soil without any plant growth.

Van Cleeemput (1971) found that wet soil lost nitrates rapidly producing gaseous nitrogen in alkaline soils and nitrogen oxides in acid soils by denitrification.

Whenever ammonia is added to soil, the first chemical reaction is oxidation. Oxidation of ammonia or of the ammonium ions is a two-step process, with nitrite (NO₂⁻) as intermediate product and nitrate (NO₃⁻) the final one.

Building et al. (2005) mentioned that there is reduction in rice production at the Agricultural Research Station in India due to residual effect of ammonium sulphate and urea fertilizers in soil. Tisdale and Nelson (1993) pointed that there is a residual effect of nitrogen fertilizer added to the soybean in the US state of Illinois compared to fertilizer added to rice in sandy and sandy loam soils.

The use of huge amounts of nitrogenous fertilizers leads to the increase of nitrates in drinking water and rivers. It was observed that nitrate and ammonium ions dissolved in soil water and absorbed by plant roots, regardless of the existence of nitrogen form in the fertilizer which must be converted to nitrate or ammonium by microorganisms in the soil such as bacteria and fungi (Savci, 2012). However over the time, pollution, deterioration of soil fertility and soil reaction can cause imbalance of elements in the soil beside the accumulation of poisons ions in cultivating plants which lead to negative effects on human beings and animals (Correll, 1983). Russel (1973) found that Under suitable conditions, a heavy dressing of a nitrogen fertilizer to one crop can have a residual effect on the succeeding crop, as one would expect from the ability of some soils to store nitrates in their subsoil over winter. He found at Rothamsted, the average residual effect of 190 kg/ha N as sulphate of ammonia given to potatoes, for the following wheat crop was equivalent to 63 kg/ha N as top dressing in the spring, and that the residual effect of 125 kg/ha N top dressing on winter wheat was equivalent to 25 kg/ha N applied to the following potato crop.

2. Materials and methods

A study was conducted on a number of fields of the Barrak agricultural project in Wadi al-Shati in southern Libya in sandy soil classified as part of the Great Soil Group (Typic Torrifluvent).

The project have 22 wells, each well irrigates 12 farms. The soil samples were collected from the farms of 5 wells randomly as follows, farm 1 from well 18, farm 12 from well 19, farm 5 from well 20, farm 6 from well 21, and farm 10 from well 22. Soil samples were taken from four different depths: (0 – 45, 45 -90, 90 – 135 and 135 – 180 cm) for four times in year 2009 represent middle of each season, the first one in January, second one in April, third one in July and the fourth one in October. Three replicates (about 1 kg each) were taken from each depth and were collected in polythene bags and taken to laboratory, dried in air then sieved through 2 mm sieve. Soil samples of uncultivated soil near the site of experiment were taken as a reference (table 1).
Table 1. Some physical and chemical properties of virgin soil.

| Parameters                             | unit depth(cm) |
|----------------------------------------|----------------|
|                                        | 0-45          | 45-90         | 90-135        | 135-180        |
| pH                                     | 7.57          | 7.60          | 7.41          | 7.29           |
| Electrical conductivity                | ds.m⁻¹        | 0.66          | 1.78          | 1.84           | 1.85           |
| Total p                                | ppm           | 56.23         | 49.37         | 33.62          | 26.12          |
| Nitrate                                |               | 0.167         | 0.546         | 0.466          | 0.431          |
| Total calcium carbonate                | %             | 1.75          | 1.87          | 2.32           | 1.5            |
| Active calcium carbonate               |               | 0.12          | 0.07          | 0.05           | 0.05           |
| Organic matter                         |               | 0.06          | 0.06          | 0.06           | 0.05           |
| Total N                                |               | 0.035         | 0.035         | 0.018          | 0.018          |
| Humidity                               |               | 0.031         | 0.052         | 0.054          | 0.099          |
| Saturation                             |               | 26.25         | 20.50         | 26.55          | 22.85          |
| Field capacity                         |               | 14.28         | 13.55         | 13.55          | 10.07          |
| Soil texture                           |               | sandy          | sandy          | sandy          | sandy          |
| Cation exchange capacity               | ml equ.g⁻¹ soil | 2.874        | 2.330         | 2.473          | 2.373          |
| Available k                            |               | 0.23          | 0.23          | 0.11           | 0.15           |
| Calcium                                | mmole L⁻¹     | 20.0          | 18            | 21             | 20             |
| Ammonium                               |               | 0.032         | 0.0013        | 0.007          | 0.005          |
| Potassium                              |               | 5.12          | 8.80          | 8.71           | 8.09           |
| Sodium                                 |               | 25.2          | 27.6          | 26             | 28.3           |
| Chlorine                               |               | 0.3           | 0.8           | 0.9            | 1.15           |
| Sulphates                              |               | 93.8          | 102.0         | 110.4          | 135.4          |
| Carbonate                              |               | 0             | 0             | 0              | 0              |
| Bicarbonate                            |               | 0             | 0             | 0              | 0              |

Ammonium ion in soil was measured as mentioned by Walkley (1974), nitrate ion in soil was measured as described by Sommez et al. (2007), percentage of organic matter in soil was measured as mentioned by Kratzan et al. (2004). Cation exchange capacity, soil texture, percentage of active Calcium carbonate and available Potassium was measured as described by Franson (1995). Total phosphorus in soil was measured as described by Astofan and Abdullrashid (2003), Available phosphorus in soil was measured as mentioned by Watanable and Olsen (1965). Nitrogen in soil was determined as described by Keldahl (Black, 1965).

