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Ammonium and Nitrate Status of the First Crop Corn Fields at Cukurova Region

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ABSTRACT

The ammonium (NH_4) and nitrate (NO_3) are the available nitrogen (N) forms that plants need in large quantities. Their existence in the soil is limited, and concentrations are kept low due to the losses by leaching in the soil profile and microbial consumptions. Sustainability of the plant available nitrogen forms in soil profile is important for plant growth and crop production. In this research, our main objective was to evaluate mineral nitrogen (Nmin) status of the first crop corn soils and plants in Akarsu Irrigation District of Cukurova Region in 2007. Soil samples prior to sowing and after harvest were taken from 0-30, 30-60 and 60-90 cm soil depths, and analyzed for ammonium and nitrate concentrations. Plant samples were also taken during harvest, and analyzed for N content for determination of total N uptake. There was considerable amount of ammonium and nitrate in the soil profile during preplanting and postharvest. Since the soils were mostly heavy texture, there is tendency to have ammonium also in the soil solution. However, ammonium concentration was far below the nitrate concentration throughout the profile. Plant nitrogen uptake in the irrigation district was very close to the amount that was applied by the local farmers. The results indicated that soil mineral nitrogen level is an important criteria for fertilization practices, especially the preplant Nmin values need to be considered to decrease the amount of N fertilizer that will be applied.

Key Words: Soil Mineral Nitrogen, Nitrate, Ammonium, Corn N Uptake, Irrigation District

BACKGROUND

One of the factors directing crop production in terms of quality and quantity is well-balanced by plant nutrition and therefore suitable fertilization. Nitrogen fertilizers are one of the most used fertilizers in Turkey and the world, and its application level increases day by day. Particularly since hybrid varieties were densely used in Turkish agriculture, the use of N fertilizer has increased greatly with effective irrigation. On the other hand, it is one of the elements that carries potential risk to environmental (e.g. soil and water sources) pollution (Marilla et al., 2004, Gallardo et al., 2005). Human health and environmental quality have been and will be under danger because of the polluted soil and water resources with residual fertilizer nitrogen (Halvarson et al., 2005).

Part of the nitrogen fertilizer which could be absorbed by plants enters into a cycle in which chemical and biological processes occur. This cycle shows great variety depending on the soil, climate and land usage. Depending firstly on water parameters and soil texture, accumulation of nitrogen in

the soil, its leaching and deformation determine the amount of fertilizer to be used (Hofman and Cleemput, 2004).

On the other hand, although there is available mineral nitrogen (Nmin) (NO_3-N + NH_4-N) in the soil (Wehrmann and Sharph, 1986, Bock and Hergert, 1991) which could be used by plants, both farmers and experts ignore its consideration in the fertilization program. For instance, Cukurova University and other regional agricultural institutes have determined the nitrogen amount which should be applied to maize as 25 kg N da^{-1} on average, this amount reaches up to 50 kg N da^{-1} in farmers' practices. Including the amount of Nmin and other N forms, some N is ready present in the soil, this figure needs to be accounted in fertilization practices further (Ibrikci et al., 2001). To increase the crop yield and its quality in the Cukurova region (Lower Seyhan Plain) of Turkey, various field and greenhouse studies have been conducted. However, the N studies in a large irrigation district are very limited or hardly studies. Thus the aim of this study is to determine mineral nitrogen status of first crop corn soils and corn-plant N uptake in this specific area. The results will be evaluated and extended to at farmers' level.

MATERIALS and METHODS

Location

The Project area in Turkey is located in Lower Seyhan Plain (LSP), named after the River Seyhan, in the eastern part of the Mediterranean region, Adana, Turkey. The LSP covers a gross area of 213 200 hectares of land, of which 174 088 ha are suitable for irrigation. Akarsu irrigation district (AID) within LSP were selected for this project (Fig. 1, Fig. 2). The AID is located between 36^{o} 57′ 32″ and 36^{o} 50′ 43″ N latitudes and 35^{o} 40′ 22″ and 35^{o} 28′ 42″ E longitudes. It is in south-east of Adana and west part of the Ceyhan River. With a 630 mm precipitation a year and 18.7 ^{0}C average degrees, the region has the characteristics of the Mediterranean climate.

