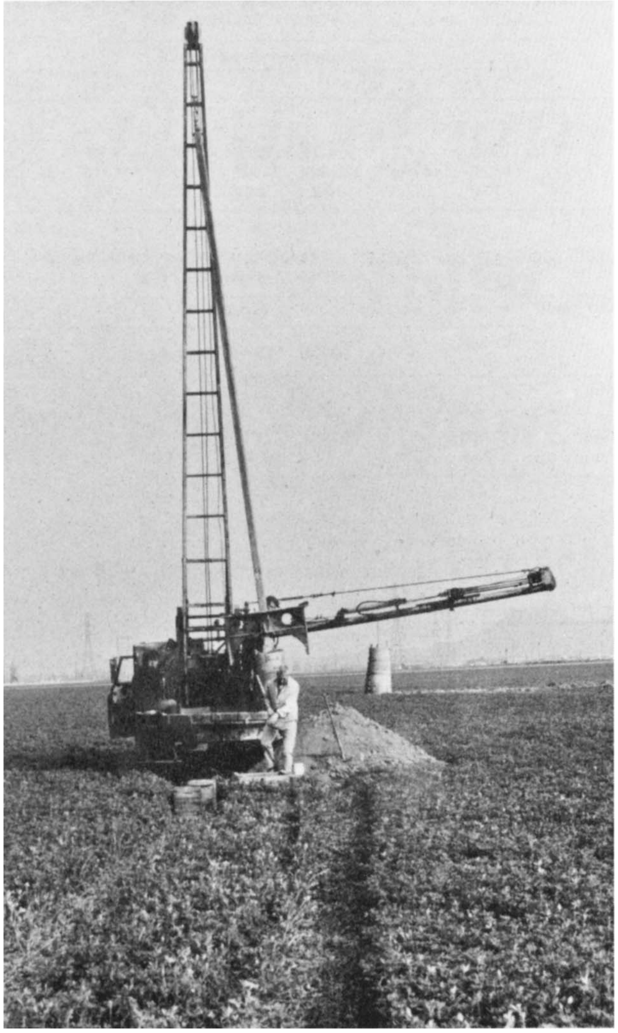

Drilling equipment used to take soil samples to the 50-ft depth or water table.

NITRATE CO

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NINE SITES in the Santa Ana Drainage Basin were selected for this study: five in Riverside County; two in San Bernardino County; and two in Orange County. Site 1 was a strawberry field; site 2 was a celery and sweet corn field; sites 3 and 6 were planted to vegetable crops such as carrots, cabbage, green onions, and romaine lettuce; sites 4 and 5 were planted to sugar beets and cereal crops; and sites 7, 8, and 9 were planted to potatoes and cereal crops (see table). Records for N fertilization, irrigation, and crop yields for these sites were known for a number of years. The average annual fertilizer rate ranged from 145 (sites 4 and 5) to 1,204 (site 2) lbs per acre per year. The fertilizers used were either one, or a combination, of the following materials: $(NH_4)_2SO_4$, NH_4NO_3, aqua NH_3, $Ca(NO_3)_2$ solutions, cyanamid, mixed fertilizers, chicken manure, or barnyard manure.

Three holes at least 200 ft apart were drilled in each site with a power-driven auger (see photo) to the 50-ft depth (or water table) during winter, 1971. Soil samples were taken at different depths, air dried, and reweighed. The loss in weight after air drying was equated to the volume of soil solution or drainage water. Saturation pastes were prepared and NO_3^- analyzed in the extracts.

The N data are summarized in the table, which essentially includes the N balance for each site studied. Where accurate records were available on fertilization, irrigation, and cropping practices they are indicated for each site. The average yearly input takes into account the N from fertilizers and irrigation waters but does not include the N from other sources such as rainfall and NH_3 from the atmosphere. The average yearly fertilization rate is based only on the fertilizers, including animal manures, applied. Thus, the difference between the average yearly input and the average yearly fertilizer rate was due to the N from the irrigation water. The average yearly crop removal was calculated as the yield of harvested

CORRECTION:

NITROGEN LOAD OF SOIL AND GROUNDWATER FROM LAND DISPOSAL OF DAIRY MANURE

Our apologies to the authors for a number of errors appearing in the article, "Nitrogen Load of Soil and Groundwater from Land Disposal of Dairy Manure," on pages 12 and 13 of the December, 1971 issue of California Agriculture, Vol. 25, No. 12. Corrected reprints of the entire article are available by addressing your request to CALIFORNIA AGRICULTURE, Agricultural Publications, University of California, Berkeley, 94720.

