1. Introduction

In Turkey, fertilizers containing nitrogen are consumed the most. One reason is the deficiency of nitrogen in our soil and the other is the effect of this fertilizer on the growth of plants which is a visual event. The producer has insufficient knowledge in terms of both the amount of fertilizer necessary and the form of the fertilizer. The selection of the form of nitrogen in hydroponic medium which is employed in the agriculture system without soil in the undercover conditions using modern under cover techniques, becomes a problem. This study was employed to answer all these questions.

Our reason to use hydroponic medium was the difficulty of the stabilization of ammonium nitrogen in soil conditions. The other reason is that corn is a monocotyledon test plant. Corn is consumed as bread and animal food in our country.

The nitrification of NH₄ was controlled with a nitrate inhibitor N-Serve. Since hydroponic medium has changed periodically, water culture was used. However, it is very difficult to control in soil.

XU et al. (1992) found the highest dry material formation in case of nitrate feeding in their study with corn in water culture conditions.

MENGEL (1991) stated that there was a week development in several plants that were fed by NH₄ compared to those ones that were fed by NO₃ under water culture conditions with a possibility that they may be poisoned by NH₃. However, there are also some opposite results (BRETELER & SMITH, 1974; SAMATER et al., 1998).

The uptake rates of NH₄ carrying N fertilizers are relatively lower due to its adsorption to the binding sites in the soil. In this respect, IKEDA et al. (1962) state that C fixation of tomato and paddy roots fertilized by NH₄-N was three fold that of NO₃-N.

Similar situation was assessed in maize by 5 fold (CRAMER et al., 1993). KAFKAFI (1990), speculates that plants fertilized with NH₄ contained lower sugar in their roots. It is also reported that NO₃ uptake increases the negative charge of cytoplasm which stimulates the cation uptake (THIBAUD and GRIGNON, 1981; KIRKBY and KNIGHT, 1977). In plants that are supplied with NO₃ organic acids increase parallel.
to cations due to released OH during NO₃ reduction causing organic anion synthesis and malate formation. This is the main reason of enhanced organic acid content in the case of NO₃ fertilization.

2. Material and Methods

A water culture experiment was performed under greenhouse conditions where two maize seedlings were placed in 4.5 l pots full of nutrient solution. Table 1 shows the chemical composition of the solution.

The medium solution with pH 4.7 was weathered for 24 hours. This solution was changed once a week. The experiment continued 11 weeks until the tassel growth in corn. In this experiment, SG 304 was used as a corn type.

The layout of the experiment was randomized parcels with 4 replications and a control treatment. In order to reduce the nitrification of NH₄-N, 2 mg kg⁻¹ of a nitrification inhibitor (N-Serve (2-chloro 6-trichloromethylpyrdyn) was added to each pot (GORING, 1962).

Total nitrogen was determined by KJELDAHL (SCHALLER, 1993) method, using samples of the root stem the body leaves dried at 70 °C and ground. The samples of stem and leaves were burned with a HNO₃ + HClO₄ (4+1) mixture to determine the minor and major elements. The flame fotometer was used to analyze major elements, K, Ca, Na and the AAS (Atomic Absorbsion Spectrofotometer) was used to analyze micro elements, Mg, Fe, Zn, Mn, Cu. Phosphorus was determined colorimetricaly (KACAR, 1972). The sugar fractions in the samples of the stem and the leaf were determined by GC using N₂ as a carrier gas and FID detector (NEUBELLER and BUCHLOCH, 1975). The fraction of organic acid in the samples was determined by extracting with 0.2% H₃PO₄ mobile gas and with the help of C18 coloumn (SAATÇI, 1990).

The samples (stem and the leaf) were hydrolysed with 6N for 24 hours to analyze aminoacids. The amount of aminoacids in the hydrolized samples were measured by Biotronic LC 3000 amino acid analyser (EMIRO LU and MARQUARD, 1984).

3. Results and Discussion

3.1 Effect of N forms on leaf, stem and root yield and on their Macro and microelement and Yield contents

Results showed that nitrogen forms were significantly (1 %) effective on the leaf, stem and root yield of maize (Figure 1, 2). Results also showed that NH₄-N form yielded lowest in agreement with some researchers (SERNÁ et al., 1992; GERENDAS et al., 1990). MENGEL (1991) states that NH₄ has a NH₃ toxic effect on the protoplasm.
The N (%) content of the studied plant parts were not significantly affected by the tested N forms (Figure 3). However, compared to that of the control plant, other treated plants had considerably higher N contents similar to the results of EDIZDO AN (1997).

