Proceedings

1973 CALIFORNIA PLANT and SOIL CONFERENCE

Sponsored by the

CALIFORNIA CHAPTER - A. S. A.

Sacramento, California
January 31, February 1 and 2, 1973

1973

CALIFORNIA PLANT AND SOIL CONFERENCE

Sponsored by the

CALIFORNIA CHAPTER

AMERICAN SOCIETY OF AGRONOMY

January 31, February 1, 2, 1973

WOODLAKE INN

SACRAMENTO, CALIFORNIA

ELECTED OFFICERS OF THE CALIFORNIA CHAPTER

OF THE AMERICAN SOCIETY OF AGRONOMY

FOR 1973

THE EXECUTIVE COMMITTEE:

President:	Iver J. Johnson Cal-West Seeds, Woodland
Fist Vice President:	Milton D. Miller Agricultural Extension University of California, Davis
Second Vice President:	Malcolm H. McVickar Chevron Chemical Company, San Francisco
Past President:	D. S. Mikkelsen Department of Agronomy and Range Science University of California, Davis
Executive Secretary-Treasurer:	George R. Hawkes Chevron Chemical Company, Richmond

COUNCIL OF REPRESENTATIVES:

One-Year Term:	P. F. Pratt Department of Soil Science and Engineering University of California, Riverside
	L. E. Wittsell Shell Development Company, Modesto
	R. B. Bahme Agricultural Development Company, Orinda
Two-Year Term:	O. A. Lorenz Department of Vegetable Crops University of California, Davis
	Donald L. Smith Pacific Oilseeds, Inc., Woodland
Three-Year Term:	Robert S. Ayers Agricultural Extension University of California, Davis
	Stephen T. Cockerham Cal-Turf, Camarillo
	R. L. Luckhardt Union-Collier, Los Angeles

CONFERENCE REPORTS

Page

GENERAL SESSION - Theme: Interrelationships Between Genetics, Crop Management, Soil Fertility and Crop Quality
Duane S. Mikkelsen, Program Chairman

Genetic Engineering for Nutritional and Organoleptic Quality
M. Allen Stevens. 1

Chemistry, Cornfields and Computers (Abstract)
R. S. Loomis. 7

Coordinated Program for Nitrogen and Water Quality Research
Victor J. Kilmer and Roland D. Hauck. 8

Nitrate Accumulation in Vegetables
O. A. Lorenz and B. L. Weir 14

Luncheon Speaker - Honorable Ronald Reagan, Governor of California

ENVIRONMENTAL MANAGEMENT SECTION - V. P. Osterli, Program Chairman

Panel Discussion: "Water Supply and Management"
Robert M. Hagan, Panel Moderator

1. The Problems - An Overview
Robert M. Hagan 20

2. Obtaining More Water From Surface and Groundwater Supplies
John R. Teerink 21

3. Recycling Used Water
John D. Parkhurst . . . . Abstract Not Available

4. Desalting Seawater and Brackish Waters
Manuel Lopez, Jr. 21

5. Managing Water Quality
Dwight C. Baier 22

6. Reviewing the Alternatives, Legislators' Viewpoints
Peter H. Behr and Howard Way. . . . . Abstract Not Available

"Energy Supply and Management"

Energy Requirements in Food Production
Perry R. Stout 23

Energy Sources for the Future
Craig B. Smith 25

"Solving Environmental Problems"

Progress in Animal Waste Management
W. C. Fairbank 26

Management of Food Processing Wastes
George K. York 27

Nitrogen Movement Below Crops
Robert S. Ayers. 28

Page

Comprehensive Water Quality Control Planning
Bill B. Dendy. 29

Application of the Living Filter in Regional Wastewater Management
W. E. Vandenberg 30

California Pesticide Program and Progress Report
David J. Bingham 31

SOILS AND PLANT NUTRITION SECTION - Roy L. Branson and Roy Rauschkolb, Program Chairmen

R. R. Hunziker, Presiding

The Need for Standardization in Agricultural Laboratory Testing
James Quick . . . . Abstract Not Available

Testing Soils, Plants and Waters
H. M. Reisenauer. 32

Zinc Fertilization of Rice
D. Marlin Brandon and D. S. Mikkelsen 32

The N, K and P Nutrition Characteristics of Sesame: A Promising Role for California
George Mitchell and Frank Bingham 33

Mineralogical and Chemical Correlations With Plant Accumulation of Potassium
O. R. Lunt and R. L. Branson. 34

Aggregate Effects of Nutrients and Gibberellin on Orange Crop Value
Tom W. Embleton, Winston W. Jones and Charles W. Coggins, Jr. 35

Salt Tolerance of Mexican Wheats
F. T. Bingham and C. Torres 35

Irrigation Water Application of Soluble Agricultural Chemicals
Albert W. Marsh 36

Nutritional Problems With Hydroponic Greenhouse Expansion in California
H. Johnson, W. L. Berry and J. Davidson 38

James T. Thorup, Presiding

A Look Ahead at Fertilizer Supplies
John R. Douglas, Jr.. 39

Getting the Most Efficiency Out of Fertilizers
R. S. Rauschkolb. 40

Some Factors to Consider in Using Animal Manures for Fertilizer
K. B. Tyler 41

Soil Productivity in Relation to High Loading Rates With Manure
Burl Meek 42

Process and Product Development Research in Fertilizers
Warren J. Sharratt. 43

Page

Panel Discussion: "Controlled Release Fertilizers"
Warren Sharratt, Panel Moderator

