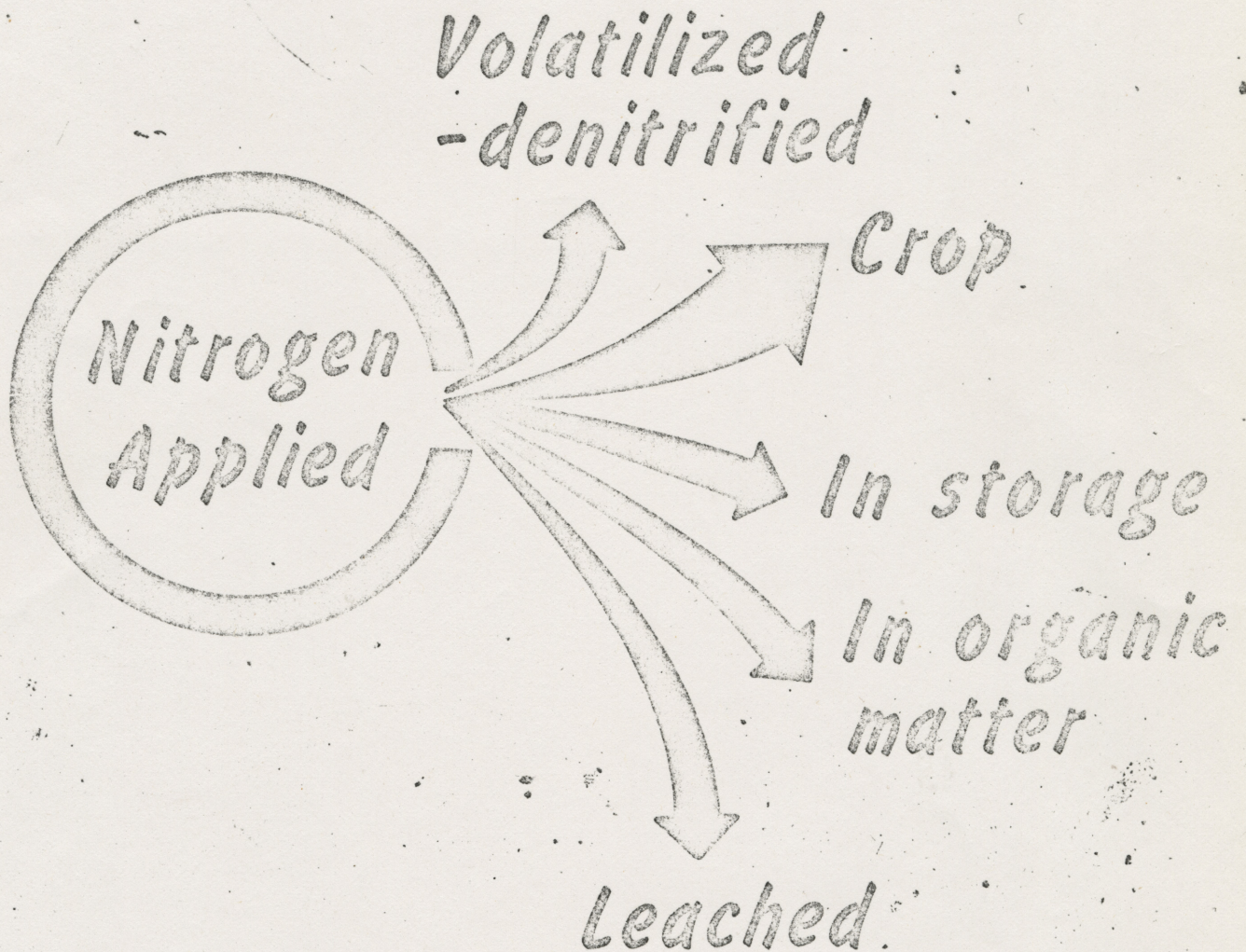


20 Nov. 1974
Tree Crops

RS Ayers

RANIN objectives

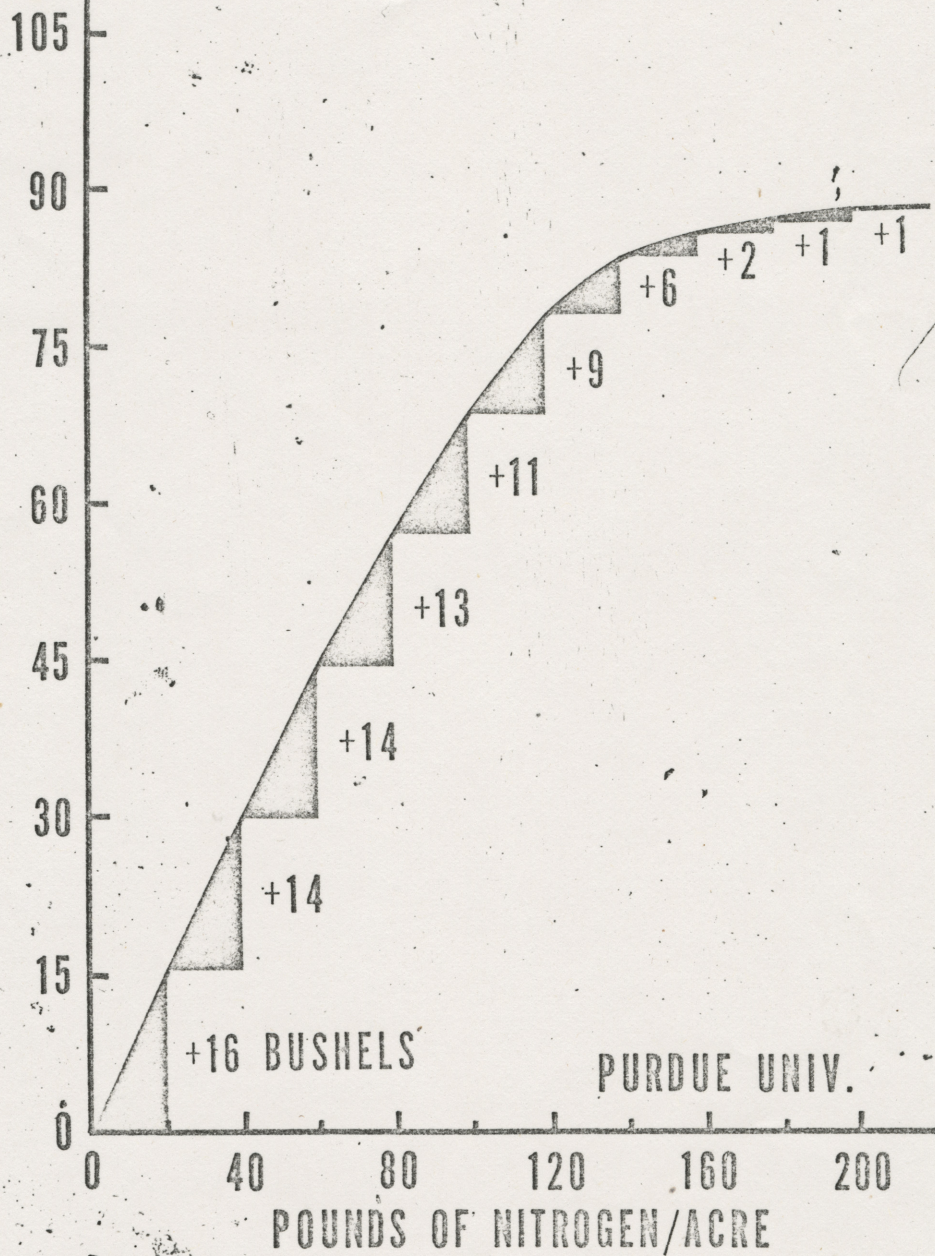
Fate of Fertilizer N ???