Figure 1. Geographical location of the study area

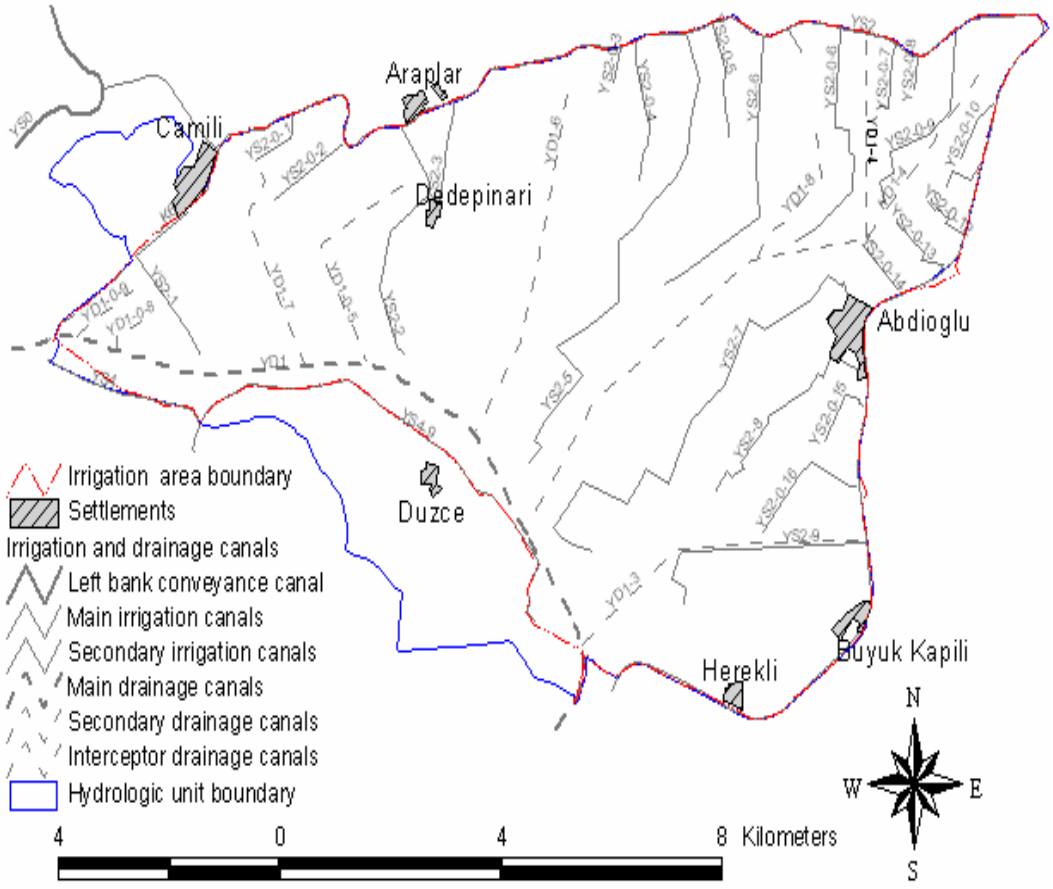

Figure 2. General layout of study area selected in Akarsu Irrigation District

Cropping pattern of the region according to the data in 2007 was 35% the first and second crop corn (80% of total corn was the first crop corn), 28% cereals, 25% citrus and 9% cotton (Figure 3).

