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## NITROGEN BALANCE STUDIES FOR DIFFERENT EGYPTIAN SOILS CROPPED WITH CORN

by M. H. A. EL-SHAKWEER, A. S. ABDEL-GHAFFAR,  
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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 attempts have been made to draw up nitrogen balance sheets for cropped soils<sup>1 2 9 10</sup>. In general, these attempts 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<sup>1 2 6 16 20</sup>. According to Allison<sup>2</sup> 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 mize* 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	75.54	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 <sub>0</sub>	206	201	209	201
N <sub>1</sub>	468	607	607	591
N <sub>2</sub>	730	1013	1008	981
N <sub>3</sub>	992	1419	1403	1371
N <sub>4</sub>	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<sup>17 18 20</sup>. 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<sup>3 5 11 13</sup>. The work of Broadbent and Norman<sup>7</sup> 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 <sub>0</sub>	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>
<i>N content, g/pot</i>						
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
<i>N loss, % of initial</i>						
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	—	48.76	52.47	48.95	44.66	50.83

TABLE 4  
Nitrogen recovered in the corn plants (mg/pot)

Soil	Plant materials	Treatment				
		N <sub>0</sub>	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>
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 <sub>0</sub>	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>	
Clay loam	2.76	2.86	3.17	3.22	3.20	3.13
Calcareous S.L.	1.46	1.59	2.50	2.73	3.23	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.

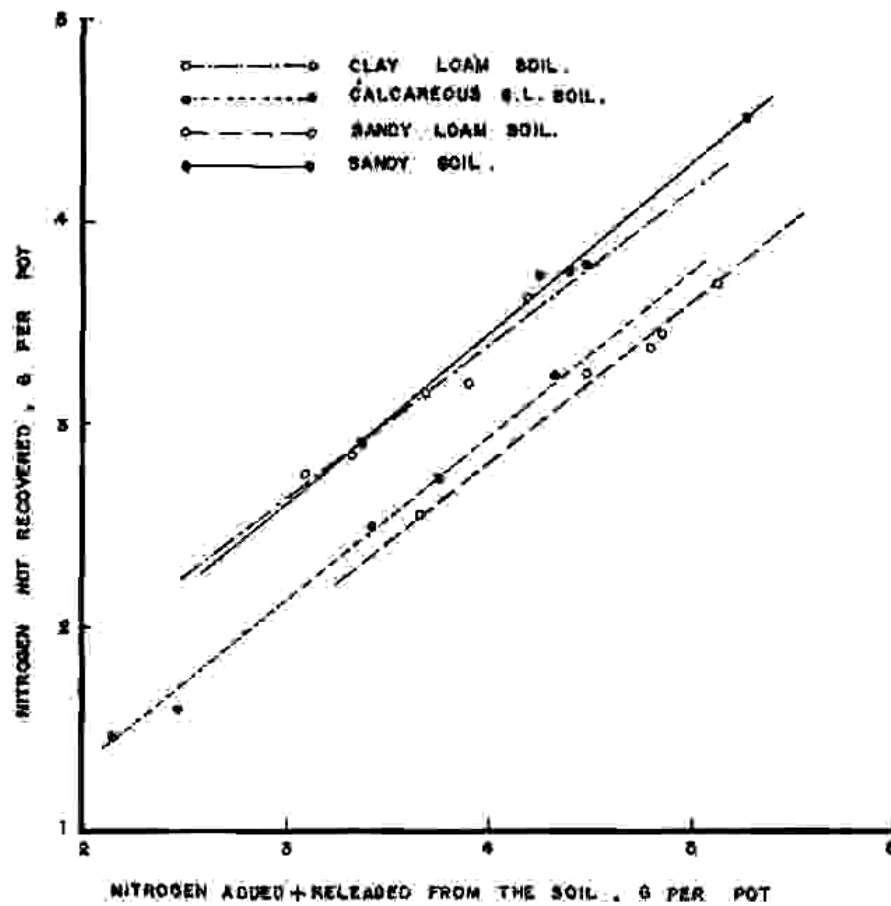
Soil type  $\times$  Amount of N fertilizer = Not significant.

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



$$\text{Unaccounted N} = (\text{Initial soil N} + \text{Added N}) - (\text{Final soil N} + \text{N removed by plants}).$$

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 <sup>1 2 5 8 10 12 14 15 19 21</sup>.

#### *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 <sub>0</sub>	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>
<i>Clay loam</i>					
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
<i>Calcareous sandy loam</i>					
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
<i>Sandy loam</i>					
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
<i>Sandy soil</i>					
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 <sup>1 2 9 10 15</sup>.