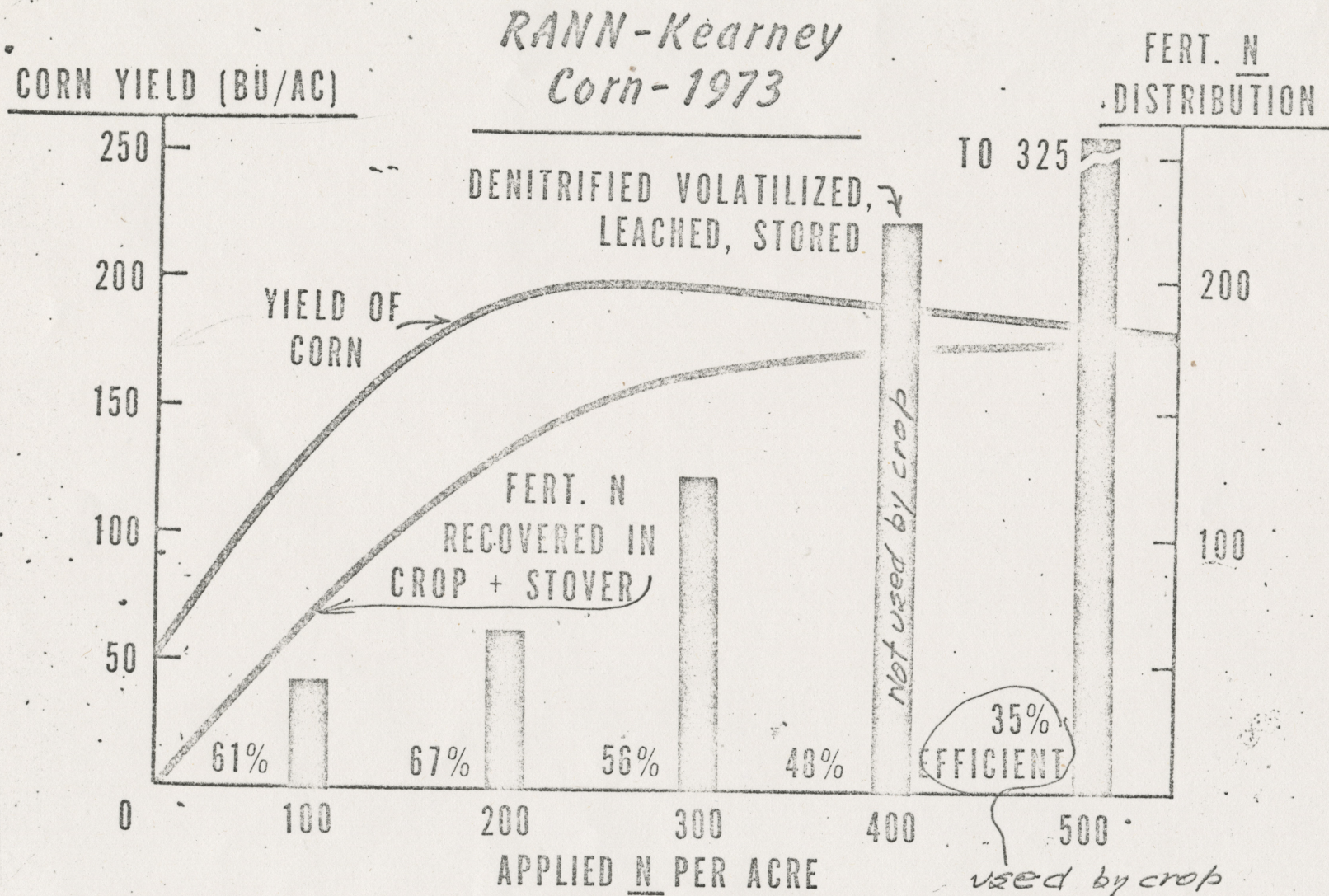
Tree crops
20 Nov. 1974
PSC/germ

Typical yield response to N

CORN YIELD
BUSHEL/ACRE



Tree crops
20 Nov. 1974