1. Nitrification Inhibitors
Cleve A. I. Goring. 44

2. Urea-Formaldehyde and IBDU
O. R. Lunt. 45

3. Controlled Release Fertilizers: Coated Materials
Hollis M. Barron. 45

GENETICS AND PLANT BREEDING SECTION - Donald L. Smith, Program Chairman

Is the Gene the Unit of Selection?
R. W. Allard. 46

Cotton Breeding
Hubert B. Cooper, Jr. 46

Flower Breeding
Glenn A. Goldsmith. 46

A New Genus of Cereals
Earlene A. Rupert 47

Problems, Progress, and Promise in Citrus Breeding
R. K. Soost 47

Genetic Vulnerability
David J. Thompson 48

"What is the Mission of Public Institutions and Private Firms in the Training and Education of Plant and Soil Scientists?"

An Administrator's Point of View
L. D. Whittig. 49

Learners All Learn
Marinus Van Elswyk 49

An Undergraduate Education Point of View
Fred D. Howard . . . . Abstract Not Available

Industry's Needs For Trained Personnel
I. J. Johnson. 50

University-Industry Cooperation in Graduate Education
M. L. Peterson 51

Futures Unlimited
John J. McCabe 52

Profile of a Successful Commercial Agronomist
Malcolm H. McVickar. 53

Page

AGRICULTURAL EDUCATION SECTION - E. L. Zicker, Program Chairman

"Undergraduate Education in Agriculture and Natural Resources in California"

The Role of Community Colleges in Agricultural Education
J. D. Axtell 54

Agronomic Education in the Community College
Byron E. Harrison. 55

Natural Resources Offerings in the California State University and Colleges System
D. W. Hedrick. 56

Undergraduate Education in Agriculture and Natural Resources in California
O. J. Burger 56

The Conservation of Natural Resources Program at University of California, Berkeley
Arnold M. Schultz. 57

Agricultural Environmental Education
Harry O. Walker. 58

SPECIAL SECTION - R. Merton Love, Program Chairman and Moderator

"Maintaining Environmental Quality of California Wildlands"

Introduction
R. Merton Love 58

1. National Park Service
Howard H. Chapman 59

2. United States Forest Service
William G. Graham 59

3. Multi-Use Management of Pacific Gas and Electric Company's Wildland
R. E. Hayden. 60

4. Maintaining Environmental Quality in the Public Domain
E. J. Petersen. 60

5. The Role of Fire in Maintaining Forest Wilderness Quality
Harold H. Biswell 61

TURFGRASS SECTION - Hollis M. Barron, Program Chairman

Carbohydrate Relationships in Turfgrasses
V. B. Youngner. 62

Use of Washed Dairy Manure Mulch as an Aid in Seed Germination Under a Saline Condition
Richard L. Baldwin, Ervin L. Bramhall and Vic A. Gibeault 62

Turf Colorants - A Method to Preserve Winter Greenness While Reducing Costly Winter Maintenance
Kent W. Kurtz and John Van Dam. 62

Page

Common Bermudagrass Overseeded With Cool Season Turfgrasses for an Evergreen Lawn in Coastal Southern California
S. E. Spaulding and V. B. Youngner. 63

Nitrogen Source in Relation to Turfgrass Establishment in Sand
Kenneth D. Gowans and Edward J. Johnson 63

Annual Bluegrass Control in Hybrid Bermuda Turf
Stephen T. Cockerham. 64

Evaluation of Cool Season Turfgrass Species and Varieties Throughout California
Vic A. Gibeault 64

GENETIC ENGINEERING FOR NUTRITIONAL AND ORGANOLEPTIC QUALITY

M. Allen Stevens
Department of Vegetable Crops
University of California, Davis

United States culture has evolved to the point that, from necessity, maintenance and improvement of the quality of life have become prime considerations. In recent years, the public, and particularly consumerism advocates, have developed a keen interest in the quality of our food. In June, 1971, the Food and Drug Administration (FDA) ruled that varieties which have had significant alteration of nutritive value or of the concentrations of toxic constituents cannot be classified as "Generally Recognized As Safe" (GRAS). The FDA ruling and increased consumer interest in food quality undoubtedly mean that breeders must become more active in efforts to maintain and improve quality of new varieties.

Traditionally, plant breeders have been concerned with those characteristics that relate to yield, including much effort for disease resistance. Quality has not been a principal objective in most plant breeding programs. Most breeders have been satisfied to maintain the status quo for many quality characters rather than to pursue an active program to improve them. This is particularly true for nutritional and organoleptic qualities.

Developing a new variety is difficult even when the goals can be well-defined. Often, quality characteristics cannot be clearly defined. Quality has many facets, and it often means different things to the various groups concerned with a new variety. The consumer wants the best appearance and flavor for the money he is willing, or able, to pay. The processor wants a raw product that will give him maximum case yields of a finished product that sells well and gives maximum return. This may represent high quality, not in absolute terms, but only relatively. Frequently, quality and price are closely related, and the consumer may not be able to afford highest quality. If breeders are able to increase quality of predominant varieties, higher quality at a reduced price should result. The grower wants a crop that meets the grade requirements of the processor or shipper. If the primary requirements are color and freedom from physical defects, those are his chief concerns.

