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

TABLE 1. LEAF, STEM AND PROTEIN PRODUCTION BY TEN SESAME VARIETIES, BEFORE AND AFTER DRYING

Variety	Weights and moisture contents before drying					Weights and protein content after drying					
	Total green weight	Leaf weight*	Stem weight*	Leaf moisture	Stem moisture	Leaf weight*	Stem weight*	Protein content leaves	Protein content stems	Protein produced leaves	Protein produced stems
	kg/ha	per cent				per cent				kg/ha	
Venez-52	18,474	33	67	78	64	23	77	24.9	4.7	332	211
Venez-44	19,827	29	71	84	74	20	80	23.8	6.6	216	239
Aceitera	17,914	41	59	86	71	25	75	24.7	6.6	247	199
Rana	14,648	41	59	87	67	22	78	23.1	7.8	187	220
Inamar	17,815	30	70	83	69	19	81	25.9	4.4	232	169
Glauca	17,550	48	52	87	73	32	68	23.9	5.0	271	122
Blanquina	16,462	39	61	84	76	29	71	19.7	7.5	200	183
Oro	16,065	36	64	88	75	21	79	22.4	6.6	152	169
Morada	9,062	4	56	88	79	31	69	24.9	6.9	119	73
ER-7	4,948	25	75	81	84	27	73	26.8	8.8	62	51

* Expressed as per cent of total weight of plant (minus roots).

and leaves and their protein content are shown in table 1.

The mean amino acid composition of the leaves of three of the varieties used in this study is shown in table 2. In spite of the very diverse genetic background and the major morphological and physiological differences of these varieties, the amino acid composition of their leaves is very similar. Compared with the amino acid composition (expressed as per cent of total amino acids recovered) of the undecorticated lipid free meal of the seed of the same varieties, the leaves were higher in lysine, aspartic acid, proline and leucine, but lower in arginine, glutamic acid and methionine. Sesame meal is highly prized for its high methionine content which distinguishes it from all other oil seed meals; thus, it is interesting to note the low relative methionine content of the leaves. A comparison between sesame leaves and alfalfa indicates that they are both very similar except for higher glutamic acid, aspartic acid and methionine in sesame leaves. Four amino acids (arginine, aspartic acid, glutamic acid and leucine) make up 43% of all amino acids in sesame leaves, 50% in sesame meal and 38% in alfalfa. All 17 of the amino acids recovered make up about 21% of the weight of dried leaves and 48% of the undecorticated lipid-free sesame meal (table 2).

Table 3 shows the ratio of each essential amino acid to the total essential amino acids (excluding tryptophane) in leaves and in meal. The ratios in the leaves compare favorably with those recommended by FAO/WHO in 1957 and with the meal ratios, except for methionine.

The yields of leaves and stems reported in this study are considered as average rather than as maximum. Cool nights in Riverside tend to slow down vegetative development of sesame. Earlier tests with the same varieties at Shafter, and in the Imperial Valley, showed that tropical sesame varieties exhibited strikingly greater vegetative growth. Further increases in yield should be expected from better cultural practices maximizing vegetative growth rather than seed production. The plant populations used in this study were those recommended for highest seed yields. Closer spacing and higher populations would probably increase leaf and stem yields and palatability by reducing the crude fiber content. Other aspects that deserve further investigation are the possibility of having two cuttings, and the selection or breeding of superior varieties in terms of forage, protein production, and quality.

No effort is made in this report to indicate how tropical sesame could fit into different crop rotation schemes. Alfalfa dehydration plants yearly experience shortages of raw materials around August, when the supply of alfalfa is low. Grown as a second crop after cereals, tropical sesame, which reaches its maximum development in August, could conceivably be initially used to supplement the amounts of alfalfa available for dehydration.

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TABLE 2. TOTAL AMINO ACID COMPOSITION OF DRIED SESAME LEAVES, UNDECORTICATED LIPID FREE SESAME MEAN AND ALFALFA PROTEIN CONCENTRATES.*

Amino acid	Amino acid composition				
	Sesame†		Sesame‡		Alfalfa‡
	Leaf	Meal	Leaf	Meal	Concentrates
	%	%	%	%	%
Lysine	1.08	1.40	5.20	2.94	6.2
Histidine	.44	1.13	2.12	2.37	2.5
Ammonia	.53	.36	2.55	.76	. . .
Arginine	1.29	6.49	6.21	13.64	6.5
Aspartic Acid	2.77	4.15	13.33	8.72	10.2
Threonine	.98	1.78	4.72	3.74	5.3
Serine	.83	2.37	3.99	4.98	5.3
Glutamic Acid	3.10	10.12	14.92	21.27	11.2
Proline	1.06	1.47	5.10	3.10	5.3
Glycine	1.13	2.51	5.44	5.28	5.6
Alanine	1.22	2.28	5.87	4.79	6.5
Half Cystine	.27	.74	1.30	1.56	.9
Valine	1.21	2.37	5.82	4.98	5.9
Methionine	1.21	2.37	5.82	4.98	5.9
Isoleucine	.96	1.87	4.62	3.93	5.3
Leucine	1.68	3.27	8.08	6.87	9.9
Tyrosine	.78	1.60	3.75	3.36	4.0
Phenylalanine	1.20	2.22	5.77	4.67	6.8

* Mean composition of the varieties Venezuela-52, Oro, and Rana.
† Per cent total amino acid composition.
‡ Amino acids expressed as per cent of total amino acids recovered.

TABLE 3. MILLIGRAMS OF INDIVIDUAL AMINO ACIDS PER GRAM OF TOTAL ESSENTIAL AMINO ACIDS IN SESAME LEAVES AND MEAL

Amino acid	Recommended pattern*	Sesame leaf	Sesame meal
Lysine	134	147	98
Threonine	89	133	124
Valine	134	164	165
Methionine	71	34	100
Isoleucine	134	130	130
Leucine	152	228	228
Phenylalanine	89	164	155

* 1957 FAO/WHO recommended pattern.