Calculation of nitrogen fertiliser requirements for grain crops, using soil-residual ammonium and nitrate analyses

The nitrogen fertiliser requirements of grain crops are not conventionally calculated according to the results from soil analyses, as is done with other plant nutrients (P, K, etc.). This is because the nitrogen forms that occur in the soil and are used by plants, are highly mobile through leaching and volatilisation.

Plant roots take up nitrogen from the soil solution principally as inorganic ammonium (NH$_4^+$) and nitrate (NO$_3^-$) ions. Firstly, the ammonium ions are mineralised from organic amino groups by soil micro-organisms, and finally, nitrate is formed from ammonium through nitrification.

Research done on dryland maize in the Republic of South Africa has shown that the recommendations regarding nitrogen fertilisation for grain crops can be scientifically adjusted taking soil-residual NO$_3^-$, or residual NH$_4^+$ and NO$_3^-$ into account.

**IMPORTANT RESEARCH FINDINGS**

The following significant findings concerning relative maize yield were recorded:

- In dryland cropping where only one crop is planted a year, most of the NH$_4^+$ has been converted to NO$_3^-$ by planting time. Only residual nitrate-nitrogen (NO$_3^-$-N) need then be analysed.
- Residual NO$_3^-$-N determined after the previous harvest accounted for 34% of the variation in the relative yield of maize planted in the following season.
- The application rate of fertiliser nitrogen alone could only account for 29% of the variation in relative yield of maize.
- Residual NO$_3^-$-N determined before planting accounted for 81% of the variation in relative yield of maize.
- Correlations between relative maize yield and residual NO$_3^-$-N from 0 to 600 mm soil depth were better than correlations between relative maize yield and residual NO$_3^-$-N from 0 to 300 mm.
- In one study, 72% of the variation in relative yield of maize could be accounted for by taking the nitrogen fertiliser application rate and soil NO$_3^-$-N (0 to 600 mm) into account. When data from two different studies were pooled, the combination of the nitrogen fertiliser application rate and NO$_3^-$-N accounted for 59% of the variation in relative maize yield.

Residual NH$_4^+$-N and NO$_3^-$-N are determined using the 1 N KCl extraction method.

**RECOMMENDED PRACTICE**

In applying this practice of determining soil-residual nitrogen in the field, the following aspects are important:

- Take soil samples for analysis as close to planting time as possible before planting.
- Take samples at 0–300 mm and 300–600 mm soil depths. The average of these two samples will be used in the calculations.
- Although determining both residual NH$_4^+$-N and NO$_3^-$-N may be undertaken, in ‘one-crop-per-year’ conditions, most NH$_4^+$-N would already have undergone nitrification – so only residual NO$_3^-$-N need be determined.
- For determining residual NH$_4^+$-N, it is important that samples are kept cool (e.g. in a cool box) and delivered to the laboratory as soon as possible.
- If laboratory results are not yet available by planting time, plant with an optimum amount of nitrogen. Nitrogen side-dressings may then be adjusted taking laboratory results into account.
CALCULATION FOR RESIDUAL NO₃-N

The following formula may be used to calculate residual NO₃-N in the field in kilograms per hectare:

\[
\text{Soil-residual NO₃-N (kg/ha)} = \frac{\text{NO₃-N (ppm) × 9}}{1,500 \text{ kg/m}^3}
\]

Where * is the NO₃-N (ppm) analysis for 0-600 mm.
Where 9 is the factor used if bulk density of the soil is assumed to be 1,500 kg/m³. This factor (9) must be reduced if NO₃-N (ppm) is only determined at reduced soil depth (4.5 for NO₃-N at 0 to 300 mm).

CALCULATION OF NITROGEN FERTILISER REQUIREMENT

Example:

**Supplied information**
- Potential/planned maize yield = 3 t/ha
- Nitrogen fertiliser recommended (conventional) = 45 kg/ha
- Residual NO₃-N (0-600 mm) (laboratory analysis) = 1.5 ppm

**Calculation:** Soil-residual NO₃-N (kg/ha)
- 1.5 ppm × 9 = 13.5 (≈13) kg/ha

**Calculation:** Nitrogen fertiliser application (kg/ha)
- 45 kg/ha N needed minus 13 kg/ha residual NO₃-N = 32 kg/ha

ECONOMIC VALUE

In the above example, a nitrogen saving of 13 kg N/ha from the conventional nitrogen application recommendation (45 kg/ha) is realised.

Table 1 below shows the savings that could be realised at different probable nitrogen fertiliser costs (N$/kg N) for different probable field areas planted:

<table>
<thead>
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<th>Field area (ha)</th>
<th>6.00</th>
<th>8.00</th>
<th>10.00</th>
<th>12.00</th>
<th>14.00</th>
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<td>104.00</td>
<td>130.00</td>
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<td>1,040.00</td>
<td>1,300.00</td>
<td>1,560.00</td>
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<tr>
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<td>7,800.00</td>
<td>10,400.00</td>
<td>13,000.00</td>
<td>15,600.00</td>
<td>18,200.00</td>
</tr>
</tbody>
</table>

References


Bloem, AA. 2005. Personal communication; Assistant Director, Soil Science, North West Agricultural Development Institute, Department of Agriculture, Potchefstroom, South Africa.


Author: HJF Grobler; Directorate of Agricultural Research and Training; Ministry of Agriculture, Water and Forestry, PO Box 464, Mariental, Namibia (Tel. 063-240389).

Photographs: HJF Grobler (as above)

Content Editor: Paul van der Merwe; Directorate of Agricultural Research and Training; Ministry of Agriculture, Water and Forestry, Private Bag 13184, Windhoek, Namibia.

Language Editor: The Word Factory, PO Box 11465, Windhoek.