RS Ayers



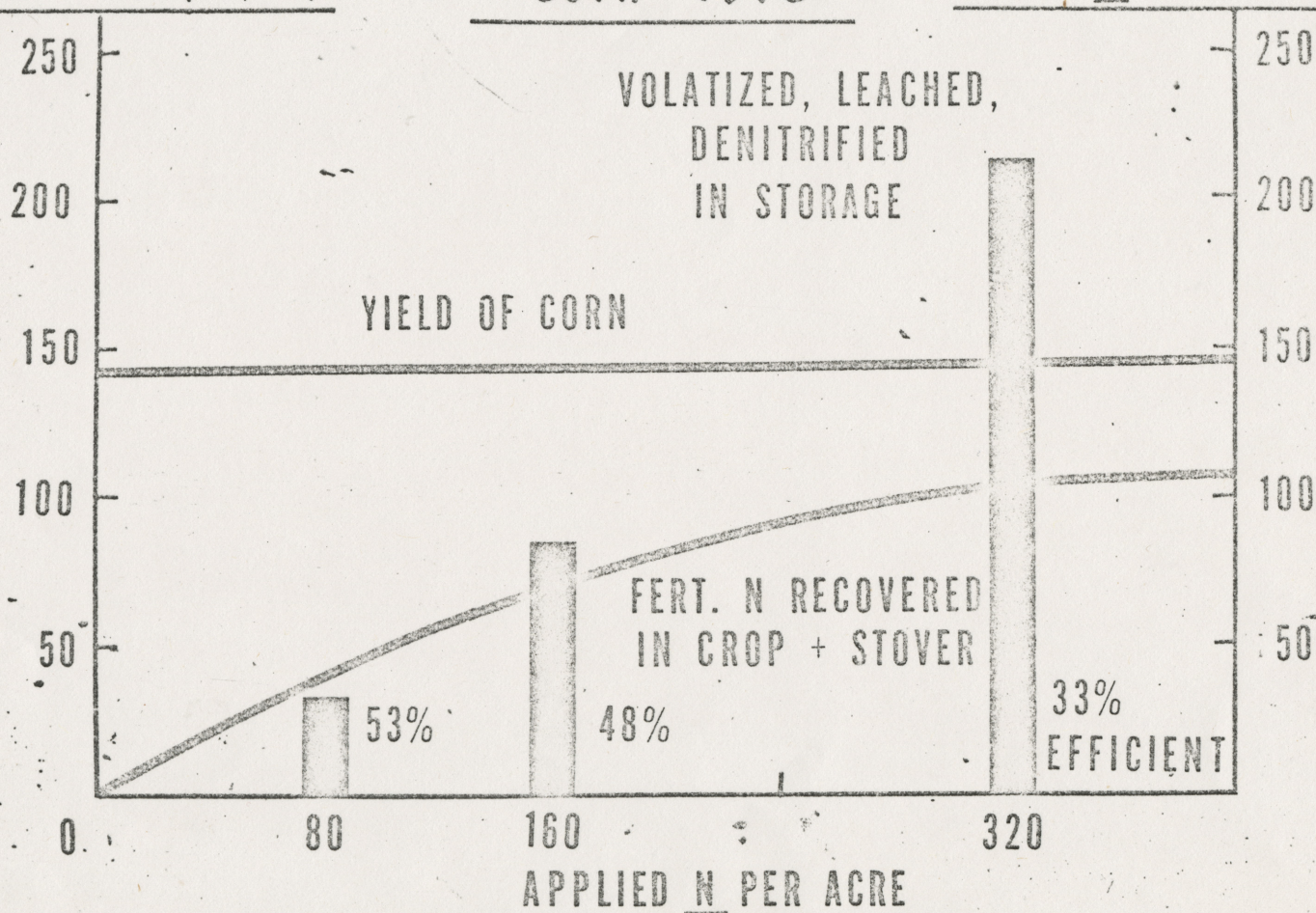
Good yield response to N applied

Tree crops
20 Nov. 1974
REAYERS

RANN-Davis
Corn-1973

CORN YIELD (BU/AC)

