Rational Nitrogen Fertilization Plans for selected crops in dry and wet regions of Turkey

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Nitrogen fertilization plans

In order to implement the Nitrates Directive in Turkey, rational nitrogen fertilization plans were suggested for the main crops.

A set of factors was used to formulate a nitrogen balance sheet, for the various climatic zones of Turkey.

Factors have been taken into consideration:
- nitrogen uptake by plants for a targeted yield
- nitrogen losses (leaching, emissions)
- residual nitrogen
- input from rainfall or irrigation
- amount of nitrogen mineralisation.
Climate of Turkey

- Climatic conditions in Turkey varies greatly, and Turkey has been classified into seven agri climatic zones

Figure 1  Distribution of mean annual precipitation in Turkey
(State Meteorological Directorate, 2010)
The components of a rational fertilization plan for the main crops of Turkey

To calculate the required nitrogen per each crop, a Microsoft Office Excel spreadsheet was compiled. The components for N fertilization plans are:

\[ N_f = N_{\text{req}} - [(N_m + N_{\text{in}} + N_r) - (N_l + N_d + N_v + N_{\text{runoff}})] \]

where:
- \( N_f \) is the quantity of recommended N fertilizer
- \( N_{\text{req}} \) is the total N required to produce a crop of a targeted yield
- \( N_m \) is N released from crop residues and mineralized from SOM
- \( N_{\text{in}} \) is the residual plant available inorganic N
- \( N_r \) is the N input from rainfall
- \( N_l, \ N_d, \) and \( N_v \) are N losses through leaching, denitrification, and volatilization
- \( N_{\text{runoff}} \) is the quantity of N lost by runoff in the sloping areas
Table 1: Textural soil classes used for N fertilization

<table>
<thead>
<tr>
<th>Soil class</th>
<th>General soil texture</th>
<th>Mean clay% used for calculation of N leaching</th>
<th>SOM %</th>
<th>Nmin (kg/da)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Light</td>
<td>15</td>
<td>1%</td>
<td>1.0</td>
</tr>
<tr>
<td>III</td>
<td>Heavy</td>
<td>40</td>
<td>3%</td>
<td>4.0</td>
</tr>
</tbody>
</table>

10 da*= 1 ha
Table 2 Nitrogen and total water requirements for certain yield of the main crops in Turkey *

<table>
<thead>
<tr>
<th>Crops</th>
<th>Targeted yield (kg/da)</th>
<th>Required Nitrogen (kg/da)</th>
<th>Water requirements (mm/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple-pear trees</td>
<td>4500</td>
<td>23</td>
<td>712-800</td>
</tr>
<tr>
<td>Corn</td>
<td>1200</td>
<td>24</td>
<td>780</td>
</tr>
<tr>
<td>Wheat</td>
<td>400</td>
<td>10</td>
<td>446</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>9000</td>
<td>18</td>
<td>827</td>
</tr>
<tr>
<td>Potatoes</td>
<td>3000</td>
<td>14</td>
<td>465</td>
</tr>
</tbody>
</table>

*Soil, Water and Fertilizer Resources Central Research Institute, Ankara
Ombrothermic diagramme of Ankara

Ombrothermic diagramme of Trabzon
N mineralization (plant residues and manure)

In the absence of experimental results concerning the N mineralization dynamics in various soil classes, values were used in the fertilization plans (Table 4) which are almost similar with values used in the proposed fertilization plans for Greece (Karyotis et al., 2002).

Table 3  Nitrogen mineralization in various soil classes

<table>
<thead>
<tr>
<th>SOM %</th>
<th>SOC %</th>
<th>Nmin (kg/da)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>1%</td>
<td>0.58%</td>
</tr>
<tr>
<td>Class III</td>
<td>3%</td>
<td>1.74%</td>
</tr>
</tbody>
</table>
Table 4  Values for residual nitrogen in the arable soils of Turkey

<table>
<thead>
<tr>
<th>SOM %</th>
<th>Residual N (kg/da)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I 1%</td>
<td>2.0</td>
</tr>
<tr>
<td>Class III 3%</td>
<td>4.0</td>
</tr>
</tbody>
</table>
Table 5  Nitrogen inputs from irrigation