It is generally believed that fruits and vegetables are bought for flavor and appearance, i.e., for the enjoyment they provide, not for their nutritive value. This is probably true today, but the situation appears to be changing. Through the efforts of various groups, people are becoming more aware of nutrition, and, in the future, there will probably be increased insistence by consumers that foods have good nutritional value. As a consequence, varieties which provide this will be more popular.

A number of factors contribute to the plant breeder's lack of attention to quality. Most of these are related to the complexity of breeding programs, which increases exponentially with the number of genes being manipulated. For example, in a cross segregating for 21 genes, a perfect population of tomatoes, which is one in which each phenotype occurs at least once, would require over 420,000 acres. Another factor is the lack of pressure most plant breeders have felt to hybridize and select for increased quality. To keep a breeding program manageable requires setting priorities. It is almost impossible to develop a variety with all of the desired characteristics. The best tasting, most nutritious variety is doomed to failure unless it has good yield, disease resistance, and the other characters essential to growers, shippers, and processors. Thus, most quality characteristics necessarily greatly complicate breeding programs. To be successful, a high-quality variety must also possess all the characters that make money for growers, shippers, or processors at an acceptable price to the consumer.

A further complication in breeding for quality is that fruits and vegetables are usually harvested when the edible portion is undergoing rapid change in composition. Furthermore, it is usually difficult to pinpoint a definable stage of maturity. Thus, in a breeding program where it is often desirable to evaluate single plants, sampling becomes a major source of error. It is difficult to determine whether observed differences are due to environment, stage of maturity, or genetic variation. As a consequence, even when constituents can be accurately and readily measured, data obtained may not represent genetic potential. For example, in the tomato, acid concentration changes dramatically during fruit development and maturation. It increases during early development, reaches a maximum near incipient color, then decreases into senescence. The magnitude of change is dependent upon the genetic constitution of the plant, some lines maintaining acid concentration better. Tomato acidity is also affected by the nutritional and moisture status of the plant. A potash deficiency causes a decrease in acidity, whereas moisture stress causes an apparent increase, partially because of a concentrating effect.

AMINO ACIDS

In recent years, geneticists and physiologists have been investigating the possibility of improving the nutritional value of staple crops by increasing concentrations of limiting amino acids and total protein. There have been some notable successes and probably the most striking is the improvement of the nutritional value of corn by increasing its lysine concentration. Lysine is a limiting amino acid in corn, which means that the nutritional value of this crop is limited by its lysine concentration. In 1964, researchers at Purdue University discovered that the opaque-2 gene conditions a change in the composition of corn. A comparison of normal and opaque-2 corns shows differences in all major components. Protein and fats are higher in the latter, but carbohydrates are lower. The lysine concentration of opaque-2 is about double that of common varieties. Assuming that eggs have the optimum distribution of lysine, tryptophan, methionine and cystine, normal corn is deficient in all of these essential amino acids while opaque-2 corn has a nearly ideal distribution.

In a vigorous test of its nutritive value, high lysine corn was given as the only source of protein to children severely ill with kwashiorkor. In four months, the children made remarkable recoveries and all evidence of the disease disappeared. When the high lysine corn (opaque-2) is fed to rats, there is a dramatic increase in weight gain. Over a four-week period, rats on opaque-2 gained almost four times as much as rats on a common hybrid.

Unfortunately, high lysine corn also has several disadvantages. The reduced starch and higher solubility of the gluten fraction makes it disadvantageous to wet millers. The floury nature of high lysine corn endosperm poses problems to dry millers who generally want to maximize output of larger grits. The lower carbohydrates reduce its value to distillers. High lysine corn yields about 5 to 25% less than high yielding hybrids. This yield disadvantage coupled with the processing shortcomings of the highly nutritive crop means that additional agronomic improvements must come if it is to compete successfully. At present, the greatest potential for high-lysine is in developing countries where corn is a diet staple and increased nutritive value outweighs the yield and processing disadvantages.

There is potential for increasing the nutritional value of other staple crops by increasing concentrations of limiting amino acids; e.g., Kelly has shown that it should be possible to triple the methionine concentrations of dry beans.

VITAMINS

The most important nutritive contributions of fruits and vegetables are vitamins A and C. In 1971 about 95% of the vitamin C in the US food supply was provided by fruits and vegetables. In addition, about 50% of the vitamin A, 30% of the vitamin B_6 and about 20% of the thiamin and niacin were provided by these crops.

Vitamin A: As a result of their relationships to color, the components contributing to vitamin A concentration have received far more attention than have other nutrients. Carotenoids are vitamin A precursors, but to have vitamin A activity a carotenoid must have at least one unsubstituted β-ionone ring with an 11 carbon polyene side chain.

Among major fruits and vegetables carrots rank at the top, both for vitamin A concentration and contribution to consumption of this nutrient.

There has been considerable research on the carotenes of carrots. In a comprehensive study, Sadana and Ahmad calculated vitamin A activity among red, orange, yellow and violet carrot varieties and found it to range from 30 to 19,500 IU/100 g.

If the historical records embodied in the works of artists are accurate, orange carrots are a product of the last 500 years. Only white carrots can be found in paintings done prior to 1500 A.D., at which time yellow carrots appeared. Orange carrots were first seen about 1700. The later appearance of orange carrots tells us something about the genetic system. As organisms are more apt to lose a genetic function via mutation than gain one, it can be assumed that orange represents a loss of function, and therefore is probably recessive.

