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# Determination of Plant Available Nitrogen of Erzurum Plain Soils

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The purpose of this investigation is to determine most suitable chemical extraction method(s) for determining plant available nitrogen in Erzurum plain soils. For this purpose 22 representative soil samples (cultivated and uncultivated) were sampled. A glasshouse experiment was conducted using randomized block design, each test plant replicated three times. Corn (*Zea mays* L.Var. Karadeniz Yildizi) plants were harvested 8 weeks after germination and dry matter, nitrogen and total nitrogen uptake of the test plants were determined. In order to determine available nitrogen contents of soils, 10 different chemical methods were used. On the other hand, in order to select the most suitable chemical extraction methods mainly, dry matter content, nitrogen content and nitrogen uptake of test plants were taken as biological indexes. The results of the correlation analysis showed clearly reported methods gave the highest correlation with biological indexes. As a results of data obtained it may be concluded that the most suitable chemical methods may be used in determining available nitrogen contents of Erzurum plain soils.

**Key Words: N-Availability, Soil-N tests, N-Availability indexes, N-Extraction methods.**

## INTRODUCTION

Nitrogen is one of the most widely distributed elements in nature. It is present in the atmosphere, the lithosphere and the hydrosphere. The atmosphere is the main reservoir for nitrogen. The soil acconts for only a minute fraction of lithospheric nitrogen and of this soil nitrogen, only a very small proportion is directly available to plants[1]. Chemical soil analysis indicates the potential availability of nutrients that roots may take up under conditions favourable for root growth and root activity. The most direct way of determining nutrient availability in soils is to measure the growth responses of plants by means of field fertilizer trials. This is a time-consuming procedure, however and the results are not easily extrapolated from one location to another. In contrast, chemical soil analysis-soil testing are

comparatively rapid and inexpensive procedure for obtaining information on nutrient availability in soils as a basis for recommending fertilizer application. Soil testing has been practised in agriculture and horticulture for many years with the relative success. The effectiveness of procedure is closely related to extent to which the data can be calibrated with field fertilizer trials, as well as to the interpretion of the analysis. Soil testing make use of whole range of conventional extraction methods involving different forms of dilute acids, salts or complexing agents. Depending on the method used, quite different amounts of plant nutrient have been extracted. This method is the most suitable for characterizing the availability of a given mineral nutrient and thus for predicting fertilizer response must be evaluated by means of growth experiments. Quite often several methods are equally suitable for soil testing of the some mineral nutrients[2]. The properly soil testing gives the most accurate assesment of the nutrient environment of the plant. When supported by research and interpreted properly it gives the best estimation of fertilizer needs. A soil test measures the amount of nutrient soluble in the chemical reagent used. It is not a measure of the absolute nutrient level in the soil but is an index which can indicate the nutrient supplying power of the soil over the next growing seasons. Since a soil test value is only an index, it is of no value unless backed by extensive correlation studies which tell us how much fertilizer, if any, is needed to produce a healthy crop or plant.

There have been many studies for determining suitable extraction method for different soil conditions[3-13]. The purpose of this investigation is to determine nitrogen status of Erzurum plain soils and also to find out most suitable chemical extraction methods (nitrogen index) to be used in determining plant available nitrogen in these soils.

## EXPERIMENTAL

Some physico chemical properties of the soil sample were determined as follows; grain size distribution[14], pH in 1:2.5 (w/v) soil water suspension by pH meter, organic material by using modified Walkley-Black method[15], lime content by Scheibler Calsimeter[16], available potassium, calcium and magnesium in 1:5 (w/v) soil moisture capacity[17].

Corn plants were grown in pots under glasshouse conditions using randomized block design and each test plants replicated three times[18]. Plants were harvested 8 weeks after germination and dry matter amount, nitrogen content and total nitrogen uptake of the test plants were determined. In determining plant available nitrogen contents of experiment soils the following several different chemical methods[19-23] are given in Table-1.

The correlations between different chemical methods extracted available soil nitrogen with biological index were calculated[24].