FERT. N DISTRIBUTION

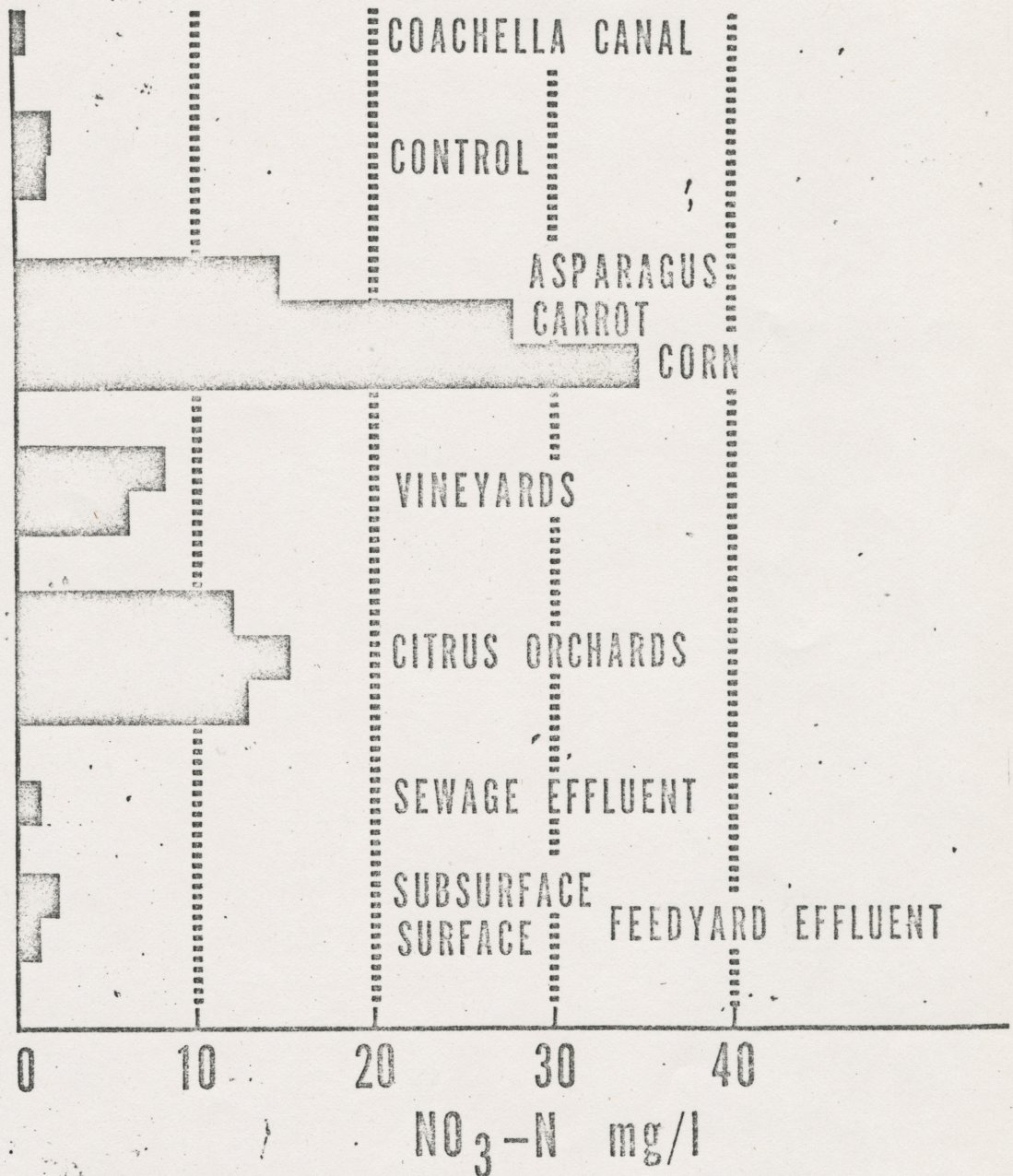


No yield response to applied N!!!

Tree crops -
20 Nov. 1974
RSCyers

NITRATE-N IN WATER FROM COACHELLA VALLEY

(USPHS drinking
water stds allow
10 ppm $\text{NO}_3^- \text{N}$)



Oertli & Bradford UC-R

Annual Report on Field Trials with Isotopes, UCD Site

F. E. Broadbent

A detailed description of the experimental layout is given in the 1973 annual report. The experimental site contains 48 plots with 3 irrigation regimes equivalent to 1/3, 1.0 and 5/3 of the normal evapo-transpiration requirement for corn in this location. Fertilizer levels are equivalent to 0, 90, 180 and 360 kg. N/hectare applied as $(\text{NH}_4)_2\text{SO}_4$ containing less than 50 ppm ^{15}N . All treatments are replicated 4 times.

Soil solution samples were taken at frequent intervals during and after the growing season by means of suction probes buried at depths ranging from 30 to 300 cm. These were analyzed for NH_4^+ , NO_3^- and the isotopic composition determined.

The corn crop was harvested September 13-14, 1973 and the plant material divided into grain, cobs, stover and root crowns, each of which was analyzed separately.

Analysis of soil solution samples continued after the crop was removed.

Crop Harvest Data

Yield of total dry matter is given in Table 1 and of corn grain in Table 2.

Table 1. Total dry matter in 1973 corn harvest.

Irrigation	N added, kg/ha				Irrigation mean
	0	90	180	360	
		80 lbs./Ac	160 lbs./Ac	320 lbs./Ac	
		tons/hectare			
1/3 ET	18.0	18.1	17.4	17.7	17.8
1 ET	18.4	20.1	19.3	19.5	19.2
5/3 ET	19.1	21.3	19.9	19.3	19.8
Fertilizer mean	18.5	19.7	18.8	18.8	

8.25 T/Ac 8.79 8.38 8.38
23.6 T silage 25.1 T/Ac 23.9 T/Ac 23.9 T/Ac
@ 65 moisture

Table 2. Yield of grain, 1973 corn harvest. (dry wt)

Irrigation	0	N added, kg/ha			Irrigation mean
		90 80 #/ac tons/hectare	180 160 #/ac	360 321 #/ac	
1/3 ET	7.56	7.62	7.43	7.55	7.54 ✓
1 ET	7.92	8.94	8.14	8.85	8.46
5/3 ET	8.09	8.60	8.39	8.10	8.29
Fertilizer mean	7.85	8.39	7.99	8.17	

OK
@ 15% moisture 3.50 T/ac 3.74 T/ac 3.56 3.64 T/ac
147 bu/ac 157 bu/ac 150 bu/ac 153 bu/ac
With respect to total dry matter production the 1/3 ET irrigation

level produced significantly less dry matter than the other levels.