It is shown that the fertilizers contain nitrogen affected the amount of Phosphorus in the leaf + stem significantly (Table 2). This is in accord with the findings of other researchers (COIC, 1964; BLAIR et al., 1970). The form of the fertilizer nitrogen affected the potassium level by 1% which is significant. The highest potassium amount in the leaf + stem was determined in the case of NH4-N form. The lower amount in phosphorus and potassium nitrate is most probably due to the dilution effect of the formation of biomass in excess. There is no difference between the treatments with respect to the amounts of calcium element. In nitrate application, the high amount of Mg is due to synergistic effect of nitrate (MENGEL, 1991). Nitrogen increased the iron uptake which was highest in the form of NH4 as a level of 1%. Similar study was done by GÜNES¸ and AKTAS¸ (1991) with corn in water culture conditions. They found an increase in the total and active iron by application of nitrate. This is because of the lowest amount of iron determined in NO3 form among the others. The highest zinc amount was found with the NO3 form with 1 % significance level. This is most probably due to the interaction between iron and zinc (MARSCHNER, 1995). Manganese decreased compared to the blank with an application of nitrogen. This is because of the antagonistic effect of iron and zinc on manganese. Because of N applications, increase of Fe and Zn elements, is the result of their competition in respect to transport places. The highest copper uptake was observed with the NO3 form. A positive relationship between the uptake of copper and the nitrate nitrogen is possible. While the copper level is low in the other forms of nitrogen, the high level of copper in case of nitrat nitrogen is probably due to the balance present between anions and cations.

3.2 Effect of N forms on the Quality Criteria of maize leaves and stem

No statistically significant effect of N forms on sugar contents were determined and the dominant sugar fraction was found β-Galactose in NH4 fertilized plants (Table 3). In this regard, α-galactose, fructose and sucrose subsequently followed. In the case of urea-N form, the dominant sugar fractions were in the order of β-Galactose, sucrose, α-galactose and fructose in a similar study (HEHL, 1971). With 3 different crops from Graminacea family namely Lolium perenne, Arrhenatherum elatius, Phleum pratense, glucose, fructose and saccharose were measured as the dominating sugars in the vegetative parts.

Briefly, the results pointed out β-galactose as the dominating and fructose as the least existing sugar fraction. No statistically significant effect of N forms on sugar contents were determined and the dominant sugar fraction was found β-Galactose in NH4 fertilized plants (Table 3). In this regard, α-galactose, fructose and sucrose subsequently followed. In the case of urea-N form, the dominant sugar fractions were in the order of β-Galactose, sucrose, α-galactose and fructose in a similar study (HEHL, 1971). With 3 different crops from Graminacea family namely Lolium perenne, Arrhenatherum elatius, Phleum pratense, glucose, fructose and saccharose were measured as the dominating sugars in the vegetative parts.

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### Table 2: Macro and microelement contents of leaf+stem of maize plant grown

<table>
<thead>
<tr>
<th>Element</th>
<th>Control</th>
<th>NH4-N</th>
<th>NO3-N</th>
<th>UREA-N</th>
<th>LSD</th>
<th>LSD n.s</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>1,56</td>
<td>3,08</td>
<td>2,63</td>
<td>2,81</td>
<td>n.s</td>
<td>n.s</td>
</tr>
<tr>
<td>P (%)</td>
<td>0,62</td>
<td>0,56</td>
<td>0,36</td>
<td>0,39</td>
<td>0,10</td>
<td>**</td>
</tr>
<tr>
<td>K (%)</td>
<td>4,97</td>
<td>5,93</td>
<td>4,63</td>
<td>3,76</td>
<td>1,00</td>
<td>**</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0,57</td>
<td>0,56</td>
<td>0,50</td>
<td>0,45</td>
<td>n.s</td>
<td>n.s</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0,22</td>
<td>0,11</td>
<td>0,21</td>
<td>0,14</td>
<td>0,02</td>
<td>**</td>
</tr>
<tr>
<td>Na (%)</td>
<td>0,03</td>
<td>0,03</td>
<td>0,02</td>
<td>0,01</td>
<td>0,01</td>
<td>*</td>
</tr>
<tr>
<td>Fe ppm</td>
<td>81,0</td>
<td>133,0</td>
<td>102,2</td>
<td>126,3</td>
<td>18,84</td>
<td>**</td>
</tr>
<tr>
<td>Zn ppm</td>
<td>38,40</td>
<td>58,00</td>
<td>79,50</td>
<td>49,60</td>
<td>19,22</td>
<td>**</td>
</tr>
<tr>
<td>Mn ppm</td>
<td>149,3</td>
<td>122,1</td>
<td>127,4</td>
<td>102,8</td>
<td>12,33</td>
<td>**</td>
</tr>
<tr>
<td>Cu ppm</td>
<td>11,00</td>
<td>9,40</td>
<td>12,10</td>
<td>9,90</td>
<td>1,75</td>
<td>**</td>
</tr>
</tbody>
</table>