TABLE-1
NITROGEN AVAILABILITY EXTRACTION METHODS
USED IN ERZURUM PLAIN SOILS

| Extraction procedure | Available nitrogen | Ref. |
|---|---|---|
| Extractant: 2 M KCl Extraction rate:30 g soil /100 mL 2 M KCl, Shaking time: 1 h | Initial $NH_4$-N and $NO_3$-N (ppm) | 19 |
| Extractant: 0.7 g $Ca(OH)_2$ extraction rate: 10 g toprak + 0.7 g $Ca(OH)_2$; 200 mL distilled water | $NH_4$-N (ppm) $NH_4 + NO_3$ (ppm) | 20 |
| Extractant: 32 % $KMnO_4$ and 2.5 % NaOH Extraction rate: 20 g soil; 100 mL 32 % $KMnO_4$ and 100 mL 2.5 % NaOH | $NH_4$-N (ppm) $NH_4 + NO_3$ (ppm) | 21 |
| Extractant: 1:4 $KMnO_4$ and $NaCO_3$ Extraction rate: 10 g soil; 10 g $KMnO_4$ + $NaCO_3$ 200 mL distilled water | $NH_4$-N (ppm) | 23 |
| Extractant: 0.1 N $Ba(OH)_2$ Extraction rate: 10 g soil: 100 mL 0.1 N $Ba(OH)_2$ Extraction time: 0.5 h | Extractable nitrogen (%) $(NH_4 + NO_3)$-N | – |
| Extractant: 1 N $H_2SO_4$ + 0.1 N $KMnO_4$. Extraction rate: 1 g soil + 25 mL 0.1 N $KMnO_4$/1 N $H_2SO_4$ Extraction time: 1 h | Hydrolizable organic soil nitrogen $NH_4$-N (ppm) | 22 |
| Total nitrogen was assessed using the Kjeldahl method | Total nitrogen (%) | – |

## RESULTS AND DISCUSSION

22 Surface soils represeting in Erzurum soils were chosen for the glass-house experiments.The pH values, $CaCO_3$ contents, organic matter, CEC, texture class of Erzurum plain soils were found: 6.86-8.26, 1.01-13.9, 0.46-3.60, 20.42-55.55, L-CL-S-L, respectively (Table-2).

TABLE-2a
SOME PHYSICAL AND CHEMICAL PROPERTIES OF
EXPERIMENT SOILS

| Soil samp | Ca (cmol/kg) | Mg (cmol/kg) | P (ppm) | Clay (%) | Silt (%) | Sand (%) | Moisture (%) |
|---|---|---|---|---|---|---|---|
| 1 | 12.19 | 11.28 | 17.01 | 19.31 | 27.54 | 52.55 | 5.93 |
| 2 | 13.17 | 11.64 | 13.95 | 19.96 | 27.60 | 52.44 | 6.16 |
| 3 | 12.19 | 10.50 | 18.36 | 23.98 | 31.15 | 44.89 | 3.83 |
| 4 | 14.04 | 9.98 | 21.92 | 13.50 | 33.75 | 52.75 | 5.48 |
| 5 | 13.85 | 11.37 | 22.47 | 19.92 | 38.14 | 37.71 | 5.93 |
| 6 | 13.75 | 11.64 | 19.87 | 15.60 | 35.83 | 48.57 | 5.37 |
| 7 | 13.65 | 11.46 | 17.62 | 13.50 | 46.41 | 40.09 | 5.48 |