NCENTRATIONS

zone

ted row-crop fields

Today's nitrogen fertilization practices for row-crop production (especially vegetables) in the Santa Ana Drainage Basin leave various amounts of NO_3^-–N in drainage water. In nine sites selected for this study, the average NO_3^-–N concentrations in the drainage water in the unsaturated zone (that portion of the soil profile from the root systems to the 50-ft depth or water table) were all above the 10 ppm NO_3^-–N public standard for drinking water. Six sites had average NO_3^-–N concentrations more than five times greater than this standard, whereas, two sites had NO_3^-–N concentrations more than 10 times greater. The amount of NO_3^-–N in drainage water was affected by N inputs, removal of N when crops are harvested, drainage volume, and gains and losses of NO_3^-.

crop times its N content. The average ppm NO_3^-–N at the 11- to 50-ft depths in the unsaturated zone was determined from NO_3^- in the extracts and recalculated to the soil solution basis through a dilution factor. Moisture variation due to evapotranspiration and irrigation was considered negligible at the 11- to 50-ft depth.

The yearly excess N in the soil was calculated from a dilution equation:

$$\text{excess N} = \frac{NO_3^- \times D}{4.4}$$

where excess N is in lbs per acre per year and represents the amount available for leaching; NO_3^- is concentration of NO_3^-–N in ppm in soil solution (drainage water) in unsaturated zone past the root systems (11 ft) to the 50-ft depth or water table; D is drainage volume in surface inches per year (data not presented); and 4.4 is a constant to convert the NO_3^-–N concentration and drainage volume to lbs per acre per year and has a unit value of ppm inches lbs^{-1} per acre.

The amount of N removed by crops plus excess N should be about equal to the input if there was (1) no net change (no mineralization or immobilization) in the organic N pool in soil, and (2) no denitrification. However, data in the table show that the amount of N unaccounted-for ranged from –139 to 241 lbs per acre per year, suggesting that there were gains and losses of N in the profile. The gains (negative values) were unaccounted-for increases in input and could have been caused by net mineralization, whereas, the losses (positive values) could have been caused by net immobilization but they are probably largely a result of denitrification.

On the basis of gains or losses, the sites can be categorized into four groups: sites 3 and 9 with essentially no N loss; sites 1, 2, and 8 with losses of 14, 18, and 19%, respectively; sites 6 and 7 with rather high losses of 56 and 52%, respectively; and sites 4 and 5 with gains of 11 and 72%, respectively.

The commonly reported average losses of N from cropped soils is about 20%. Sites 3, 9, 1, 2, and 8 had reasonably open-porous profiles with varying degrees of stratification but had no layers at the 0- to 10-ft depths that would significantly restrict drainage. Sites 6 and 7 had restricting layers within the 0- to 10-ft depths which apparently caused greater denitrification losses. Sites 4 and 5 were used for feedlot waste disposal prior to cultivation and the climate in the area was such that high mineralization rates could be expected. Site 4 had a hardpan at about the 3-ft depth, whereas site 5 had an open-porous profile. Thus, site 4 was expected to have greater denitrification loss and, therefore, smaller gain in NO_3^-. Also data on Cl^- and electrical conductivity of drainage waters (data not presented) lend support to these explanations.

The average NO_3^-–N content in drainage water in the unsaturated zone ranged from 36 (site 7) to 123 (site 8) ppm. These sites had about 5 and 10 surface inches of drainage water per year, respectively. To lower the NO_3^-–N concentrations below 10 ppm for these two sites, sites 7 and 8 should have drainage volumes of at least 18 and 123 surface inches per year, respectively. However, innovations at present in farming management

NITROGEN DATA FOR AVERAGE YEARLY INPUT, FERTILIZER RATE, CROP REMOVAL, EXCESS IN SOIL, AND NO_3 CONCENTRATION IN DRAINAGE WATER FOR NINE SELECTED ROW-CROP FIELDS

SITE NUMBER:	1§	2	3	4	5	6	7	8	9
Period:	65–70	65–70	59–70	64–70	64–70	66–70	59–70	59–70	59–70
Avg. yearly input, lbs/ acre [1]	390	1,360	660	187	192	428	321	473	388
Avg. yearly fertilizer rate, lbs/acre	312	1,204	419	145	145	330	200	428	285
Avg. yearly crop removal, lbs/acre [2]	60	343	201	132	135	129	108	98	169
NO_3^- – N in drainage water,* ppm	53	119	85	60	56	62	36	123	77
Yearly excess in soil, lbs/acre [3]†	277	776	432	76	196	59	46	283	212
Sum of [2] and [3]	337	1,119	633	208	331	188	154	381	381
Unaccounted-for, lbs/acre/year‡	53	241	27	–21	–139	240	167	92	7
% unaccounted-for	14	18	4	–11	–72	56	52	19	2

* Average of three holes from the 11- to 50-ft depth or water table.