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# Plant and Soil

Contents Volume 39, No. 2, October 1973

<i>W. B. Ipinmidun</i> , Assessment of residues of phosphate application in some soils of northern Nigeria. I. Examination of L and E values . . .	213
<i>I. T. Twyford</i> and <i>D. Walmsley</i> , The mineral composition of the Robusta banana plant. I. Methods and plant growth studies . . .	227
<i>James Vlamis</i> and <i>D. E. Williams</i> , Manganese toxicity and marginal chlorosis of lettuce . . .	245
<i>Hussian Al-Saadi</i> and <i>Herman H. Wiebe</i> , Survey of the matric water of various plant groups . . .	253
<i>Jose Tarquinio Prisco</i> and <i>James W. O'Leary</i> , The effects of humidity and cytokinin on growth and water relations of salt-stressed bean plants . . .	263
<i>D. Alt</i> and <i>W. Schwarz</i> , Bor-Toxizität, Bor-Aufnahme und Bor-Verteilung bei jungen Gurkenpflanzen unter dem Einflusz der N-Form . . .	277
<i>J. Shalhevet</i> and <i>B. Yaron</i> , Effect of soil and water salinity on tomato growth . . .	285
<i>A. Monem Balba</i> and <i>T. H. Sheta</i> , Nitrogen balance sheet of $(\text{NH}_4)_2\text{SO}_4$ -gypsum pellets and mixtures and ureaformaldehyde applied to corn in pots of sand . . .	293
<i>D. Chandramohan</i> , <i>D. Purushothaman</i> and <i>R. Kothandaraman</i> , Soil phenolics and plant growth inhibition . . .	303
<i>Hans Nömmik</i> , The effect of pellet size on the ammonia loss from urea applied to forest soil . . .	309
<i>P. M. Bonish</i> , Pectolytic enzymes in inoculated and uninoculated red clover seedlings . . .	319
<i>J. Schiffmann</i> and <i>Rina Löbel</i> , Seasonal changes in symbiotic nitrogen fixation and haemoglobin content in nodules of peanuts . . .	329
<i>M. H. A. El-Shakweer</i> , <i>A. S. Abdel-Ghaffar</i> and <i>M. A. Barakat</i> , Nitrogen balance studies for different Egyptian soils cropped with corn . . .	341
<i>M. A. Singla</i> and <i>R. Samaniego</i> , Effect of flooding and cropping on the changes in the inorganic phosphate fractions in some rice soils . . .	351
<i>D. Purves</i> and <i>E. Jean MacKenzie</i> , Effects of applications of municipal compost on uptake of copper, zinc and boron by garden vegetables . . .	361
<i>J. R. Jorgensen</i> and <i>C. G. Wells</i> , The relationship of respiration in organic and mineral soil layers to soil chemical properties . . .	373
<i>S. McIntosh</i> , <i>P. Crooks</i> and <i>K. Simpson</i> , The effects of applied N, K and Mg on the distribution of magnesium in the plant . . .	389
<i>Teresa Crisanto</i> and <i>C. D. Sutton</i> , Measurement of available phosphate content of some Spanish soils . . .	399
<i>Umesh C. Gupta</i> , <i>J. A. MacLeod</i> and <i>L. B. MacLeod</i> , Effects of aluminum, manganese, and lime on toxicity symptoms, nutrient composition, and yield of barley grown on a podzol soil . . .	413
<b>Short communications</b>	
<i>U. C. Shukla</i> , <i>S. K. Arora</i> , <i>Zile Singh</i> , <i>K. G. Prasad</i> and <i>N. M. Safaya</i> , Differential susceptibility in some sorghum ( <i>Sorghum vulgare</i> ) genotypes to zinc deficiency in soil . . .	423
<i>R. O. Barnard</i> , <i>W. J. Fölscher</i> and <i>P. C. J. Oberholzer</i> , The uptake of Zn, Mn, Cu and B from spray mixtures by navel orange leaves . . .	429
<i>J. P. Voets</i> , <i>M. Meerschman</i> and <i>W. Verstraete</i> , Microbiological and biochemical effects of the application of bitumenous emulsions as soil conditioners . . .	433
<i>D. P. Ormrod</i> , <i>N. O. Adepipe</i> and <i>G. Hofstra</i> , Ozone effects on growth of radish plants as influenced by nitrogen and phosphorus nutrition and by temperature . . .	437
<i>R. P. Pareek</i> and <i>A. C. Gaur</i> , Organic acids in the rhizosphere of <i>Zea mays</i> and <i>Phaseolus aureus</i> plants . . .	441
<i>Barney W. Cornaby</i> and <i>Jack B. Waide</i> , Nitrogen fixation in decaying chestnut logs . . .	445
<i>V. Ranga Rao</i> , <i>N. S. Subba Rao</i> and <i>K. G. Mukerji</i> , Inhibition of Rhizobium <i>in vitro</i> by non-nodulating legume roots and root extracts . . .	449
<i>A. Wallace</i> , <i>E. F. Frolich</i> and <i>G. V. Alexander</i> , Effect of steam sterilization of soil on two desert plant species . . .	453
<i>J. G. Bhatt</i> and <i>K. N. Indirakutty</i> , Salt uptake and salt tolerance by sunflower . . .	457
<i>V. Iswaran</i> , <i>A. Sen</i> and <i>Rajne Apte</i> , <i>Azotobacter chroococcum</i> in the phyllosphere of water hyacinth ( <i>Eichhornia crassipes</i> Mort. Solms) . . .	461
<i>Eugene Brams</i> , Soil organic matter and phosphorus relationships under tropical forests . . .	465