Commercial carrot varieties have about 10-12 mg/100 g fresh weight of total carotene. About 60% is β-carotene, 20% α-carotene, and the remainder a mixture of polyenes and other carotenoids. Variation from 0.1 to 40 mg/100 g total carotenoids among carrot accessions has been reported. Gabelman reported three independently inherited genes which govern the amount of total carotenoids (Table 1).

Table 1. Effect of genotype on total carotenoids in the carrot.

Genotype	Total Carotenoids (mg/100 g)
yy aa bb	12.0
yy aa B_	6.0
yy A_ __	3.0
Y_ __ __	0-0.1

There is strong epistasis. Y is epistatic to A, and A is epistatic to B. The range in total carotenoids synthesized with each genotype is surprisingly narrow.

Tomatoes make an important contribution to vitamin A nutrition because of large consumption. Red-fruited varieties generally have less than 10% of the vitamin A of commonly used carrot varieties. A 100 g portion of common red tomatoes provides about 20% of the minimum daily adult requirement of vitamin A.

In a study of several tomato species, varieties, and strains; great variation in -carotene concentration has been found. A 100-fold range was found by Lincoln et al. in progeny from crosses between the common tomato, *Lycopersicon esculentum* and another species, *L. hirsutum*. Progeny with about 20 times the β-carotene of common varieties have been selected from interspecific crosses. From a cross between 'Rutgers' and *L. hirsutum*, Tomes and Quackenbush developed the high β-carotene variety 'CaroRed'. This variety has about 10 times the β-carotene of the common red tomato. The concentration of β-carotene in 'CaroRed' is near the lower limits for common carrots. 'CaroRed' is similar to 'Rutgers' (the recurrent parent) for many characters, except the high β-carotene of 'CaroRed' results in a distinctive red-orange color and different flavor. In a taste trial at the Indiana State Fair, with over 3000 individuals participating, it was shown that 'CaroRed' had a flavor distinctively different from that of 'Rutgers'. When color was masked, there was no flavor preference for 'CaroRed' or 'Rutgers'; but when color was not masked, there was a preference for the red variety, indicating a color bias.

Many tomato breeders are actively involved in attempts to incorporate the crimson and high-pigment characters, which influence vitamin A concentration, into successful tomato varieties. Compared to standard varieties, the crimson gene results in an approximately 50% decrease in β-carotene, whereas high-pigment results in about a 50% increase. High pigment, crimson, and high β-carotene are each controlled by a single gene.

FLAVOR

Nutrition is an important part of quality, but my primary interest has been the quality characteristics that relate to the organoleptic properties of vegetables. Flavor is very complex, from both a chemical and from a physiological point of view.

A major factor complicating efforts to breed for improved flavor is the difficulty describing and measuring good flavor, because of its nebulous character. What is good flavor in a peach, a strawberry, a snap bean or a tomato? It is not only difficult to describe good flavor; it may be troublesome to get people to agree on what is best flavor, because of personal preferences. Almost everyone has an acquired concept of what tastes good; and depending on background, personal preferences vary greatly. In a study of snap bean flavor, using an evaluation panel composed of staff and graduate students, we found that most of the American panelists preferred the flavor of the variety 'Blue Lake'; but there were a number of graduate students from the Middle East on the panel and, almost to a man, they preferred the stronger flavor of the variety 'Romano'.

There is no easy, reliable way to measure flavor objectively; and a breeder cannot expect to use gross, subjective evaluation techniques to select for this character. Rather, the individual components which make important contributions and are responsible for variation must be selected objectively.

Flavor is a perceptual complex; and although it depends to some extent on touch, pain and temperature, the predominant part of the flavor sensation derives from olfaction (the sense of smell) and gustation (the sense of taste).

Flavor is frequently determined by relationships among components, and the desired concentration of a compound will depend upon the concentrations of other compounds. For example, a prime factor determining intervarietal variation in tomato flavor is the sugar:acid ratio.

Sugars and Acids: A brief discussion of the solids and acids of tomatoes will illustrate some of the problems breeders can encounter in efforts to develop new varieties for a change in technology. The development of tomato varieties suitable for machine harvest resulted in many changes in fruit and vine characteristics. These were related primarily to increasing yield with a once-over harvest, and the ability of the fruits to withstand the rigors of machine harvest. Development of mechanically harvested tomatoes has had an adverse effect on some quality components, as the characters considered essential for mechanical harvesting are in opposition to the ones needed for high sugars (Table 2).

Table 2. Factors contributing to high sugars in tomato fruits.

1. Indeterminate growth habit
   A. Low fruit:leaf ratio
   B. Dispersed fruit-set
2. Late maturity
3. Low yield
4. Small fruit size
5. Restricted moisture availability

As a consequence of changes in plant morphology and setting ability, most machine-harvest tomato varieties have less sugars than do hand-pick types. Hand-pick varieties generally have a large vine and scattered fruit-set, which results in a relatively low fruit:leaf ratio. Machine-harvest varieties have a reduced vine and heavier, more concentrated fruit-set. This results in a very heavy load on available photosynthetic area over a reduced time period. Obviously, unless assimilation efficiency is improved dramatically, either yield or stored photosynthate has to decrease. Actually, yield increased, but fruit solids, primarily sugars, decreased. This reduction has had an adverse effect on the flavor of tomatoes, and has also resulted in reduced case yield of all products sold on the basis of solids content.

The processing tomato industry is now changing to bulk handling, which requires fruits that are firmer and tougher than those of most current varieties. The lines that appear to be well-suited for this type of handling have thick walls and a reduced locular area. These characteristics have an adverse effect on tomato acidity, as the acid concentration of the locular area is higher than that of the walls or interlocular area.