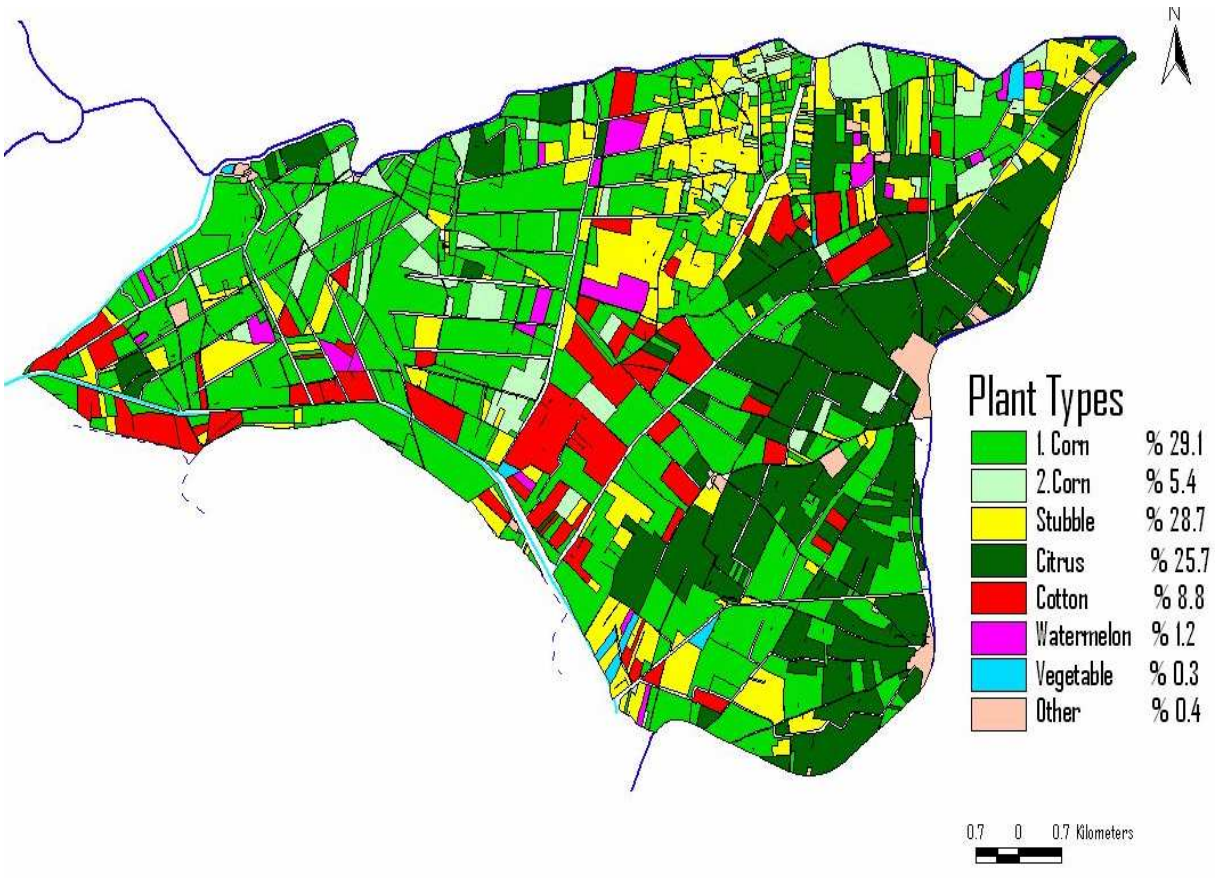

Figure 3. Cropping pattern of year 2007

METHOD

Soil Sampling and Analysis

With the assistance of the Water User Association personnel, representative fields of the first crop corn were selected for sampling purposes. During the sampling, GPS was used to determine the coordinates of the sampling points which will be used during course of the project.

In March just before the sowing and in August after harvest, soil samples were taken from the effective rooting depth (0-30, 30-60 and 60-90 cm). The samples without any treatment were immediately stored in a cold room (+4 ^{0}C) until the chemical analyses. Mineral nitrogen analysis (Nmin) (Nmin= NO_3-N + NH_4-N) were performed based on the procedure described by (Fabig, 1978). The main principle of the analysis is to measure the amounts of nitrate and ammonium in the soil solution using a spectrophotometer. Amounts of mineral nitrogen at each depth were determined as kg N ha^{-1} and calculated for the rooting depth.

Plant Sampling and Analysis

In August, representative plant samples from 54 first crop-corn fields were collected from the ground level prior to the harvest. A 1 m wooden stick was used as a sampling unit for plant sampling, and the procedure was repeated a few times for each field. These units were repeated a few times based on the size of field. The samples from each field were separately dried until the constant weight under outdoor conditions. Then shoots and grains of each sample were separated. Dry weights of whole plant, shoot and grain were taken separately for dry matter determination of a selected unit area. Dry weights of each unit area were then converted to kg N ha^{-1}.

Dry matter measurements of plant samples (shoot and grain) were taken, shoot and grain sub samples were taken from the bulk-dried samples, dried again at 65 ^{0}C (for 48 to 72 h) (Walsh and Beaton, 1973) in dryers and ground separately to pass 0.5 mm sieve for total N (Bremner,1965) analysis. Percentage N values from each field, in particular from shoots and grains, were determined, and used to calculate total N uptake by first crop corn.

In addition, we were recorded 340 kg ha^{-1} N fertilizer application to the first crop corn in survey studies.