| Soil samp | Ca (cmol/kg) | Mg (cmol/kg) | P (ppm) | Clay (%) | Silt (%) | Sand (%) | Moisture (%) |
|---|---|---|---|---|---|---|---|
| 8 | 13.65 | 11.90 | 17.50 | 13.50 | 39.97 | 46.53 | 5.49 |
| 9 | 13.27 | 11.12 | 16.86 | 13.52 | 42.28 | 42.40 | 3.52 |
| 10 | 13.55 | 10.94 | 23.25 | 9.65 | 51.87 | 38.48 | 3.73 |
| 11 | 13.07 | 10.50 | 46.91 | 17.32 | 37.11 | 45.57 | 3.10 |
| 12 | 13.27 | 10.50 | 73.05 | 21.69 | 33.06 | 45.25 | 3.31 |
| 13 | 13.85 | 11.28 | 23.72 | 30.29 | 33.20 | 36.51 | 3.73 |
| 14 | 13.65 | 11.46 | 18.11 | 17.41 | 35.25 | 47.36 | 3.63 |
| 15 | 13.56 | 10.50 | 27.59 | 23.74 | 33.31 | 42.95 | 4.10 |
| 16 | 13.56 | 10.59 | 26.74 | 19.67 | 36.66 | 43.67 | 4.60 |
| 17 | 13.65 | 11.55 | 24.19 | 17.61 | 29.34 | 33.05 | 4.80 |
| 18 | 13.46 | 10.85 | 32.68 | 15.33 | 47.66 | 37.01 | 3.60 |
| 19 | 12.77 | 10.24 | 26.38 | 4.91 | 30.67 | 64.42 | 2.25 |
| 20 | 13.26 | 10.24 | 16.19 | 4.92 | 34.84 | 60.24 | 2.46 |
| 21 | 13.56 | 9.63 | 21.04 | 13.22 | 33.66 | 53.72 | 3.31 |
| 22 | 13.28 | 9.63 | 20.09 | 9.11 | 43.48 | 47.41 | 3.52 |

TABLE-2b
SOME PHYSICAL AND CHEMICAL PROPERTIES OF EXPERIMENTAL SOILS

| Soil samp | pH 1:2.5 | $CaCO_3$ (%) | Org. matter (%) | CEC (cmol $kg^{-1}$) | Na (cmol $kg^{-1}$) | K (cmol $kg^{-1}$) |
|---|---|---|---|---|---|---|
| 1 | **6.86** | 1.29 | 2.57 | 49.60 | 0.39 | 2.45 |
| 2 | 6.93 | **1.01** | 4.49 | 52.10 | 0.35 | 2.25 |
| 3 | 7.82 | 4.33 | **0.46** | **55.55** | 0.37 | 2.71 |
| 4 | 7.44 | 5.31 | 3.79 | 47.58 | 0.41 | 2.33 |
| 5 | 8.82 | 7.16 | 3.55 | 49.19 | 0.70 | 3.69 |
| 6 | **8.26** | 8.23 | 2.04 | 45.80 | 0.86 | 1.36 |
| 7 | 8.10 | 6.74 | 1.98 | 48.27 | 0.90 | 1.99 |
| 8 | 7.92 | 4.36 | 2.79 | 51.34 | 0.78 | 1.71 |
| 9 | 7.92 | 3.16 | 0.79 | 38.84 | 0.53 | 1.53 |
| 10 | 7.89 | 2.96 | 1.56 | 36.01 | 0.78 | 0.84 |
| 11 | 7.39 | 1.07 | 1.20 | 29.98 | 0.43 | 2.72 |
| 12 | 7.44 | 1.36 | 2.63 | 29.75 | 0.51 | 3.76 |
| 13 | 7.88 | 4.92 | 3.43 | 44.57 | 0.49 | 1.20 |
| 14 | 8.02 | 5.51 | 2.53 | 32.64 | 0.76 | 1.11 |
| 15 | 7.96 | 7.94 | 2.39 | 44.19 | 0.39 | 2.15 |
| 16 | 7.85 | 10.16 | **3.60** | 49.93 | 0.41 | 3.72 |
| 17 | 8.10 | **13.97** | 2.24 | 40.74 | 0.86 | 1.68 |
| 18 | 8.34 | 5.57 | 3.31 | 37.92 | 0.72 | 3.01 |
| 19 | 7.31 | 1.04 | 1.63 | 22.85 | 0.45 | 1.26 |
| 20 | 7.33 | 2.59 | 1.74 | **20.42** | 0.39 | 1.65 |
| 21 | 7.67 | 2.88 | 1.21 | 30.83 | 0.39 | 1.54 |
| 22 | 7.66 | 3.10 | 1.55 | 35.77 | 0.44 | 1.89 |

Dry matter yield, total nitrogen content and nitrogen uptake of test plants were determined and values shown in Table-3.