Organic acids are crucial to the flavor and processing characteristics of tomatoes. High sugars and a favorable sugar:acid ratio are essential to good quality tomatoes. Acid concentration is an important processing characteristic, as it must be high enough to give a pH less than 4.4 to avoid problems with thermophilic organisms. Higher pH values necessitate longer processing times increasing the difficulty of obtaining a high quality product.

Citric is the predominant acid in tomato fruits and malic usually accounts for the remainder of the total acidity of fresh tomatoes. Inheritance of concentration differences among some varieties is under simple genetic control. The differences in concentration of citrate and malate between two varieties, with widely different concentrations, are controlled by a single gene for each compound. The genes controlling the differences in concentration are linked in coupling phase. The study of divergent tomato accessions indicated that there are a number of genetic factors which influence varying concentrations of citrate and malate. There is a great variation in concentration of acids among tomato accessions. Titratable acidity from 0.31 to 0.91%, as citric acid, has been reported for Lycopersicon esculentum. Slightly higher values were reported for certain L. esculentum x L. pimpinellifolium accessions.

It is possible to breed for varying citrate:malate ratios. The question thus arises as to the merits of breeding for a specific ratio. Several studies have involved definition of the taste thresholds of citric and malic acids. Although reported thresholds vary greatly among studies, generally the difference between citric and malic in any one study were small, indicating that there is little taste potency difference between the two compounds. As there is an easily managed genetic potential for citrate plus malate concentration (total acidity), it is doubtful that attempts to control citrate:malate ratio would serve any practical purpose.

Although small in quantity, the volatile compounds are great in their impact on flavor. In most food crops, volatiles occur at a concentration of a fraction of a part per million: yet, in most instances, they are responsible for the characteristic aroma and flavor. In some vegetables and fruits, a single class of compounds has been found that has an aroma typical of that crop - for example, sulfides in onions, and the phtalides in celery. In other crops, e.g., snap beans and tomatoes, it appears that the typical aroma results from a combination of several unrelated compounds.

To cope effectively with flavor, the breeder must have an appreciation of the chemistry of important coumpounds, as the composition of fruits and vegetables is greatly affected by environment and postharvest treatment. I have little faith in the ability of breeders to select effectively for flavor by tasting fruits from several hundred plants each day or by setting up several dozen trays of fruits in a large room and asking associates to decide which has the best flavor.

The origin of volatile compounds is of great interest to the individual studying intervarietal flavor differences. If the genesis of the compounds of interest is understood, the chances of elucidated inheritance and successfully breeding for desired concentrations are considerably enhanced.

There are three general sources of volatile flavor compounds in fruits and vegetables. First, there are compounds naturally present in intact tissue; second, additional compounds are enzymatically produced after the tissue is damaged; and third, the volatile compound composition is further changed chemically, usually with heating. The latter two groups are actually artifacts, but they are of extreme importance in flavor. There are many compounds in intact tissue that are enzymatically produced in much larger quantities after tissue damage. There are at least three biosynthetic pathways which can result directly in volatile flavor compounds. Terpenoid compounds are formed by the isoprenoid pathway, but may also result from enzymatic degradation of other compounds. Terpenes have been found in most vegetables. The shikimic acid pathway leads to the production of aromatic compounds. Phenols and other aromatics have been found in vegetables. -Oxidation can result in esters, alcohols and aldehydes.

There is increasing evidence that many of the important volatile flavor compounds in vegetables are enzymatically produced after tissue damage. There are several well-established precursors of volatiles. The best studies precursor system in vegetables is that of amino acids in onions. The methyl and propyl disulfides, which are important flavor compounds in onions, apparently result from enzymatic degradation of methyl-cysteine sulfoxide and n-propyl-cysteine sulfoxide. Enzymatic oxidation of unsaturated fatty acids results in many volatile compounds of potential importance in vegetable flavor. In those vegetables where enzymatic production of volatile compounds has been studied, there is evidence that oxidation of fatty acids is important to flavor. It has been shown that important flavor compounds of the cucumber are enzymatically produced after the fruits are ruptured. Denaturation of enzymes by heating prior to blending resulted in a dramatic decrease in compound concentration. The nona-2,6-dienal (the cucumber odor compound) and 2-hexenal which are so important in cucumber flavor, result from oxidation of linolenic and 2-nonenal comes from linoleic acid. In tomatoes, trans-2-hexenal and -hexanal are important in fresh tomato flavor and a loss of these compounds contributes to the cooked flavor. It has been shown that 2-hexenal results from enzymatic oxidation of linolenic acid. When tomatoes are blended in a nitrogen atmosphere, there is a dramatic decrease in concentration of these important C_6 aldehydes.

There is great genetic potential for variation in tomato fruit color. Mature tomato fruit color is dependent upon carotenoid content and can vary from green to red. We have shown that carotenoid composition of tomatoes has an effect on flavor, apparently because several of the major volatile compounds of tomatoes result from enzymatic induced oxidation of the pigments. The oxidation is most prevalent at the first conjugated diene bonds. From lycopene, the prevalent carotenoid of red tomatoes, the predominant compounds produced are 6-methyl-5-heptene-2-one and citral. From -carotene, the prevalent compound is -ionone, the odor of which is readily apparent in high -carotene varieties.