<table>
<thead>
<tr>
<th>Nitrates (mg/l)</th>
<th>Quantity of irrigation water (m³/da)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
</tr>
<tr>
<td>10</td>
<td>0.452</td>
<td>0.678</td>
<td>0.904</td>
<td>1.130</td>
<td>1.36</td>
</tr>
<tr>
<td>20</td>
<td>0.904</td>
<td>1.356</td>
<td>1.808</td>
<td>2.260</td>
<td>2.720</td>
</tr>
<tr>
<td>30</td>
<td>1.356</td>
<td>2.034</td>
<td>2.712</td>
<td>3.390</td>
<td>4.068</td>
</tr>
<tr>
<td>40</td>
<td>1.808</td>
<td>2.712</td>
<td>3.616</td>
<td>4.520</td>
<td>5.440</td>
</tr>
<tr>
<td>50</td>
<td>2.260</td>
<td>3.390</td>
<td>4.520</td>
<td>5.650</td>
<td>6.780</td>
</tr>
</tbody>
</table>
N deposition (wet)

The amount of nitrogen which originates from precipitation varies and the following quantities were used: 0.5 kg N/da/y and 1.0 kg N/da/y, for the respective rainfall regimes where the annual precipitation is 500 and 1.500 mm.

In general, annual nitrogen inputs from rainfall ranges between 3 and 5 kg N/ha in drier environments (McNeill and Unkovich 2007) and are higher in wet and polluted environments.
Nitrous oxide emissions
Emissions from commercial fertilizer use can be estimated using the following equation:

\[ \text{N}_2\text{O Emissions} = (\text{FC} \times \text{EC} \times 44/28) \]

FC = Fertilizer Consumption (tons N-applied);
EC = Emission Coefficient = 0.0117 tons N\textsubscript{2}O-N/ton N applied; and
44/28 = The molecular weight ratio of N\textsubscript{2}O to N\textsubscript{2}O as N(N\textsubscript{2}O/N\textsubscript{2}O-N).

Denitrification
An average value 16.8 kg N ha\textsuperscript{-1} (equivalent to 1.68 kg N da\textsuperscript{-1}) was suggested. This is the average value derived from 10 years experiments (David et al., 2006) in arable areas and seems to be at normal level.
Nitrates Leaching
In the absence of experimental data, various countries have used pedotransfer functions and leaching is included as a component of N fertilization plans. De Willigen (2000) developed a regression model to estimate the amount of leached N. The pedotransfer function used in this report consists of the following factors:

\[ N_{\text{leaching}} \text{ (kg/ha)} = 21.37 + (P/C \times L) \times (0.0037 \times N_{fr,m} + 0.0000601 \times O_c - 0.00362 \times N_u) \]

where:

| \( P \) | annual precipitation (mm/year); |
| \( C \) | clay content (percent); |
| \( L \) | rooting depth (m); |
| \( N_{fr,m} \) | applied inorganic, residual and mineralized fertilizer N; |
| \( O_c \) | organic carbon content of the soil (percent); |
| \( N_u \) | N uptake by the crop (kg/ha/year). |
Table 6: Effective rooting depth for selected crops (FAO, 1998)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Root depth under irrigation (m)</th>
<th>Rainfed conditions (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>0.75</td>
<td>1.5</td>
</tr>
<tr>
<td>Potato</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Sugar Beet</td>
<td>0.75</td>
<td>1.2</td>
</tr>
<tr>
<td>Cotton</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Wheat, Barley</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Maize, (grain)</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Apples, Cherries, Pears, Peaches</td>
<td>1.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*The smaller values may be used for irrigated crops and the higher values for rainfed conditions*
Results and discussion

