NITROGEN FERTILIZATION IN CALCAREOUS SOILS

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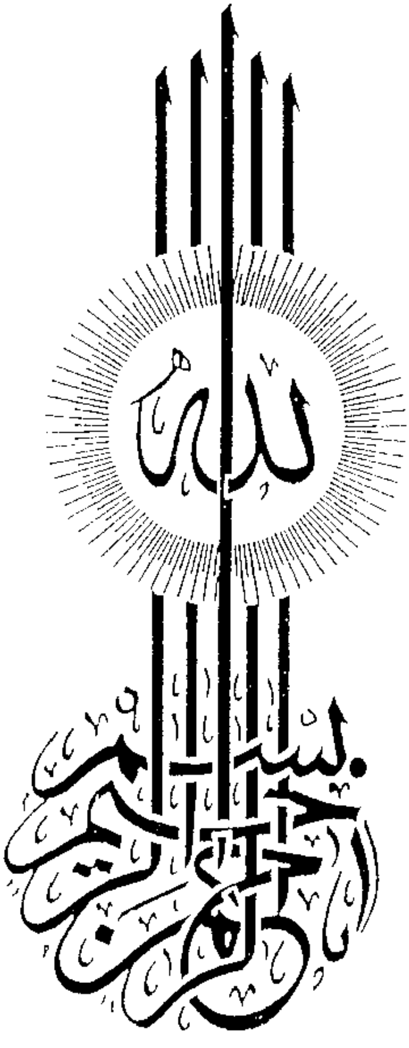
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I. INTRODUCTION

Soils of Egypt contain very little nitrogen, usually less than 0.1%. Essentially, all of the nitrogen required for plant growth must come from biological nitrogen fixation and nitrogen fertilizers. When nitrogen in the form of fertilizer is added to soils, it is common for great part of it to be lost in different ways. Fundamental information is needed on how much nitrogen is lost through various channels and under a variety of conditions.

Many attempts have been made to draw up nitrogen balance sheets for cropped soils. In general, these attempts showed that the income and outgo of nitrogen were seldom balanced. Some of soil nitrogen may be lost by leaching or by volatilization as ammonia, elemental nitrogen and oxides of nitrogen due to various chemical and biological processes. These channels of nitrogen losses are fairly well understood but their relative magnitude under various soil-plant conditions are not well known.

The present investigation illustrates an attempt to make up nitrogen balance sheets for some calcareous soils of Egypt cropped with corn in pots and fertilized with two levels of nitrogenous fertilizers i.e. calcium nitrate, ammonium sulphate and urea at two levels of soil moisture. Such a work could give some information on plant utilization and losses of soil nitrogen. This kind of information is required as a basis for practical recommendations that lead to more efficient use of nitrogen in crop production.

2. REVIEW OF LITERATURE

The nitrogenous fertilizers in the calcareous soils are usually subjected to chemical reactions and biological activities when they are added to the soil. Residual effect was also reported by Fuller *et al.* (1950) to be involved, it was shown to be dependent on the form of nitrogen applied. When an anion was associated with the ammonical nitrogen, the residual effect would tend to be acidic. Urea on the other hand, during its hydrolysis to ammonium carbonate and then to ammonia, was shown to be weakly basic. This was confirmed by Broadbent *et al.* (1958) who reported that although urea initially acted as a nonpolar substance, it was usually transformed rapidly in soils of agricultural value that it might be considered almost as ammonia from the practical standpoint. Sukov (1972) pointed out that transformation of the N^{15} into organic nitrogen and losses of N^{15} from the soil-plant system occurred mainly in the first 3 weeks after applications. Freul *et al.* (1968) found that the ammonium ions flow through soil bed, adsorption occurred only with minor biological interference under limited aeration. Broadbent (1965) suggested that the ionic exchange between fixed and exchangeable ammonium and between exchangeable ammonium and amino nitrogen was to be negligable. Rates of exchange resulting from biological activity were increased as a result of increasing the level of fertilizer nitrogen applied. Bakheit (1972) stated that urea adsorption in Gezira soil was related with both exchangeable capacity and clay content. Musa (1968) studied the nitrification of urea and ammonium sulphate, and found a marked accumulation of NO_2 in the first two weeks, particularly in moist closed bags followed by a decrease to low values.