The 70 or more volatile compounds of tomatoes have a total concentration of less than 2 ppm, yet they are very important to tomato flavor. There is evidence that 2-isobutylthiazole, methyl salicylate, engenol, trans-2-hexenal, and several isoprenoid carbonyls are important to flavor and specifically to flavor differences among varieties, but no compound has been found that has a characteristic tomato aroma.

Two tomato varieties with differences in flavor were studied to determine which compounds are responsible for flavor differences. 'Campbell 146' is an old hand-pick variety that is noted for its excellent quality, particularly flavor. 'Campbell 1327' is a newer variety that has a smaller vine and a more concentrated fruit set, but it lacks the excellent flavor of 'Campbell 146'. Intensive study of these two varieties showed large differences in the concentrations of three compounds. These were identified as 2-isobutylthiazole, methyl salicylate and eugenol. These three compounds are naturally present in intact tissue; the two phenols probably result from the shikimic acid pathway and thiazole is involved in thiamine biosynthesis.

A study of the inheritance of these compounds showed that 2-isobutylthiazole concentration is simply inherited with additive gene action. Methyl salicylate and eugenol concentrations are simply inherited with dominance for the low concentration. The genes controlling concentrations of these two compounds are closely linked.

'Campbell 146' has higher concentrations of all three compounds than does 'Campbell 1327'. The next problem was to determine if these compounds are factors in the flavor difference between these two varieties and, if so, their relative importance. The contribution that a compound makes to flavor is determined largely by its concentration and potency. By dividing the concentration by the threshold, which is a measure of potency, a value called the unit flavor base is obtained, which is a measure of relative contribution to flavor. Calculation of unit flavor base values for 2-isobutylthiazole, methyl salicylate and eugenol indicated that 2-isobutylthiazole is much more important in the flavor difference between 'Campbell 146' and 'Campbell 1327' than are the other two compounds.

When we added 2-isobutylthiazole to 'Campbell 1327', flavor evaluation panelists were no longer able to distinguish it from 'Campbell 146'. After 2-isobutylthiazole had been synthesized and its aroma had become familiar, it became apparent that the odor of this compound could be detected in 'Campbell 146', but not in 'Campbell 1327'. This compound has a very pleasant aroma at the concentration in 'Campbell 146'; and it is believed to be an important contribution to good tomato flavor.

Many new opportunities and obligations currently face all plant breeders, private as well as public. Now that FDA has decided that new varieties are within its domain, and now that seed companies have obtained some degree of protection with the varietal protection act, breeders must reassess their programs. The company that capitalizes on techniques for quality breeding may be the one that will gain most from varietal protection, as it is difficult to usurp and maintain a high quality variety without the same technology that was used to develop it. There is undoubtedly much that breeders can do to improve quality, if and when active programs for quality become more prevalent and improved quality receives a top priority.

CHEMISTRY, CORNFIELDS AND COMPUTERS
(ABSTRACT)

R. S. Loomis
Professor, Department of Agronomy and Range Science
University of California, Davis

Yield and quality are integrative measures of plant behavior. That is, they depend upon the interaction with environment of all of a plant's physiological capabilities. There have been two levels of research on such problems: empirical field studies; and cause-and-effect laboratory research. Field studies provide broad answers on the general effects of management variables such as water, nitrogen, spacing and new varieties. But they are expensive and usually cannot be used to predict the behavior of a different set of varieties and systems of culture or of subtle differences in quality characters. On the other side, our knowledge of plant physiology is still fragmentary and research on how to integrate such information into predictions of field behavior has only just begun.

Continued progress in agricultural production will require emphasis by growers on the technology of crop production, and new patterns in research.

Now directions in agricultural research are needed for progress on the physiology of quality. Brute-force empirical research is still needed but these to be placed in a more directed system closely coupled with causal research in genetics and physiology. And those more basic sciences need a much broader range of research in controlled climates and computer-aided integration and prediction. Finally, the future farmers must once again become competent in the technology of crop production.

A COORDINATED PROGRAM FOR NITROGEN AND WATER QUALITY RESEARCH

Victor J. Kilmer and Roland D. Hauck
National Fertilizer Development Center
Tennessee Valley Authority
Muscle Shoals, Alabama

The purpose of this paper is to direct attention to a stable isotope production program presently in progress at AEC's Los Alamos Scientific Laboratory and to suggest how these stable isotopes, particularly ^{14}N and ^{15}N, can be effectively used to better define the N cycle under field conditions.

During 1971, more than 7.5 million metric tons of fertilizer N were used in the United States and more than 32 million metric tons worldwide. Farm-site N requirements in the United States are currently estimated to be around 17 million tons annually (3). This high N requirement, amounting to about 170 pounds per capita, is a result of the high level of animal-based protein that constitutes a large part of the American diet. About 15 million out of the 17 million tons of farm-site N are used to produce meat, milk, cheese and eggs (3).

While the production and use of fertilizer N is vital to a continued well-fed and well-clothed population, the steadily increasing N inputs to the environment has greatly stimulated interest in the many aspects of N cycle processes. The difficulties involved in obtaining such data under field conditions are well-known to those who are involved in such studies.

Somehow, these difficulties must be surmounted or mitigated. It is evident that non-point sources of N, particularly in discharge waters from agricultural lands, will be given a good deal of attention during the next decade. It is also apparent that funds will be insufficient to carry out fruitful research in this area unless a combined and coordinated effort is launched by state and federal agencies. The interest and welfare of the public are clearly involved here and it is high time that the nitrate problem as related to nonpoint sources be tackled in earnest. Fundamental studies involving biological N_2 fixation and denitrification, as well as mineralization-immobilization processes are essential requirements for N cycle descriptions (1). Substantial progress in these fields will require the extensive use of N isotope.