TABLE-3
DRY MATTER YIELD, NITROGEN CONTENT AND NITROGEN UPTAKE OF CORN PLANTS GROWN IN ERZURUM PLAIN SOIL SAMPLES

| Soil no. | Dry matter (g $pot^{-1}$) | Nitrogen content (%) | Nitrogen uptake (mg $pot^{-1}$) |
|---|---|---|---|
| 1 | 11.48 | 0.83 | 95.28 |
| 2 | 9.84 | 0.75 | 73.80 |
| 3 | 6.73 | 0.65 | 43.75 |
| 4 | 13.15 | 1.70 | 223.6 |
| 5 | 2.35 | 0.94 | 22.09 |
| 6 | 2.63 | 1.21 | 31.82 |
| 7 | 6.54 | 0.80 | 52.32 |
| 8 | 6.89 | 0.52 | 35.83 |
| 9 | 5.20 | 0.68 | 35.36 |
| 10 | 10.90 | 0.80 | 87.20 |
| 11 | 13.08 | 0.64 | 83.71 |
| 12 | 13.67 | 0.64 | 87.49 |
| 13 | 8.36 | 1.03 | 86.11 |
| 14 | 6.86 | 0.81 | 55.57 |
| 15 | 6.31 | 0.83 | 52.37 |
| 16 | 13.98 | 1.05 | 146.79 |
| 17 | 5.22 | 0.77 | 40.19 |
| 18 | 5.25 | 0.91 | 47.78 |
| 19 | 10.18 | 0.66 | 67.19 |
| 20 | 9.78 | 0.59 | 57.70 |
| 21 | 5.05 | 0.65 | 32.83 |
| 22 | 10.46 | 0.66 | 69.04 |

For determination of available nitrogen contents of Erzurum plain soils different chemical methods were used. Results were shown in Table-4.

The results of this study showed that plant available nitrogen obtained with reported methods[19-23] were interelated with biological indexes in the Erzurum plain soils respectively. Results also showed that this methods might be used for plant available nitrogen at least in the soils invastigated[24] (Table-5).

TABLE-4
CONCENTRATIONS OF AVAILABLE NITROGEN OBTAINED DIFFERENT CHEMICAL EXTRACTION METHODS IN ERZURUM PLAIN SOILS

| Method | Ref. 19 | Ref. 19 | Ref. 20 | Ref. 20 | Ref. 21 | Ref. 21 | Ref. 23 | Ref. 26 | Ref. 22 | Ref. 25 |
|---|---|---|---|---|---|---|---|---|---|---|
| Soil no. | $NH_4$ (ppm) | $NO_3$ (ppm) | $NH_4$ (ppm) | $NH_4 + NO_3$ (ppm) | $NH_4$ (ppm) | $NH_4 + NO_3$ (ppm) | $NH_4$ (ppm) | $NH_4 + NO_3$ (ppm) | Hidrolizable $NH_4$ (ppm) | Total soil no. (%) |
| 1 | 4.80 | 3.00 | 7.00 | 9.80 | 52.50 | 60.55 | 39.20 | 35.0 | 77 | 0.07 |
| 2 | 20.65 | 7.70 | 32.20 | 99.10 | 71.40 | 179.90 | 210.40 | 46.2 | 119 | 0.17 |
| 3 | 17.85 | 7.00 | 20.30 | 100.10 | 53.55 | 71.55 | 168.00 | 37.8 | 63 | 0.04 |
| 4 | 63.00 | 15.05 | 122.50 | 375.20 | 146.3 | 293.30 | 380.00 | 156.8 | 189 | 0.23 |
| 5 | 26.95 | 10.50 | 42.00 | 205.10 | 143.5 | 242.90 | 315.00 | 63.0 | 70 | 0.13 |
| 6 | 6.50 | 3.10 | 9.10 | 16.00 | 38.50 | 99.00 | 68.60 | 42.0 | 42 | 0.09 |
| 7 | 4.87 | 3.45 | 40.60 | 208.60 | 67.90 | 267.40 | 270.00 | 86.8 | 119 | 0.09 |
| 8 | 6.15 | 3.75 | 10.50 | 31.50 | 60.90 | 126.00 | 103.60 | 49.0 | 63 | 0.13 |
| 9 | 10.50 | 4.00 | 20.30 | 79.80 | 48.65 | 156.10 | 113.50 | 35.0 | 49 | 0.06 |
| 10 | 33.95 | 9.70 | 61.60 | 176.40 | 94.50 | 347.90 | 159.60 | 155.0 | 161 | 0.08 |
| 11 | 10.15 | 6.75 | 18.20 | 62.30 | 84.00 | 116.90 | 190.40 | 70.0 | 84 | 0.05 |
| 12 | 24.50 | 8.40 | 67.90 | 329.00 | 53.90 | 116.90 | 295.60 | 103.6 | 154 | 0.07 |
| 13 | 15.75 | 4.55 | 15.40 | 72.80 | 46.20 | 99.75 | 215.60 | 42.0 | 105 | 0.12 |
| 14 | 11.55 | 4.20 | 9.10 | 45.50 | 49.35 | 82.25 | 226.80 | 35.0 | 77 | 0.09 |
| 15 | 14.70 | 4.90 | 17.50 | 82.10 | 50.40 | 96.60 | 93.80 | 46.2 | 105 | 0.06 |
| 16 | 60.55 | 20.3 | 160.30 | 436.10 | 45.50 | 67.90 | 250.60 | 88.2 | 266 | 0.10 |
| 17 | 18.20 | 7.00 | 42.70 | 142.80 | 69.30 | 197.40 | 112.00 | 58.8 | 70 | 0.07 |
| 18 | 14.00 | 5.95 | 33.60 | 84.00 | 61.95 | 124.95 | 145.60 | 61.6 | 70 | 0.10 |
| 19 | 11.20 | 5.60 | 21.00 | 58.80 | 45.50 | 99.40 | 154.00 | 35.0 | 91 | 0.05 |
| 20 | 11.55 | 3.90 | 18.20 | 56.00 | 50.10 | 79.10 | 75.60 | 35.0 | 84 | 0.08 |
| 21 | 8.05 | 4.65 | 18.20 | 56.70 | 48.65 | 100.10 | 61.60 | 57.4 | 70 | 0.05 |
| 22 | 23.10 | 6.30 | 39.20 | 148.40 | 91.35 | 270.90 | 212.60 | 77.0 | 91 | 0.05 |

