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Spotlight on Agriculture

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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.

Maize

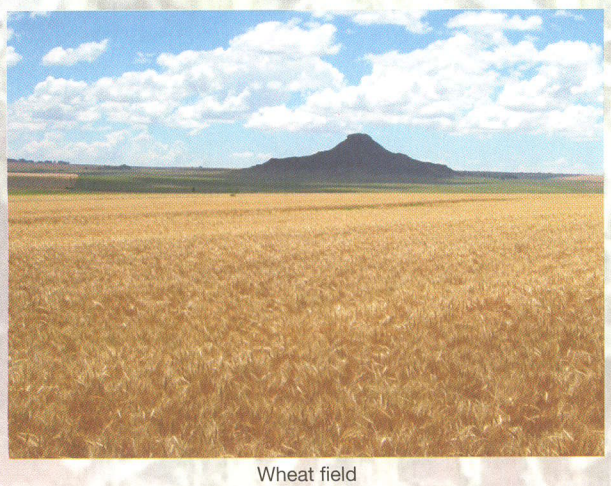
IMPORTANT RESEARCH FINDINGS

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



Wheat field

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 NO_3-N

The following formula may be used to calculate residual NO_3-N in the field in kilograms per hectare:

Soil-residual NO_3–N (kg/ha) = NO_3–N (ppm)[a] x 9[ß]

Where [a] is the NO_3–N (ppm) analysis for 0–600 mm.

Where [ß] is the factor used if bulk density of the soil is assumed to be 1,500 kg/m^3. This factor (9) must be reduced if NO_3–N (ppm) is only determined at reduced soil depth (4.5 for NO_3–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$^{\Omega}$**
Residual NO_3–N (0–600 mm) (laboratory analysis)	=	1.5 ppm
Calculation: Soil-residual NO_3–N (kg/ha)		
1.5 ppm x 9	=	13.5 (≈13) kg/ha
Calculation: Nitrogen fertiliser application (kg/ha)		
45 kg/ha N$^{\Omega}$ needed minus 13 kg/ha residual NO_3–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 1: Projected savings (N$) on nitrogen fertiliser at different probable costs per kilogram N and different field areas planted

Field area (ha)	Probable cost of nitrogen (N$/kg)				
	6.00	8.00	10.00	12.00	14.00
1	78.00	104.00	130.00	156.00	182.00
10	780.00	1,040.00	1,300.00	1,560.00	1,820.00
100	7,800.00	10,400.00	13,000.00	15,600.00	18,200.00

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