Field plots and watersheds

Studies designed to determine the relationship between N fertilizer use and water quality will require suitable field plots and watersheds, properly equipped and instrumented. The following discussion of the subject is taken from Kilmer and Joyce (2).

Numerous studies have been made by land-grant universities and the USDA dealing with soil, water, and nutrient losses under various conservation practices. Runoff plots are well-suited to this type of activity and much valuable information has been learned. However, nutrient loss data obtained through these studies are of generally limited value when one attempts to relate these data to fertilizer use. This is particularly true of work carried out prior to the current concern over water quality. Runoff plot studies have certain obvious advantages including control of soil, crop, and treatments. When used in conjunction with a rainfall simulator, precipitation characteristics can also be controlled within limits.

There are also distinct disadvantages associated with runoff plots: (a) only nutrients lost in runoff are usually measured, (b) the data are difficult to interpret because of the system employed, and (c) agricultural conditions cannot wholly represent those present in farmers' fields. Plots providing for the measurement and sampling of both runoff and base flow would come close to meeting the ideal. The University of Illinois' installations near Joliet are of this nature. The plots are underlain by impervious glacial till, and thus have well-defined surface and subsurface boundaries. In effect, these are large lysimeters minus some of the shortcomings that lysimeter installations possess. The Illinois setup is an unusual one and comparable conditions are not likely to be commonly found elsewhere in the U. S. There are other methods of studying nutrient transport including tile drains, lysimeters, farm ponds, and the monitoring of streams, lakes, and wells. The latter methods are apt to provide only circumstantial evidence because control or comparative data are difficult to obtain. This difficulty is common to all studies of this nature.

Watersheds

While the utility of small plot studies is recognized, nutrient loss research on a watershed basis is highly desirable. There are two basic approaches to obtaining control data in watershed studies. The paired watershed concept involves two or more watersheds, as nearly adjacent to one another as possible. One is left untreated to provide a control for obtaining comparative data. This approach provides a relatively rapid means of obtaining data, since several treatments can be studied simultaneously. Unfortunately, no two watersheds have been found to possess the same hydrologic characteristics and the paired concept is faulty in this respect. The second approach, the single watershed involves a period (usually a year or more) of "no treatment" followed by imposing suitable controlled variables. This approach has the advantage of employing the same site for control and experimental data. However, precipitation characteristics may vary from year to year resulting in data interpretation difficulties unless long-term periods of study are undertaken. This is true for all watershed work involving hydrology.

Requirements of watersheds suitable for nutrient loss studies

Ideally, a watershed to be used for nutrient loss studies should possess the following characteristics:

- Be representative of agricultural practices in the area where located.

- Boundaries, both surface and subsurface, should be sharply defined to permit the measuring and sampling of all discharge water originating only within these boundaries.

- Be accessible by car.

- Permit the installation of a weir plus measuring and sampling equipment.

While not an absolute necessity, proximity to electric power is highly desirable for servicing sampling equipment and heating cable where below freezing temperatures are encountered. A knowledge of past hydrologic behavior is also extremely helpful in the interpretation of nutrient loss data.

Precipitation can contribute potentially significant amounts of nutrient materials to a watershed, particularly in industrialized areas. The Wong precipitation sampler has two containers, one of which remains open during dry weather while the other is closed. When precipitation of any type occurs, the moisture sensor and its electronic circuit reverse this situation, closing the dry fallout collector and opening the one which will receive precipitation.

In summary, a hydrologically tight watershed equipped with automatic measuring and sampling equipment is idea. Pesticide and nutrient loss studies can be carried out simultaneously if desired.

Use of stable isotopes in N loss studies

While unlabeled N fertilizers may be employed in fertilizer use-water quality studies, tracer techniques have many advantages. Among these are:

- Positive identification of N sources.

- No control or base data collection required.

- Data collection on fertilizer N loss can be started immediately, saving 1-2 years in time.

- Studies involving labeled N fertilizers are often more accurate because analytical measurements are made on compounds of direct interest.

There are disadvantages, too:

- N isotopes are expensive to use and specialized knowledge and techniques are required.

- A mass spectrometer is required for analysis.

- Dilution effects may negate an experiment by lowering the concentration of the isotope to a point where accurate interpretation is not possible.

The normal abundance of ^{15}N in the atmosphere is 0.3663 atom %. Enriched materials generally have a ^{15}N concentration of 90 atom % or higher. These enriched materials are usually diluted by the experimenter to a concentration varying between 0.75 and 10 atom %. For single season N uptake and movement, 1 atom % is satisfactory.

It is possible also to use ^{14}N materials. These have an unnaturally low concentration of ^{15}N, generally below 0.03 atom % which is equivalent to an enrichment of about 0.75 atom % above natural abundance. ^{14}N materials are not suitable for denitrification studies.

ICONS (Isotopes of carbon, oxygen, nitrogen and sulfur)

In a recent AEC report (4), one of the stated objectives is to produce at relatively low cost the following quantities of separated isotopes by 1974:[1]

^{12}C	2 MT/yr	^{16}O	5 MT/yr
^{13}C	40 kg/yr	^{17}O	2 kg/yr
^{14}N	4+ MT/yr	^{18}O	12 kg/yr
^{15}N	18 kg/yr		

While these production schedules are subject to modification, it is clear that stable isotopes will be available in large amounts for the first time in history. Of particular interest at this time are the stable isotopes of ^{14}N and ^{15}N. The utility of both of these isotopes in soil-plant-fertilizer systems has been amply demonstrated. Experiments on a field-scale are now possible, particularly where the utilization of ^{14}N is involved.