The effect of fertilizer was slight, with only the 90 kg level differing significantly from the check plots.

In the production of grain there were no significant effects of fertilizer level, but at 1/3 ET irrigation the grain yield was significantly lower than with the other two irrigation regimes.

Total nitrogen uptake by the corn crop was increased by addition of fertilizer, though no differences were found between the 90, 180 and 360 kg N levels (Table 3). Nitrogen uptake was unaffected by irrigation.

~~#N~~
In contrast the nitrogen content of the grain was modified to a pronounced degree by both irrigation and fertilizer level. These data are presented in Table 4.

Table 3. Total nitrogen in above-ground portions of 1973 corn crop.

Irrigation	0	N added, kg/ha			Irrigation mean
		90 80 #/ac kg/ha	180 160 #/ac	360 321 #/ac	
1/3 ET	155	180	186	196	178
1 ET	154	196	195	210	188
5/3 ET	145	190	199	205	185
Fertilizer mean	151	189	193	204	

OF
134.7 #/ac 148.6 172.2 182.0
#N from 0 42.8 #/ac 78.5 106.5 #N/ac
Fert. N
#N from 134.7 125.8 93.7 75.5 #N/ac
2000

Table 4. Total nitrogen in grain, 1973 corn crop.

Irrigation	N added, kg/ha				Irrigation mean
	0	90	180	360	
	kg N/ha				
1/3 ET	106.5	120.9	120.9	126.9	118.7
1 ET	105.7	129.1	120.1	136.3	123.0
5/3 ET	96.1	119.4	124.4	121.6	115.5
Fertilizer means	102.9	123.0	121.9	128.4	

Moreover, there were very large differences in the quantity of fertilizer-derived nitrogen in the crop as shown in Tables 5 and 6.

Table 5. Per cent of total nitrogen in 1973 corn crop derived from added fertilizer.

Irrigation	N added, kg/ha			
	0	90	180	360
1/3 ET		23.0 %	42.4 %	52.9 %
1 ET		23.0	44.9	61.2
5/3 ET		27.9	48.3	64.9

Fertilizer N uptake was significantly affected by irrigation, fertilizer level, and irrigation x fertilizer interaction.

Table 6. Weight of nitrogen derived from fertilizer in 1973 corn crop.

Irrigation	N added, kg/ha			
	0	90	180	360
		80%	160%	320%
		kg N/ha		
1/3 ET	0	40.8 45%	76.4 42%	101 28%
1 ET	0	47.9 53%	87.5 49%	126 35%
5/3 ET	0	53.8 60%	95.7 53%	130 36%
Recovered	0	52.9%	48.2%	33.2%

An important finding was that the isotopic composition of plant materials

was remarkably uniform at a given fertilizer level. This is emphasized by the data of Table 7, which is typical of the other two irrigation treatments.

These data are relevant to estimates of fertilizer uptake during the growing season obtained by analysis of leaf samples. On July 26 leaf samples were taken which showed that in plots receiving 360 kg N at 1/3 ET the % uptake of fertilizer N was 52.0, compared with the value obtained from the mature crop reported in Table 5 of 52.9. At 5/3 ET the July leaf samples showed 62.8% of N derived from fertilizer whereas in the mature crop the value was 64.9. Data on additional leaf sampling dates will be obtained during the 1974 season.

Table 7. ^{15}N content of components of 1973 corn crop, 5/3 ET water applied.

N added, kg/ha	% ^{15}N			
	Grain	Cobs	Stalks & Leaves	Root Crowns
0	.365±.007	.364±.004	.359±.004	.361±.004
90	.264±.006	.274±.021	.252±.012	.252±.009
180	.190±.004	.191±.003	.186±.008	.195±.009
360	.130±.004	.134±.005	.137±.013	.141±.005

Calculations of the quantity of fertilizer N in the crop in relation to the level applied showed at 90 kg 52.9% was recovered, at 180 kg the value was 48.2%, and at 360 kg 33.2% was recovered. These figures indicate that half to two-thirds of the applied nitrogen either remained in the soil or had been lost.

Uptake of soil nitrogen by the corn crop was inversely related to the quantity of fertilizer added (Table 8) with nearly twice as much soil N in the plants grown without fertilizer as in those receiving 360 kg N.

Native N

Table 8. Soil nitrogen in 1973 corn crop.

Irrigation	0	N added, kg ha			Irrigation means
		90	180	360	
		kg N/ha			
1/3 ET	154	139 + 41 = 180	109 + 77 = 186	95.4 + 106.6 = 202	124 + 54 = 178
1 ET	155	148 + 48 = 196	104 + 91 = 195	84.1 + 115.9 = 200	122 + 66 = 188
5/3 ET	145	137 + 53 = 190	103 + 96 = 199	74.6 + 130.4 = 205	115 + 70 = 185
Fertilizer means	151	141	105	84.6	
	134.7 #/Ac	125.8	93.7	75.5 #/Ac	

Soil Solution Data

A large amount of analytical work was done to obtain concentrations of nitrate in soil solutions withdrawn from the 384 suction probes located in the field. It is difficult to present these data concisely even in summary form, but some representative values obtained during the growing season for plots receiving 1 ET irrigation at 3 fertilizer levels are shown in Figures 1-3. Missing values may be attributed to a variety of causes, including inadequate sample for analysis, particularly as the upper soil dried out toward the end of the season. At all depths above 300 cm, there was a decrease in nitrate concentrations during the season, due to crop removal and/or leaching. At 90 kg N the concentration at 300 cm remained essentially unchanged, whereas at 180 and 360 kg N levels the nitrate concentration at 300 cm increased 17-23%, indicating some downward leaching. The isotope data show little of the added fertilizer penetrated below 240 cm. At 1/3 ET (Figure 4) the soil solution contained virtually no fertilizer N even at the 360 kg rate, remaining in the upper soil which was too dry to provide samples of soil solution. Even with excessive water application and a high fertilizer level, 5/3 ET and 360 kg N, (Figure 5) fertilizer N did not reach the 240 cm depth until August 27, and had not reached 300 cm on September 7.