Residual effects of nitrogenous fertilizers on various properties of calcareous soils due to the continued use of the ammonium ions were found to be different from those of nitrate ones El-Hamshary (1972). Martin & Richard (1959) and Pratt _et_ _al_. (1959) reported that in soils which were very poorly buffered and contained only traces of lime, long time use of ammonium sulphate reduced the pH to a strongly acid condition (from pH 6.1 to pH 4).

Distribution of nitrogenous fertilizers were subjected to a lot of investigations. Decau (1968) studied the distribution of ammonia nitrogen and ammonium nitrogen in 92 soils, he attributed the difference in their distribution to differences in leaching or adsorption under different pedoclimatic and cultural conditions. Lorenz _et_ _al_. (1955) and Fuller ((1963) pointed out that ammonium was seldom uniformly distributed throughout the soil, regardless of the method of application.. The distribution was reported to be dependent upon the kind of fertilizer applied, method of placement, soil texture and soil moisture. Aleksic *et al*. (1968) pointed out that the gaseous losses of labelled $(N^{15}H_4)_2SO_4$ were decreased and utilization of the fertilizer was increased through its application at depth of 7 cm. Both aqua ammonia and ammonia gas were found to form a more diffuse pattern than ammonium sulphate when banded in a calcareous alkali sandy soil. Fuller (1963) proved that the movement of ammonical nitrogen in the soil was dependent on the nature of the ammonium source, soil type, cation exchange capacity, rate of nitrification and kind of cations on exchange complex.

Nitrifying flora was reported by several investigators, such as Broadbent *et al*. (1957) to be enormous in most calcareous soils, members of such flora usually had a great capacity to convert large quantities of ammonical nitrogen to nitrate in a relatively short time. Conversion rates of nitrigying flora about 40 ppm per day were obtained in two calcareous soils with pH values ranging between 8.0 and 8.1.

Chemical behaviour of ammonical fertilizers in soil usually result in the production of soluble inorganic forms.

These forms could either be partly adsorbed or fixed on the exchange complex of the soil, the remainder is supposed to be left in solution. El-Hamshary (1972).

An important phenomenon involving major part of the chemical behaviour of nitrogenous fertilizers in soil is the loss of nitrogen by the process of volatilization. Martin and Chapman (1951) obtained an increase in the voltalization loss of nitrogen from calcareous soils when their pH was above 7.2, loss as high as 51% has been observed in a soil of pH about 8.0 when certain ammonical fertilizers were applied to the surface. Greater losses were obtained from both ammonium sulphate and ammonium nitrate in contrary to that from urea and dried blood which were comparatively small except in the poorly buffered soils. Testini (1962) concluded that volatile losses of ammonical nitrogen were substantially higher from Ca-clay containing $CaCO_3$ than from Ca-clay alone and were lowest from Ca-H clay. Losses were almost as high from urea as from ammonium sulphate but rather low when considering the various urea fertilizers. Khan and Haque (1965) obtained a 20-70% loss of nitrogen added as urea from certain soils. They added that loss of nitrogen from urea and the rate of hydrolysis to ammonium carbonate were greatest within the first week and loss was more in the calcareous soils.

Under local conditions in ARE, Balba and Nasseem (1968) found that losses from nitrogenous fertilizers applied to soil were decreasing in the order NH_4OH, $(NH_4)_2SO_4 \cdot NH_4NO_3$ $CO(NH_2)_2 > Ca(NO_3)_2$. They noticed that losses were greatest in the soil of high calcium carbonate content or in soils to which $CaCO_3$ had been added, losses were found to be increased with increasing soil moisture content up to 50% of field capacity and then being decreased. Musa (1968) showed that higher total losses of ammonia occurred from $(NH_4)_2SO_4$ than from urea at all levels of N applications and soil moisture. Balba <u>et al</u>. (1969) mentioned that the factors affecting the loss of NH_3 by volatilization are; the form of nitrogenous fertilizers applied to the soil, pH of the soil, soil content of calcium carbonate, temperature of the soil, depth of fertilizers placement and the soil moisture content.