**Abbrennung:** NO3, NH4-N, Urea-N

Figure 3: Effect of N forms on the N content of roots

Abbildung 3: Effekt der N-Formen auf Stickstoffgehalt der Wurzeln

Effect of N Forms on Maize yield and Leaf Components
Monosaccharates are by-products in young plants. Their level is low and they transform to the other products quickly. The form of sugar carried by sucrose transform to the other sugar form polysaccharites in a very short time (Evans and Wildes, 1971). Fructose, the sweetest sugar was found as highest with NH4 applications whereas other monosaccharides and sucrose were highest at urea application. The lower sugar fractions in nitrate nitrogen is probably due to the intense carbon skeleton provided for the nitrogen compounds by the formation of more biomass with NO3-nitrogen.

NH4-N and urea treated maize plants contained malate in their leaves and stems as the dominating organic acids (Table 4). Malat is lowest in NO3-nitrogen where the amount of product is also low. Malat is high in NO3-N, urine, NH4-N and control subsequently. Malat transforms to the trans and cis-aconitate easily (Richter, 1998). In NO3-N application, malat transforms to the cis and trans-aconitata. The similar situation is also seen in case of urea in smaller amount. This is most probably due to the preparation of carbon skeleton of aminoacids and also the higher energy requirement of nitrogen uptake in nitrate form in the cells compare to the other forms (Nauholz, 1989). In the case of NO3-N treatments, cis-aconitate and trans-aconitata were measured in highest amounts (Figure 4, 5). Grieb (1977), Scherer (1978) and Scherer and Höfner (1980) reported citrat, malate and aconitate as dominating organic acids of maize.

Cis-aconitate was found highest in the NO3-N treated plants and statistically compared with the other N forms this organic acid significantly (1%) differed from the others. The cis-aconitate content of NH4-N and urea-N treated plants contained the least trans-aconitate even lower than the control. In this regard, Edizdoğan (1997) notified cis-aconitate as the dominating organic acid in this studies.

Results related to total amount of organic acids showed that NO3-N treated plants had the higher concentrations in agreement with the reports of Bergmann (1988).

In general, Glutamine, asparagines and alanine type of aminoacids are dominant in plants which belong to Gram-
The highest amino acid was found in threonin, glycine, alanin, valin, isoleusin, leusin and tyrosin in NO₃-nitrogen. Prolin in urea, asparagin and histidin in NH₄-nitrogen application was higher. In several studies conducted, it was determined that NO₃-nitrogen increases the amount of amino acid (SCHULZ et al., 1980; SCHRADER et al., 1972). In a study with corn in water culture conditions, it was determined that the glycine and aspartat increased the most in NO₃-N and NH₄-N applications respectively. BARKER and BRADFIELD (1963) also setted that the amount of aspartat increased in the leaf of corn in water culture conditions by NH₄-N application.

4. Conclusion

In this study, the following conclusions were found:
- Nitrogen applications (300 ppm) and N forms affected the maize leaf + stem and root biomass yield significantly. The highest canopy and root yield resulted with nitrate and urea treatments.
- Leaf + stem and root yields of the ammonium treatments
were found lower than in the control. Result proved that ammonium-nitrogen was toxic under water culture conditions.

- Results related to sugar fractions of leaf+stem proved the dominancy of β-Galactose and the presence of α-Galactose, Fructose and Saccarose.
- Malate and aconyte (cis and trans) organic acids were determined in leaf + stem parts of the maize plants. The highest aconyte content and the lowest malate were measured in nitrate forms of the nitrogen treatments.
- Although the amount of aminoacids were higher in compare to control, it has no statistical importance.

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