TABLE-5
THE LINEAR CORRELATION COFFICIENTS BETWEEN DIFFERENT NITROGEN EXTRACTION METHODS WITH BIOLOGICAL INDEXES FOR ERZURUM PLAIN

| MbaChib I Ref. 19 | MbaChib II Ref. 19 | Prasad I Ref. 20 | Prasad II Ref. 20 | Sahrawat *et al.* Ref. 21 | Sahrawat *et al.* Ref. 21 | Synghal Ref. 23 | Keeney *et al.* Ref. 26 | Satandford and Smith Ref. 22 | Bremner (Kjeldahl) Ref. 25 | Dry matter (g $pot^{-1}$) | Plant nitrogen content (%) | Plant nitrogen uptake (mg $pot^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.911** | 0.865** | 0.890** | 0.438** | 0.406** | 0.678** | 0.644** | 0.464** | 0.418** | 0.438** | 0.410** | 0.667** |
| | | 0.784** | 0.792** | 0.348* | 0.287 | 0.582** | 0.435** | 0.314* | 0.357* | 0.273 | 0.420** | 0.534** |
| | | | 0.904** | 0.321* | 0.285 | 0.587** | 0.668** | 0.454** | 0.397** | 0.479** | 0.360* | 0.666** |
| | | | | 0.374* | 0.351* | 0.724** | 0.664** | 0.397** | 0.334* | 0.444** | 0.301* | 0.601** |
| | | | | | 0.747** | 0.613** | 0.572** | 0.128 | 0.548** | 0.089 | 0.160 | 0.171 |
| | | | | | | 0.475** | 0.670** | 0.204 | 0.338* | 0.044 | 0.087 | 0.096 |
| | | | | | | | 0.547** | 0.335* | 0.530** | 0.303* | 0.273 | 0.423** |
| | | | | | | | | 0.350* | 0.369* | 0.443** | 0.221 | 0.530** |
| | | | | | | | | | 0.373* | 0.342* | 0.165 | 0.416** |
| | | | | | | | | | | 0.043 | 0.423** | 0.270 |

*Significant at the 0.05 probability level; **Significant at the 0.01 probability level.

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