074

IRRIGATION 1 ET, 90 kg N/hectare
80²N/Ac

8.07" drainage water

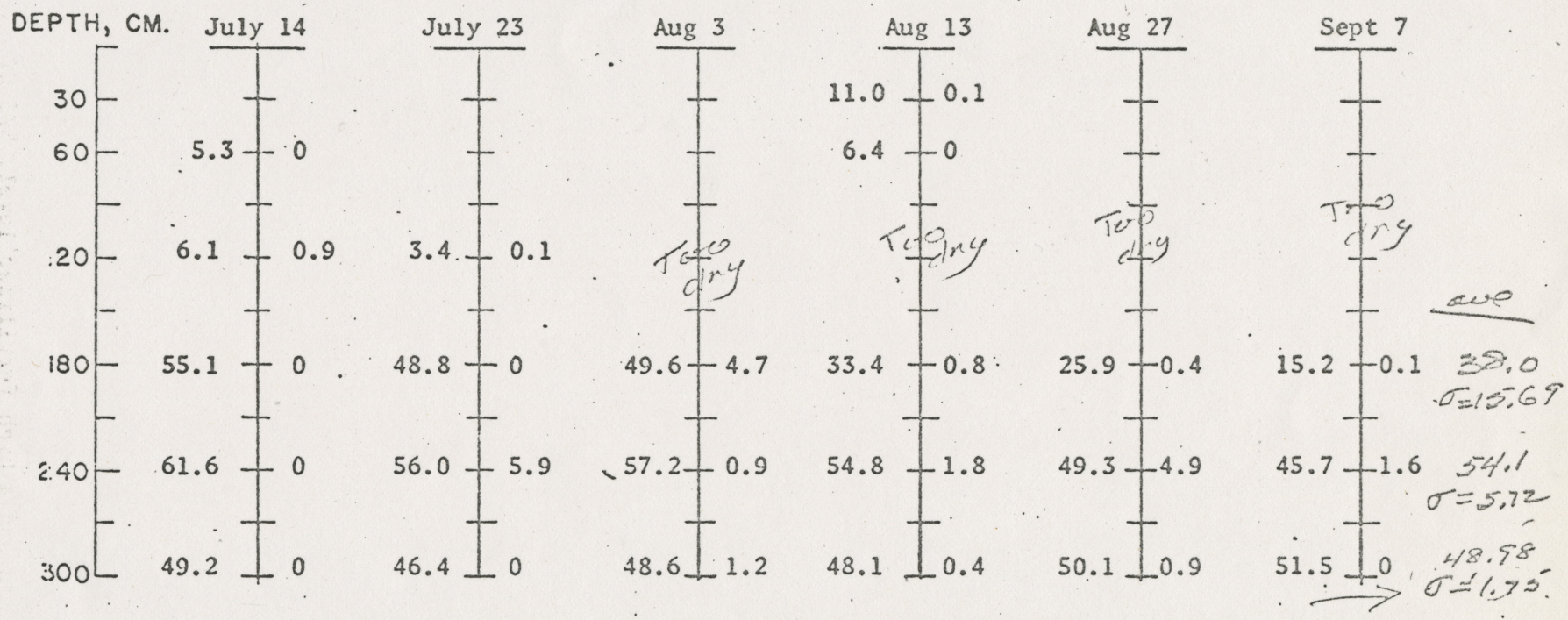


Figure 1. Concentrations of total (left of line) and tagged (right of line) $\text{NO}_3\text{-N}$ in soil solution extracts during growth of 1973 corn crop. Values in ppm.

8.07 inches drainage @ 48.98 ppm $\div$ 4.42 = 89.43[#] N in drainage

assuming
all drainage
contains
48.98 ppm
 $\text{NO}_3\text{-N}$

OK

OK

IRRIGATION 1 ET, 180 kg N/hectare
160 # N/Ac

8.07 inches drainage

DEPTH, CM.	July 3	July 14	Aug 3	Aug 13	Aug 27	Sept 7	ave.
30		19.2 — 8.9	11.3 — 0	11.2 — -	17.6 — 3.2	19.8 — 4.4	15.82
60	20.0 — 6.5	11.3 — 2.5		12.1 — -	9.9 — 1.2	14.1 — 2.0	54.25
							13.48
							$\sigma = 3.95$
120	17.0 — 0	21.5 — 0	26.5 — 0.5	22.4 — 0.5	15.9 — 0.6	19.5 — 2.1	20.45
							$\sigma = 3.87$
180	50.1 — 0	46.4 — 0	35.8 — 1.8	38.3 — 2.2	36.5 — 2.7	35.5 — 4.5	40.43
							$\sigma = 6.24$
240	60.6 — 0	60.2 — 0	59.1 — 1.6	56.3 — 1.4	50.9 — 0.5	48.3 — 0.1	55.9
							$\sigma = 5.17$
300	25.4 — 0	26.4 — 0	28.6 — 0.2	29.1 — 0	29.4 — 0	29.7 — 0	28.10
							$\sigma = 1.77$
							ave

Figure 2. Concentrations of total (left of line) and tagged (right of line) $\text{NO}_3\text{-N}$ in soil solution extracts during growth of 1973 corn crop. Values in ppm.