Nitrate form of nitrogen, whether produced from nitrification process of ammonical fertilizers or added as nitrate fertilizers usually behaves in a manner different to that of ammonical form, Larsen (1965). Mobility of nitrate ions could be considered as the most outstanding characteristic. Nitrogen in the nitrate form moves with wetting front in irrigated calcareous soils, it may be readily lost by leaching below the root zone Clark <u>et al</u>. (1960).

Losses of nitrogen from ammonium forms are related especially to soil factors, El-Hamshary (1972). Ammonium can be leached only from some few soils. Loss occurs mainly by fixation in clay minerals and by volatilization from calcareous soils where suitable conditions exist, transformation to nitrate in the soil can lead to the other type of loss which are associated with that ion, Larsen (1965).

2.1. Factors influencing losses of inorganic nitrogen from soil:

2.1.1. Soil moisture:

The effect of soil moisture content on ammonia volatilization is not clear. Martin and Chapman (1951) consider that evaporation of moisture is essential for volatilization of ammonia from soil but Van Schreven (1956) found that appreciable losses can occur, when a moist airstream is passed over dry soil. It seems that moisture is unlikely to have such a full effect as first thought. This may be because only a fraction of the soil solution is in contact with the salt crystals so that loss is unlikely to decrease significantly until the soil is waterlogged. Although under waterlogged conditions, appreciable losses of ammonia have been reported, Gupta (1955).

Ammonification of urea takes place at both high and low tensions (up to air dry, and near zero bars). However, there is no agreement on the effect of moisture on urea decomposition.

Some investigators found that urea hydrylysis depends on soil moisture, however moisture content up to 50% of the water holding capacity of the soil do not affect hydrolysis (El Kholei, 1971). Nevertheloss Miller *et al*. (1964) found that different soil moisture content has a little or no effect on the rate of urea hydrolysis. Jones (1932) found that the rate of ammonia accumulation decreased with an increase in soil moisture during the early period of urea incubation.

Several investigators studied the effect of moisture on nitrification and nitrate formation. Nitrification process takes place over a fairly wide range of soil moisture. This process has been studied by Justice and Smith (1962) in the tropical soils at different moisture levels including those near the wilting point. They stated that since nitrification takes place at the colloidal surfaces, it is possible that the small film of water surrounding the soil particles at moisture levels less than the permanent wilting percentage may be sufficient to allow this process to proceed. In fertilized dry land nitrate content increased even during the period of drought El-Kholei (1971).

On the other hand, Miller *et al*. (1964) found that maximum nitrification occurred in the tension range from 0.5 to 0.15

bar, otherwise, it proceeded at a very slow rate at tensions above 15 bar tension but at a very slow rate. Parker and Larson (1962) showed that nitrate production was retarded at soil moisture tensions below 50 cm of water. However Fitts et al. (1955) stated that 100 cm water provided the most optimum moisture for the production of nitrates, and this resulted in 25% to 35% moisture, depending on the texture of the samples and was little above the field capacity. Wahhab et al. (1960) pointed out that nitrification of urea was favoured at one third of the water holding capacity. Justice et al. (1962) found that with all the more favourable temperatures, the initiation of nitrification was delayed at moisture tensions of 7, 10 and 15 bars. However, 150 ppm of ammonium 33% was transformed to nitrate during 4 weeks at moisture levels approximating the permanent wilting percentage. There was no nitrate produced during 8 weeks at 115 bars moisture tension. Greenwood (1962) showed that nitrification took place at about half of its rate when oxygen was not limiting. Sabey (1969) proposed a series of equations by which nitrate accumulation may be predicted in soil. These equations was based on taking moisture rate index, temperature index, pH, texture, aeration, and other factors into account.

Overrein and Moe (1967) concluded that losses of urea were inversely proportional to the depth of application and