RESULTS and DISCUSSION

✓ Average, maximum and minimum nitrate concentrations are reported in Table1.

Table 1. Soil nitrate concentrations (mg kg^{-1}) in the selected fields for first crop corn in Akarsu irrigation district in 2007.

Date	Crop	Number of Fields	Soil depth (cm)	Range of NO_3 conc.	Average NO_3 conc.
March, 2007	1. corn pre-plant	54	0-30	5.07-160.55	19.67
			30-60	6.52-130.47	30.46
			60-90	0.97-22.40	4.18
Aug., 2007	1. corn post-harvest	54	0-30	3.05-164.93	32.55
			30-60	3.71-175	24.84
			60-90	0.68-25.29	4.78

✓ There is a variation between pre and post harvest soil nitrate values. Average nitrate concentrations across the plant typology, soil depth and sampling time (pre plant and post harvest) throughout the irrigation season ranged between 19.7 and 32.6 mg NO_3 kg^{-1}. It could easily be attributed to the potential plant N uptake and loss from the soil through the various physical, chemical and biological processes.

✓ Nitrate values changed according to the soil depth and sampling time. In general, pre plant soil nitrate concentrations in 0-0.3 m soil depth were higher than the subsurface horizon (0.3-0.6 m).

✓ Since the N is very mobile in the soil, accumulation throughout the profile was obviously seen in the Table 1.

✓ Especially preplant high nitrate concentration in the first 60 cm needs to be considered in fertilization programs.

- Average, maximum and minimum soil ammonium concentrations are reported in Table 2.

Table 2. Soil ammonium concentrations (mg kg^{-1}) in the selected fields for first crop corn in Akarsu irrigation district in 2007

Date	Crop	Number of Fields	Soil depth (cm)	Range of NH_4 conc.	Average NH_4 conc.
March, 2007	1. corn pre-plant	54	0-30	0.34-9.63	3.86
			30-60	0.31-12.18	4.46
			60-90	0.07-1.72	0.69
Aug., 2007	1. corn post-harvest	54	0-30	0.3-8.06	2.43
			30-60	0.01-8.48	2.38
			60-90	0.08-0.90	0.40

- Ammonium values ranged throughout the profile during the both sampling times. During the both sampling periods the concentration was low in the bottom horizon.
- Even though extractable NH_4 values are low, it has valuable contribution to soil mineral nitrogen level which is the main fraction of plant available nitrogen in the soil profile.
- Although the definition of the mineral nitrogen in soil is defined as the sum of NO_3-N and NH_4-N, it is generally accepted as only NO_3 content. That's because NH_4 content is measured very low in many different climate and soil conditions, and therefore, it is not taken account.

However, the existence of NH_4 in the soil was determined in many controlled field and greenhouse experiments in Cukurova region.

♦ Grain yield, N concentration and N uptake by shoot and grain in 54 first crop corn fields were given in Table 3.

Table 3. Corn yield and N data

Plant part	Average N Conc.	Average yield	N uptake
	%	.....kg ha^{-1}……	
1st corn			
Shoot	1.11	12 014	129
Grain	1.44	13 738	177

n=54 first crop corn fields

♦ The grain yield is typical for the Cukurova Region.

♦ Total plant N uptake as 306 kg N ha^{-1} is very close to that the amount (340 kg N ha^{-1}) applied by the farmers.

♦ The remaining amount is a potential N source for the following crop.

Table 4. Average soil (in 0-90 cm) and plant parameters (kg N ha^{-1}) in 2007.

Crop Pattern	Pre-plant soil N	Post harvest soil N	Plant N uptake	Fertilizer Applied	Estimated Loss
1st crop corn	72.4	61.5	306.6	340	44.3

Estimated loss is calculated as 44.3 kg N ha^{-1} (N applied + pre soil N) – (plant N uptake + post soil N).

► 44.3 kg N may be lost by leaching, volatilization, microbial consumption and immobilization.

CONCLUSION

- Soil and plant N data represent the Akarsu Irrigation District.
- There is considerable amount of soil mineral N in the effective rooting depth for corn plants.
- In our conditions, NH_4 is also a potential mineral N source to be taken account.
- Consideration of preplant soil mineral N is a practical tool to be used in a fertilization program.
- In 2007, plant N budget, in terms of application level and the amount taken of by plants, is well balanced in farmers' conditions.

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