assuming
all drainage water
carries
28.10 ppm $\text{NO}_3\text{-N}$

8.07 inches drainage @ 28.10 ppm $\div$ 4.42 = 51.3 # N/Ac
in the 8.07 inches
of drainage

OK

IRRIGATION 1 ET, 360 kg N/hectare

321 # N/Ac

8.07 inches drainage

Total
NO₃⁻-N
from
drainage
etc

DEPTH, CM.	July 3	July 14	July 30	Aug 13	Aug 27	Sept 7	
30		30.5 — 15.2	38.3 — 21.8	36.4 — 17.3	41.2 — 21.0	58.2 — 31.0	40.9
60		26.1 — 13.5	23.9 — 11.9	20.0 — 7.0	20.8 — 7.2	23.1 — 9.1	10.4 22.8 σ = 2.4
120		30.5 — 0	30.1 — 14.1	29.9 — 15.1	19.5 — 9.6	24.0 — 12.1	26.8 σ = 4.9
180		31.0 — 2.8	23.3 — 7.9	18.5 — 6.7	18.9 — 6.8	17.4 — 6.1	21.8 σ = 5.6
240		46.2 — 0.9	51.3 — 1.8	51.0 — 0.7	39.7 — 1.5	38.7 — 3.1	45.30 σ = 6.0
300		23.5 — 0	22.0 — 0.3	24.0 — 0	31.3 — 0	30.8 — 0.7	26.32 σ = 4.25

Figure 3. Concentrations of total (left of line) and tagged (right of line) NO₃⁻-N in soil solution extracts during growth of 1973 corn crop, values in ppm.

Assuming all
drainage water
carries 26.32
ppm NO₃⁻-N

$$8.07 \text{ inches drainage} \times 26.32 \text{ ppm} \div 4.42 = 48.05 \text{ # NO}_3\text{-N in drainage}$$

carries 26.32
ppm NO₃⁻N

drainage

OK

IRRIGATION 1/3 ET, 360 kg N/hectare
321 kg N/ha

3.3 inches of
drainage

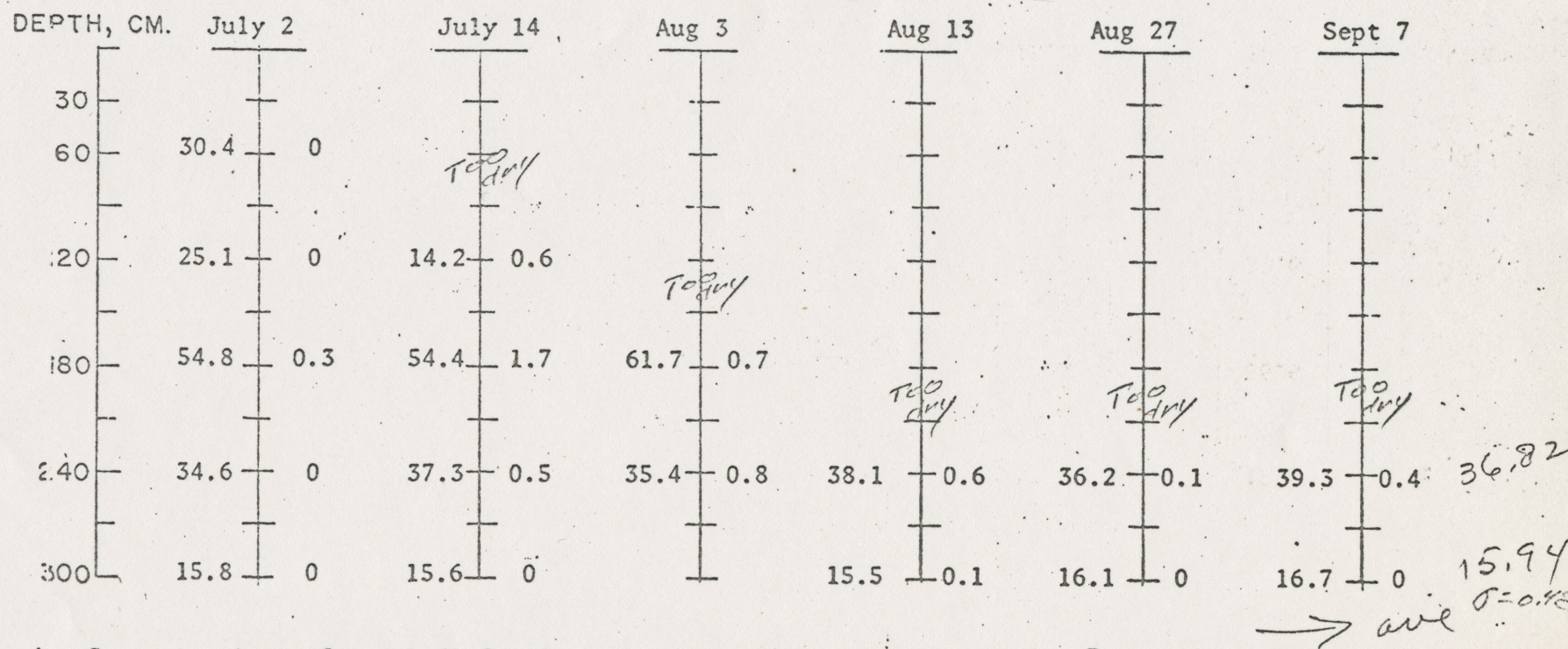


Figure 4. Concentrations of total (left of line) and tagged (right of line) NO₃⁻-N in soil solution extracts during growth of 1973 corn crop, values in ppm.

