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# NITROGEN BALANCE STUDIES FOR DIFFERENT EGYPTIAN SOILS CROPPED WITH CORN

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## SUMMARY

The nitrogen balance for four different Egyptian soils cropped with corn and fertilized with increasing amounts of ammonium sulphate was studied in pot experiments. The tested soils were clay loam, calcareous sandy loam, sandy loam and sand. Nitrogen added as seeds, fertilizers, irrigation water and insecticides, nitrogen removed by the plants including thinned plants and fallen leaves and the nitrogen content of the soils before sowing and after the harvest were determined and used to draw the balance sheet.

The obtained results showed that nitrogen loss ranged between 6.8 and 51.5 per cent depending mainly on soil type and to some extent on the rate of applied ammonium sulphate. Nitrogen uptake by the corn plants was lowest from the clay loam soil and highest from the sandy soil. In all cases it increased slightly with the addition of nitrogen fertilizer.

## INTRODUCTION

Many attemps have been made to draw up nitrogen balance sheets for cropped soils [1 2 9 10]. In general, these attemps showed that the income and outgo nitrogen seldom balance. 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 [1 2 6 16 20]. According to Allison [2] recoveries of nitrogen released from soil or added as fertilizers in harvested crops were commonly less than 50 per cent.

Soils of Egypt contain very little nitrogen, usually less than 0.1%. Nitrogen balance for Egyptian soils, hence, is of great practical value. This work is an attempt to make up nitrogen balance

sheets for some Egyptian soils cropped with corn fertilized with ammonium sulphate.

## MATERIALS AND METHODS

Corn (*Zea maize* var. Hybrid 17) was grown in four different soils: clay loam, calcareous sandy loam, sandy loam and sand. Large pots of 45 cm in diameter and 45 cm in height were used with their orifices tightly closed. Soil depth in each pot was adjusted to 36 cm. The general characteristics of these soils are shown in Table 1.

TABLE 1

General characteristics of the soils used

| Soil characteristic | Clay loam | Calcareous S. loam | Sandy loam | Sandy |
|---|---|---|---|---|
| Total nitrogen, % | 0.08 | 0.02 | 0.03 | 0.01 |
| Total soluble salts, % | 0.10 | 0.20 | 0.26 | 0.02 |
| Total carbonates, % | 0.25 | 38.40 | 0.14 | 0.06 |
| Clay, % | 42.10 | 17.30 | 13.60 | 2.70 |
| Silt, % | 30.40 | 6.90 | 10.50 | 1.40 |
| Sand, % | 27.40 | 75.64 | 75.70 | 95.78 |
| Saturation percentage | 67.29 | 34.78 | 44.91 | 20.11 |
| Cation exchange capacity, m.e./100 g | 42.00 | 24.95 | 21.40 | 5.45 |
| pH (in water saturated extract) | 7.40 | 7.90 | 7.30 | 7.60 |

In each pot, seeds of corn were sown in 3 pits and after emergence the plants were thinned to 3. Superphosphate was added at the rate of 50 mg per kg soil. The experiment comprised the following five nitrogen treatments performed in four replicates.

1. No application of nitrogen fertilizer ($N_0$)
2. 25 mg ammonium sulphate (20.5% N) per kg soil ($N_1$)
3. 50 mg ammonium sulphate (20.5% N) per kg soil ($N_2$)
4. 75 mg ammonium sulphate (20.5% N) per kg soil ($N_3$)
5. 100 mg ammonium sulphate (20.5% N) per kg soil ($N_4$)

Half the amount of ammonium sulphate was applied with the superphosphate after 14 days and the other half after 30 days from sowing. The 80 pots were distributed in complete randomized blocks in a wire greenhouse. During the vegetation period, the pots were irrigated at the same time with tap water whenever required by plants. The amounts of water added were adjusted to restore moisture in soil to its predetermined normal capacity under free drainage conditions in pots. These amounts of water

were determined by weighing the pots just before each next irrigation. Plants were sprayed with insecticide solutions to control insects.

The corn was sown on the 30th of May, 1966, and allowed to grow only to the tassel stage then harvested on the 4th of August. During the growth period, thinned plants and fallen leaves were collected from each pot. At harvest, the corn plants were divided to stalks and roots. All these plant materials were, separately, dried at 66 to 68°C for 48 hours, weighed, ground, and analyzed for nitrogen content. Also nitrogen content for the corn seeds used for planting and the applied ammonium sulphate, superphosphate, irrigation water and insecticide solutions was determined. Soil samples, before cultivation and after harvest, were analyzed for total nitrogen, ammonium–N, nitrite–N, nitrate–N and moisture content. The methods outlined by Black *et al.* [4], were used in nitrogen determinations.