Amount of applied N (kg/ha) from inorganic fertilizers and manure in the provinces of Turkey
<table>
<thead>
<tr>
<th>CORN</th>
<th>Soil Class I</th>
<th>Soil Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required nitrogen</strong> (kg/da)</td>
<td>24.00</td>
<td></td>
</tr>
<tr>
<td>Soil texture (decreased biomass production)</td>
<td>Soil Class I (-30%)</td>
<td>Soil Class III (-10%)</td>
</tr>
<tr>
<td>Decreased fertilization (kg/da)</td>
<td>-7.20</td>
<td>-2.4</td>
</tr>
<tr>
<td>Nmineralization (SOM) (N kg/da)</td>
<td>-1.00</td>
<td>-4.0</td>
</tr>
<tr>
<td>Residual N in the root zone (kg/da)</td>
<td>-2.00</td>
<td>-4.0</td>
</tr>
<tr>
<td><strong>N input from irrigation</strong> (NO₃ content 10 mg/l)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen from irrigation with 500 (tn/da) (N g/m³)</td>
<td>-1.13</td>
<td>-1.13</td>
</tr>
<tr>
<td>Leaching R=500 mm/y (kg N/da)</td>
<td>2.50</td>
<td>2.0</td>
</tr>
<tr>
<td>N input from rainfall (kg/y/da)</td>
<td>-0.50</td>
<td>-0.5</td>
</tr>
<tr>
<td>N₂O emissions (kg/da)</td>
<td>0.195</td>
<td>0.195</td>
</tr>
<tr>
<td>N₂ emission from denitrification (kg/da)</td>
<td>1.68</td>
<td>1.68</td>
</tr>
<tr>
<td>Ammonia volatiliz. (10% of req. Nitrogen) kg/da</td>
<td>2.40</td>
<td>2.40</td>
</tr>
<tr>
<td><strong>N recommended (slope &lt;6%)</strong> (kg N/da)</td>
<td>18.9</td>
<td>18.1</td>
</tr>
</tbody>
</table>
### Table 8  RAINFALL REGIME 500 mm/year

<table>
<thead>
<tr>
<th>CROP</th>
<th>Required nitrogen (kg/da)</th>
<th>Recommended N (kg/da) SOIL CLASS I</th>
<th>Recommended N (kg/da) SOIL CLASS II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple, pear trees</td>
<td>23.0</td>
<td>18.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Corn</td>
<td>24.0</td>
<td>18.9</td>
<td>18.1</td>
</tr>
<tr>
<td>Potatoes</td>
<td>14.0</td>
<td>10.9</td>
<td>8.0</td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>18.0</td>
<td>14.3</td>
<td>12.7</td>
</tr>
<tr>
<td>Tomato</td>
<td>20.0</td>
<td>16.1</td>
<td>14.9</td>
</tr>
<tr>
<td>Wheat</td>
<td>10.0</td>
<td>8.6</td>
<td>5.0</td>
</tr>
</tbody>
</table>

### Table 9  RAINFALL REGIME 1500 mm/year

<table>
<thead>
<tr>
<th>CROP</th>
<th>Required nitrogen (kg/da)</th>
<th>Recommended N (kg/da) SOIL CLASS I</th>
<th>Recommended N (kg/da) SOIL CLASS II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple, pear trees</td>
<td>23.0</td>
<td>19.3</td>
<td>18.2</td>
</tr>
<tr>
<td>Corn</td>
<td>24.0</td>
<td>20.1</td>
<td>19.2</td>
</tr>
<tr>
<td>Potatoes</td>
<td>14.0</td>
<td>11.8</td>
<td>9.0</td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>18.0</td>
<td>15.1</td>
<td>13.5</td>
</tr>
<tr>
<td>Tomato</td>
<td>20.0</td>
<td>16.7</td>
<td>15.5</td>
</tr>
<tr>
<td>Wheat (rainfed)</td>
<td>10.0</td>
<td>9.4</td>
<td>5.9</td>
</tr>
</tbody>
</table>
Conclusions

- The recommended amount of nitrogen fertilization in both soil classes for dry and wet regions of Turkey varied significantly depending mainly on nitrates leaching.

- Nitrates leaching was higher around 5 kg/ha in the coarse soils in comparison to heavy soils.

- Nitrates leaching was also higher in the wet regions of Turkey.

- Best timing to apply N fertilizer is the period of rapid N uptake in order to minimize N leaching from the field, especially in wet regions (i.e. Black Sea).

- Irrigation methods, such as drip and sprinkler irrigation, assist to reduce deep percolation, which results to nitrates pollution of shallow aquifers.

- Decreased N fertilization can be applied without significant yield reduction and this can be explained by increased N use efficiency, as a result of proper time of application and splitting of N fertilizers in doses.
Acknowledgments
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