3.3 inches @ 15.94 ppm ÷ 4.42 = 11.90 pounds NO₃⁻-N in 3.3 inches of drainage water

Assuming
all drainage
water carries
15.94 ppm NO₃⁻-N

OK

17.95" drainage
↓

total
NO₃⁻-N
from stor
age etc
in soil
solution
(concentra
tion)

IRRIGATION 5/3 ET, 360 kg N/hectare
321 #N/A=

DEPTH, CM.	July 3	July 10	Aug 3	Aug 13	Aug 27	Sept 7	
1 st 30	23.8 — 4.0	— —	— —	— —	— —	— —	
2 nd 60	92.9 — 49.4	27.8 — 15.9	17.7 — 8.2	10.8 — 4.0	15.2 — 7.0	15.0 — 5.3	29.9 σ = 31.9
4 th 120	24.6 — 0.1	26.2 — 1.5	41.8 — 25.1	19.7 — 11.1	30.3 — 17.7	36.5 — 3.3	29.9 σ = 8.14
6 th 180	36.0 — 1.2	32.6 — 0	27.8 — 2.5	27.0 — 2.9	36.2 — 6.4	32.6 — 2.6	32.0 σ = 3.9
8 th 240	20.6 — 0	25.4 — 0	42.7 — 0.1	47.6 — 0	44.2 — 3.5	— —	36.1 σ = 12.2
10 th 300	14.1 — 0	13.4 — 0	16.6 — 0	16.2 — 0.1	18.0 — 0	18.8 — 0	16.2 σ = 2.12

Figure 5. Concentrations of total (left of line) and tagged (right of line) NO₃⁻-N in soil solution extracts during growth of 1973 corn crop. Values in ppm.

Assuming all drainage water carries 16.2 ppm NO₃⁻-N
 $16.2 \div 4.42 = \text{pounds N/acre inch of drainage}$ (16.2 ÷ 4.42 = 3.67 #N)
 $16.2 \div 4.42 \times 17.95 = 65.79 \text{ lbs. N in 17.95 inches of drainage water}$

24

An interesting feature of the data in Figure 3 is the persistence of high concentrations of nitrate, much of it fertilizer-derived, throughout the season at the 30 cm depth.

Residual N in Soil

Organic and extractable N was determined in soil samples taken after corn harvest to a depth of 300 cm. The isotopic composition of these samples indicated very little of the residual N was derived from added fertilizer.

Some representative data are given in Table 9 for the 360 kg N plot with 5/3 ET irrigation.

Some of the extractable N (soluble + exchangeable) found at all depths was derived from the tagged fertilizer. However, only near the surface were measureable amounts of tagged N found in the organic form.

Table 9. Extractable and organic N at various depths in soil after 1973 corn harvest. Treatment 5/3 ET and 360 kg N.

Dry Soil Basis

Depth, cm	^N Extractable, ppm		^N Organic ppm	
	Total	Tagged	Total	Tagged
	<i>1 ac. ft soil = 4 mill. pounds</i>			
30 = 1 ft	8.0 $\times 4 = 32$	1.9 $\times 4 = 7.6$	906 $\times 4 = 3624$	5.8
60 2	6.5 = 26	4.0 = 16.0	562 $\times 4 = 2248$	0.4
90 3	8.2 = 32.8	3.2 = 12.8	538 $\times 4 = 2152$	1.1
120 4	10.0 = 40.0	4.7 = 18.8	686 $\times 4 = 2744$	0.0
150 6	7.3 = 29.2	3.6 = 14.4	718 $\times 4 = 2872$	0.0
180 6	6.4 = 25.6	1.4 = 5.6	535 $\times 4 = 2140$	0.3
210 7	7.4 = 29.6	3.8 = 15.2	420 $\times 4 = 1680$	0.0
240 8	6.2 = 24.8	1.4 = 5.6	280 $\times 4 = 1120$	0.0
270 9	7.5 = 30.0	2.2 = 8.8	402 $\times 4 = 1608$	0.0
300 10	6.7 = 26.8	1.3 = 5.2	364 $\times 4 = 1456$	0.0
	300 #N	110 #N	21644 #	total N $\times 2\% = 433\#$

very little residual tagged N detectable in Org. Mat.

Considerable variation was found in the ¹⁵N content of soil organic N in plots receiving no fertilizer. Mean values for 6 control plots and their standard deviations are given in Table 10.

*300 # NO₃-N in top 10 ft.
110 # tagged NO₃-N in 10 ft.
at end of 1973 crop season.*

water sources 16.2 ppm NO₃-N

Table 10. Mean ^{15}N enrichments and standard deviations of soil organic N in 6 unfertilized plots.

Depth, cm	$\%^{15}\text{N}$ enrichment $\times 10^3$	Standard deviation = σ $\times 10^3$
15	4.0 = .004 %	1.4
30	3.3	0.5
60	3.5	0.8
90	5.2	2.4
120	3.5	4.8
150	1.3	3.9
180	2.2	5.8
210	2.8	6.7
240	1.7	4.8
270	1.2	4.1
300	3.2	3.3

Samples below 120 cm are somewhat more variable in isotopic composition than those above this level.

Conclusions

It would be premature to draw firm conclusions after only one year of what is intended to be a long-term experiment. However, a few significant findings can be emphasized..

1. The isotopic composition of the crop is remarkably uniform and is very responsive to the level of isotopically labeled fertilizer applied N, even in the absence of yield differences.
2. Deep penetration of nitrates derived from fertilizer was minimal at this site under conditions of high fertilizer level and excessive water application.
3. It is possible to detect small quantities of labeled N in the soil solution, but fertilizer N in the organic phase loses its identity in the much larger pool of unlabeled N.