Farmers were usually using a urea (46% N) as a nitrogen source and complex fertilizer (46% P, 18% N), beside the organic fertilizer (animal manure) which contain 0.33% total nitrogen and 0.02 total Phosphorus from time to time randomly.

3. Results and Discussion

3.1. Total nitrogen with soil depth

Results in figure 1 showed that the total N concentrations decreased with increasing soil depths from 0 – 45, 45 – 90, 90 – 135, 135 – 190 cm in generally.
Figure 1. concentration of Total N\% dwt soil in 0 -45, 45 -90, 90 -135 and 135 – 180 cm depths.

Total N concentration in soil samples from farms of well 18 were : 0.16, 0.11,0.10 and 0.09\% dwt soil in the mentioned depths respectively, the statistical analysis for those values on 0.05 level indicated to a significant effect of depths on total N concentrations equal to 0.003. The decreasing percentage were 31.25, 37.5 and 43.75\% for second,third and fourth depth respectively comparing to the first depth.In the farms of well 19, the concentration of total N in the soil in the mentioned depths were 0.13, 0.10, 0.09 and 0.08 \% dwt soil, respectively, with a significant effect of depths on total N concentrations equal to 0.021. The decreasing percentage in total N concentration comparing to the first depth as follows : 23.07, 30.07 and 38.4\% respectively. In the farms of well 20, total N concentrations in soil samples were : 0.13, 0.11, 0.08 and 0.08 \% dwt soil, with a significant effect equal to 0.003 between them. The decreasing percentage comparing to the first depth about 15.3, 38.4 and 38.4\% respectively. In the farms of well 21, total N concentrations in the soil samples were : 0.12, 0.11, 0.08 and 0.08\% dwt soil, with a significant effect equal to 0.000. The decreasing percentage comparing to the first depth about 8.3, 33.3 and 33.3\% respectively. In the farms of well 22, total N concentrations in soil samples were : 0.13, 0.08, 0.08 and 0.07\% dwt soil, with a significant effect equal to 0.001. The decreasing percentage comparing to the first depth record 38.4, 38.4 and 46.1\% respectively.

Residual Total N concentration in the soil as mentioned before still high even after cultivation. Plants can used 50\% of applied nitrogenous fertilizers in ideal conditions (Troeh and Thompson 1993; Rezvan and Edalatifard 2012).

The previous results are in full agreement with those reported by Petersen et al. (2010). Rates of $N_{\text{PREV}}$ above 50-100 kg N/ha had no consistent effect on the soil N content, but this was up to 20\% greater than that in unfertilized treatments. Residual nitrogen can accumulate to sufficiently high levels so that no response to nitrogen fertilization, even with high yielding crops, is obtained (Hagin and Shmueli 1960).

3.2 Total N and duration of soil use

Results in figure 2 showed that concentrations of total N\% decreased with increasing duration of soil use from January, April, July and October.
Total N concentration in the soil samples of farms of well 18 at mentioned periods were: 0.19, 0.13, 0.11 and 0.08% dwt soil respectively, with a significant effect of duration on concentrations equal to 0.000 on 0.05 level. The decreasing percentage are 31.5, 42.1 and 57.8% on the order of the months comparing to January. In soil samples from farm of well 19 the concentrations of total N in depths comparing to time are: 0.12, 0.12, 0.09 and 0.07% dwt soil respectively, with a significant effect equal to 0.002. The decreasing of total N comparing to January as follows: 0.0, 25.0, and 41.6% respectively. In well 20, the concentration of total N in soil at the time of study were: 0.11, 0.12, 0.10 and 0.08% dwt soil respectively, with a significant effect equal to 0.016. The decreasing percentage of 9.0 and 27.2% with July and October and an increasing percentage of 9% with April comparing to January. In well 21, the concentration of total N% in soil samples were: 0.11, 0.11, 0.10 and 0.07% dwt soil respectively, with a significant effect equal to 0.000. Results shows an decreasing of total N comparing to January as follows: 0.0, 9.0 and 36.3%. In soil samples of farms of well 22, the concentration of total N comparing to time were: 0.11, 0.09, 0.07 and 0.09% dwt soil respectively, with a significant effect equal to 0.000. Results shows a decreasing of N comparing to January as follows: 18.1, 36.3 and 18.1% respectively.

![Figure 2](image_url)

**Figure 2** concentration of total N% at January, April, July and October

Van Der Pauw (1963) have shown that the value of the amount of soluble N in the whole rooting zone for the N supply of the crop should not be underestimated. This amount depends largely on the intensity rainfall, especially in winter, and on soil properties.

Bundy and Malone (1988); Ju et al. (2003) reported that the residual Nitrate in soil was an important N source for crops. It should be recognized that a large amount of accumulation Nitrate indicates that the amount of applied fertilizer N was much greater than the plant required for optimum crop yield. Therefore, the residual Nitrate may be lost from the soil-plant systems through leaching and denitrification.

In general results showed that the concentration of residual total N decreased along with downward of the depth and with increasing duration of soil use January, April, July and October. The residual total N
lost from the soil by leaching with inappropriate application may cause serious environmental risk such as nitrate pollution (shuyan Li 2017).

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