Total nitrogen in seeds, plant and soil samples was determined by the semimicro-Kjeldahl method. During determination of the nitrogen contents of fertilizers, irrigation water and insecticide solutions, Devarda's alloy was added before ammonia distillation.

All reported data represent the average of 4 replicates.

## RESULTS AND DISCUSSION

### *Nitrogen additions*

Nitrogen added was in the form of seeds, ammonium sulphate, superphosphate, irrigation water and insecticides. Corn seeds contained 1.28% N, ammonium sulphate 20.6% N, superphosphate 0.16% N, irrigation water between 0.9 and 1.6 ppm N and insecticide solutions between 1.1 and 12.8 ppm N. The amount of added ammonium sulphate varied according to treatment and weight of

TABLE 2

Total nitrogen added to the soils used

| Nitrogen fertilizer treatment | Nitrogen, mg/pot | | | |
|---|---|---|---|---|
| | Clay loam | Calcareous clay loam | Sandy loam | Sandy |
| $N_0$ | 206 | 201 | 209 | 201 |
| $N_1$ | 468 | 607 | 607 | 591 |
| $N_2$ | 730 | 1013 | 1008 | 981 |
| $N_3$ | 992 | 1419 | 1403 | 1371 |
| $N_4$ | 1254 | 1825 | 1801 | 1761 |

Total amounts of nitrogen added in insecticides, superphosphate, irrigation water and seeds were 1, 6, 68–78 and 126 mg/pot respectively

the soil in pot. The amounts of nitrogen added in the form of these substances per pot are shown in Table 2.

*Changes in soil nitrogen*

Soil total nitrogen as well as ammonium–N, nitrite–N and nitrate–N were determined before cultivation and after harvest. The obtained results indicated that mineral nitrogen content of the soil, either before sowing or after harvest were less than 2 ppm. Only total nitrogen, therefore, is taken into consideration.

Under experimental conditions, total nitrogen content of the used soils decreased due to growing corn regardless of the amount of added nitrogen fertilizer (Table 3). Usually cropping of non-legumes decreases soil nitrogen [17 18 20]. As shown in Table 3, nitrogen losses were highest from the sandy soil (45 to 52 per cent) and least from the clay loam soil (7 to 8 per cent). Generally, increasing the level of applied nitrogen resulted in somewhat greater decrease in soil nitrogen. The same effect has been reported by various investigators [3 5 11 13]. The work of Broadbent and Norman [7] suggested that such results might be due to an increase in the mineralization rate resulting from a stimulation of the microflora by the treatments.

TABLE 3

Changes in total soil nitrogen

| Soil | Initial | After harvest | | | | |
|---|---|---|---|---|---|---|
| | | $N_0$ | $N_1$ | $N_2$ | $N_3$ | $N_4$ |
| *N content, g/pot* | | | | | | |
| Clay loam | 40.37 | 37.48 | 37.51 | 37.41 | 37.17 | 37.71 |
| Calcareous S.L. | 19.34 | 17.37 | 17.48 | 16.93 | 16.93 | 16.85 |
| Sandy loam | 24.61 | 21.18 | 20.78 | 20.78 | 21.21 | 21.29 |
| Sandy | 6.97 | 3.78 | 3.31 | 3.56 | 3.86 | 3.46 |
| *N loss, % of initial* | | | | | | |
| Clay loam | – | 7.17 | 7.08 | 7.35 | 7.92 | 6.59 |
| Calcareous S.L. | – | 10.21 | 9.63 | 12.48 | 12.15 | 12.65 |
| Sandy loam | – | 13.93 | 15.71 | 15.55 | 13.80 | 13.48 |
| Sandy | – | 45.76 | 52.47 | 48.95 | 44.66 | 50.83 |