† Available for leaching and calculated at end of period from equation, excess N $= \frac{NO_3^- \times D}{4.4}$

‡ [1] – ([2] + [3]). A negative sign indicates an unaccounted-for input, whereas a positive sign indicates a loss.

§ Crops in various sites: 1—strawberries, 2—celery and sweet corn, 3 and 6—vegetable crops, 4 and 5—sugar beets and cereal crops, 7, 8, and 9—potatoes and cereal crops.

to abate the NO_3^- load of the unsaturated zone beneath these fields would not be felt until many years in the future. There was a significant correlation ($r = 0.70$, $n = 9$), at the 5% level, between the N input per year and the average concentration of NO_3^--N in drainage water. Although the NO_3^- concentration is also a function of the drainage volumes, the fertilizer rates apparently had more exerting influence.

Conclusions

From the data obtained, it is apparent that current fertilization practices for row-crops, especially vegetables, are leaving various amounts of NO_3^- in the drainage water, some more than 10 times the prescribed limit of 10 ppm NO_3^--N for drinking water established by the U. S. Public Health Service. The irrigation water pumped from a well of one site had about 20 ppm NO_3^--N, and at a rate of 4 acre-ft of water per acre per year, this would supply about 200 lbs N per acre per year. Instances in the basin were known where application rates exceeded three times the normal recommended amounts. At these rates and with the usual irrigation practices for some row crops (such as celery, potatoes, and strawberry), high concentrations of NO_3^- in the drainage water seemed ensured.

California leads the nation with about 600,000 acres used for growing vegetable crops (excluding potatoes) in 1968. Most of these vegetable areas are concentrated in San Joaquin and Sacramento Valleys, where groundwaters are used both for domestic and irrigation purposes. If drainage and groundwaters underlying the row-crop areas are to have acceptable NO_3^- loads, the following measures may be beneficial: (1) use of recommended rates, sources, and time of application of N; (2) soil fertility tests before each growing season; and (3) adequate amounts of irrigation water for maximum yields, plus additional water to maintain a suitable salt balance in the topsoil. This information is available through Experiment Station plant scientists, Extension Service specialists and local farm advisors.

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LEAF PROTEINS *from* SESAME

D. M. YERMANOS · W. SALEEB

AN INCREASING REALIZATION of the low efficiency of animals as protein producers, in comparison with plants, has stimulated a new awareness of the need for developing our plant protein resources. According to recent statistics, the world's population consumes about 70 million tons of protein annually. Of these, 35 million tons come from cereals, 25 million tons come from animals and 10 million tons from legumes. To produce the 25 million tons of animal protein, however, 135 million tons of plant protein must be fed to the animals. Seeds have, historically, served as the major source of plant proteins. To cover the existing protein shortage in the world today, novel sources of plant protein are being investigated. One such source, which already has a modest commercial utilization in California, consists of the leaves and stems of suitable plants.

Initial efforts to identify suitable plant species for leaf protein production have emphasized species with luxuriant foliage. Additional research would seem advisable with another feature of plant growth, which contributes to high leaf yields, the response to photoperiod. When a number of certain plant species adapted to tropical latitudes are grown in the temperate zone they produce little or no seed, but enormous amounts of green matter. Several varieties of dehiscent sesame developed in the tropics fall in this category. The potential for growing some of these sesame varieties in California as sources of leaf protein was investigated at the University of California in Riverside.

Eight tropical varieties of sesame were used in this study: Aceitera, Glauca, Inamar, Morada, Venezuela-44, Venezuela-52, Blanquina, and Rana. In addition, the temperate zone variety Oro and the early variety Early Russian were included. These ten varieties were planted on May 13 on raised beds, 75 cm apart and 13 m long; leaf and stem production was recorded at cutting time.

All tropical varieties exhibited greater vegetative growth in leafiness and height than the temperate zone varieties, but they produced few capsules or none at all. During the first two months, the tropical varieties grew in height at a slower rate than the temperate zone varieties. After the second month, the tropical varieties accelerated their elongation very sharply. The tropical varieties were cut when they were 90 days old. Oro and Early Russian were cut eight to 15 days earlier, respectively, because they started to bear several capsules setting seed. At cutting time Venezuela-52 and Blanquina had just started blooming and had no capsules; Glauca, Morada, and Inamar averaged five to 10 young capsules per plant; Rana and Venezuela-44 had 20 to 32. Glauca was the most succulent, leafy, and fine stemmed variety.

The leaves, including petioles, made up 29 to 48% of the weight of the green sesame plant and 19 to 32% after drying. The moisture percentage ranged from 78 to 88% in the leaves and from 64 to 84% in the stems. Yields of stems