TABLE 4

Nitrogen recovered in the corn plants (mg/pot)

| Soil | Plant materials | Treatment | | | | |
|---|---|---|---|---|---|---|
| | | $N_0$ | $N_1$ | $N_2$ | $N_3$ | $N_4$ |
| Clay loam | Before harvest* | 159 | 218 | 216 | 215 | 249 |
| | Roots | 34 | 41 | 49 | 61 | 68 |
| | Stalks | 143 | 209 | 255 | 297 | 388 |
| | Total | 336 | 468 | 520 | 573 | 705 |
| Calcareous sandy loam | Before harvest* | 185 | 133 | 127 | 135 | 145 |
| | Roots | 87 | 108 | 102 | 106 | 128 |
| | Stalks | 438 | 644 | 690 | 797 | 817 |
| | Total | 707 | 882 | 919 | 1038 | 1090 |
| Sandy loam | Before harvest* | 323 | 309 | 303 | 350 | 320 |
| | Roots | 88 | 108 | 132 | 130 | 134 |
| | Stalks | 671 | 799 | 964 | 945 | 974 |
| | Total | 1082 | 1216 | 1399 | 1425 | 1428 |
| Sandy | Before harvest* | 147 | 159 | 175 | 159 | 150 |
| | Roots | 90 | 81 | 73 | 86 | 90 |
| | Stalks | 257 | 299 | 403 | 461 | 526 |
| | Total | 494 | 539 | 651 | 706 | 766 |

* Thinned plants and fallen leaves.

*Nitrogen recovered in plants*

Nitrogen removed by the thinned plants, fallen leaves and the harvested crop are summarized in Table 4. For each soil, the dry weight of the corn materials and consequently the nitrogen recovered in the plants increased with a decline rate as the amount of applied ammonium sulphate increased. As shown in Table 4, the highest amounts of nitrogen removed by the crop were from the sandy loam soil while the lowest recoveries were from the clay loam soil irrespective of the rate of nitrogen application.

*Unaccounted-for nitrogen*

The obtained results indicated a net loss of nitrogen from the soil-plant system (Table 5). This unaccounted-for nitrogen was calculated from the following relation:

TABLE 5

Nitrogen lost (g/pot) from the soil-plant system (unaccounted-for nitrogen)

| Soil | Fertilizer treatment | | | | | Average |
|---|---|---|---|---|---|---|
| | $N_0$ | $N_1$ | $N_2$ | $N_3$ | $N_4$ | |
| Clay loam | 2.76 | 2.86 | 3.17 | 3.62 | 3.20 | 3.13 |
| Calcareous S.L. | 1.46 | 1.59 | 2.50 | 2.73 | 3.29 | 2.30 |
| Sandy L. | 2.56 | 3.26 | 3.44 | 3.38 | 3.69 | 3.27 |
| Sandy | 2.90 | 3.71 | 3.74 | 3.77 | 4.50 | 3.72 |
| Average | 2.42 | 2.86 | 3.21 | 3.38 | 3.66 | 3.10 |

LSD for N fertilizer treatment = 0.43 at 5% level and 0.57 at 1% level.
LSD for soil types = 0.38 at 5% level and 0.51 at 1% level.
Soil type × Amount of N fertilizer = Not significant.

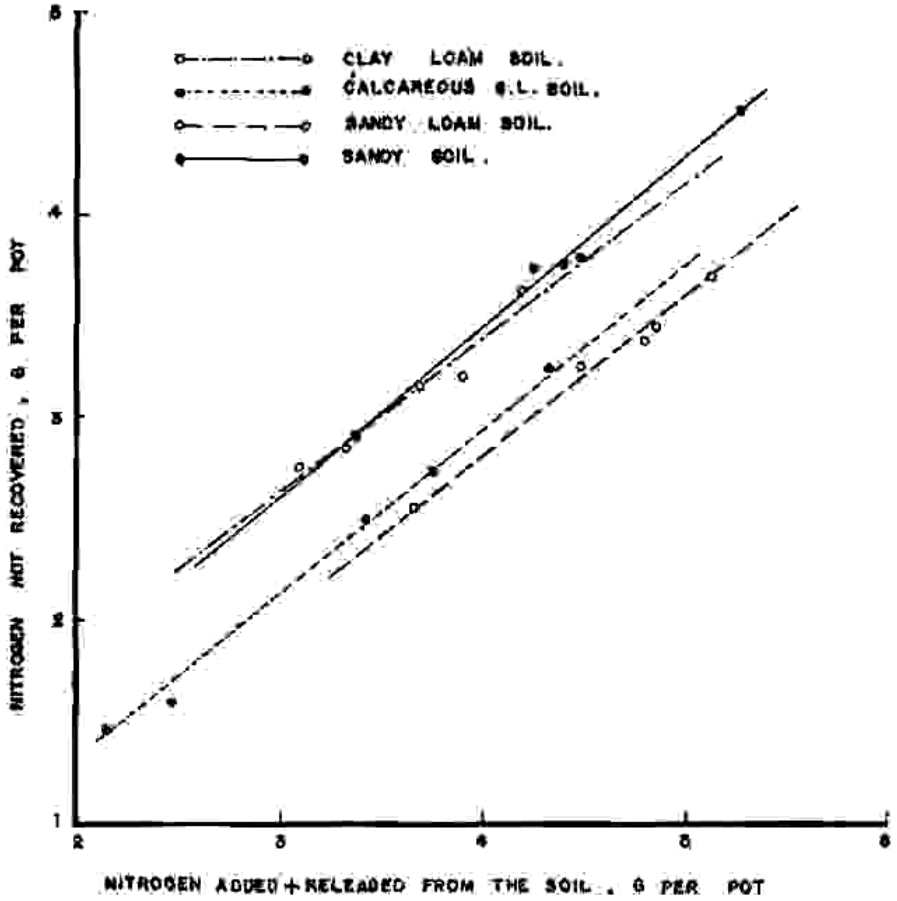


Fig. 1. Relation between the nitrogen added and released from the soil and nitrogen not recovered.

Unaccounted N = (Initial soil N + Added N) −

(Final soil N + N removed by plants).

As shown in Table 5 and Fig. 1, the unaccounted-for nitrogen varied according to soil type and rate of applied ammonium sulphate. The unaccounted-for nitrogen increased with increasing the level of added nitrogen fertilizer. Nitrogen deficit, g per pot, was highest in the sandy and least with the calcareous sandy loam soil (Table 5). This unaccounted-for nitrogen is believed to be lost from the soil-plant system in gaseous forms mainly through ammonia volatilization and denitrification [1 2 6 8 10 12 14 15 19 21].

*Nitrogen-balance sheet*

Usually measurements of nitrogen recovery are reported as a percentage of the applied nitrogen but it seems more realistic to report it in terms of added nitrogen and nitrogen initially present

TABLE 6

Nitrogen balance sheets for the soils used
(expressed as percent of initial soil N + added N)

| Nitrogen fraction | Fertilizer treatment | | | | |
|---|---|---|---|---|---|
| | $N_0$ | $N_1$ | $N_2$ | $N_3$ | $N_4$ |
| *Clay loam* | | | | | |
| Removed by plants | 0.84 | 1.15 | 1.27 | 1.38 | 1.70 |
| Found in soil (final) | 92.36 | 91.85 | 91.02 | 89.87 | 90.62 |
| Not recovered | 6.80 | 7.00 | 7.71 | 8.75 | 7.68 |
| *Calcareous sandy loam* | | | | | |
| Removed by plants | 3.63 | 4.41 | 4.52 | 5.01 | 5.15 |
| Found in soil (final) | 88.90 | 87.62 | 83.20 | 81.84 | 79.60 |
| Not recovered | 7.47 | 7.97 | 12.28 | 13.15 | 15.25 |
| *Sandy loam* | | | | | |
| Removed by plants | 4.35 | 4.84 | 5.46 | 5.46 | 5.41 |
| Found in soil (final) | 85.34 | 82.24 | 81.11 | 81.55 | 80.62 |
| Not recovered | 10.31 | 12.92 | 13.43 | 12.99 | 13.97 |
| *Sandy soil* | | | | | |
| Removed by plants | 6.83 | 7.14 | 8.18 | 8.51 | 8.80 |
| Found in soil (final) | 52.73 | 43.79 | 44.78 | 46.29 | 39.66 |
| Not recovered | 40.44 | 49.07 | 47.04 | 45.20 | 51.54 |

in the soil. Accordingly, nitrogen-balance sheets are drawn up for the experimental soils as shown in Table 6.

On percentage basis, the nitrogen not recovered was much higher from the sandy soil than from the other three soils. Generally with every soil, the nitrogen not recovered increased upon increasing the applied nitrogen fertilizer. Losses of nitrogen (not recovered) from the clay loam, calcareous sandy loam and sandy loam soils ranged between 6.8 and 15.8 per cent, but it was from 40.4 to 51.5 per cent with the sandy soil (Table 6). Pot experiments using labelled and unlabelled forms of nitrogen showed that the unaccounted-for nitrogen may reach 20 per cent but in some cases it may be much higher [1 2 9 10 15].

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