A precedent has been established utilizing AEC-produced N isotopes in cooperative soil and fertilizer N research programs during the past 10 years[2]. The AEC agreed to furnish up to 300 grams of ^{15}N over a 10-year period for use in research projects jointly approved by both agencies. In turn, TVA agreed to incorporate the isotope in an appropriate N carrier for use in cooperative research with other institutions and in its own research studies as well. This agreement has been amended and extended for a year to provide for acquiring a limited amount of ^{14}N for cooperative projects. Two such projects are presently in progress, one in Illinois and the other in Louisiana.

The proposed cooperative program set forth here is expected to involve several federal agencies (AEC, TVA, EPA and USDA), and land grant colleges. AEC is, of course, involved in isotope production and will need to recover production costs. TVA will

---

[1]At the present time, no extensive plans have been made for sulfur isotope separation.

[2]Memorandum of Understanding between the Tennessee Valley Authority and the Atomic Energy Commission, relating to A Cooperative Soil and Fertilizer Nitrogen Research Program. Approved by the AEC on June 17, 1963, and TVA on July 1, 1963.

incorporate the isotope into appropriate N carriers and coordinate "in house" and cooperative research with EPA, USDA and the land grant colleges.

While initial studies will deal mainly with fertilizer N use and water quality, fundamental research on the N cycle will be carried on simultaneously. The overall objective is to obtain the necessary data for predicting the fate of applied N under varied soil, crop and climatic conditions.

Areas of research in which N isotopes can be used to advantage

A. ^{14}N Materials

1. N transport within and from a watershed
Object: To determine the contribution of fertilizer N, if any, to the NH_4^+, NO_3^- and total N content in surface and ground water.

2. N movement into deep soil profiles
Object: To determine whether N moving out of the normal rooting zone is
a) Taken up by deep-rooted crops
b) Is denitrified
c) Is leached into the ground water
d) Is otherwise held in the soil.

3. Decomposition of tagged legumes
N loss from soils cropped to legumes may be considerable - few data are available. Does nitrate from mineralization of legume residues contribute to NO_3^- enrichment of waters?

4. Decomposition of crop roots
Data are needed on this because little is known of N release from root residues. Lack of these data introduces errors in interpretation of soil N balance data.

5. Sequential decomposition of soil organic matter
Because of limited amounts of isotope and labor, o.m. decomposition studies are made over relatively long time intervals. This results in data which represent net effects of opposing reactions. Needed are intensive series of investigations over short time intervals so that N transformation rates can be calculated. Data from 6 and 7 are essential for more accurate interpretation of N cycle processes.

6. Fall vs. spring applied fertilizers
Definitive experiments are lacking mainly because in previous experiments with unlabeled materials, no information was, or could, be obtained concerning the N which was not taken up by the crop. Study of slow-release N, such as SCU in this regard is especially applicable.

7. Redistribution of N from fertilized to nonfertilized soils
Ammonia volatilized from calcareous soils or from alkaline microsites in soils which are greater or lesser distances from the point of terrestrial origin. Such redistribution of N has been observed among fertilized and nonfertilized soils in greenhouse pot experiments. Information is needed on the magnitude of such N transfer in field experiments to improve our methodology of studying N balance and such work may offer a clue to the global redistribution of N from one terrestrial point to another.

8. Long-term effect of nitrification inhibitors
Use of such fertilizer amendments are said to reduce nitrate accumulation in soils. One can ask whether ammonium which was protected against nitrification during the growing season is

subsequently nitrified, thereby adding nitrate to the soil during a fallow period. This would increase nitrate accumulation and leaching.

B. ^{15}N Materials

1. N Balance in field soils
Object: To determine the distribution and transformation of N inputs (fertilizer N, organic residues, etc.) into a soil-crop system for a period of 5 years. Usually, 25% of applied N remains in soil for at least 1 year. About 5% of this is released for crop use the second year. Little is known concerning the remainder.

2. Denitrification in deep soil profiles
Is this an alternative mechanism of N loss which is more acceptable to environmentalists than NO_3^- leaching to ground water? This problem, although difficult to study, can be attacked with tracer N.

3. N balance in soils with high ammonia fixation capacity
There has been no N balance study in the field in which ammonia fixation has been recognized as a factory. Such fixation can be appreciable (more than 10% of applied N) for some soils and N balances made on such soils overestimate the presumed volatile and leaching losses of applied N.

4. Residual value of slow-release N
Often, slow-release N sources yield more yield and better seasonal distribution of N but the total N taken up by the crop is less than with equivalent amounts of soluble N sources. Is the N remaining in the soil of value to succeeding crops?

5. Effect of N fertilizers on mineralization
Fertilizers which form solutions of high pH solubilize soil organic matter (as much as 10-15% has been noted in the laboratory). This is especially true for anhydrous NH_3, N solutions (urea-AN) and polyphosphates. What is the long-term effect on soil organic matter from continuous use of these materials placed in high concentrations in soils - the effect on N content organic composition and physical properties.

6. N loss from plant surfaces
This is virtually a virgin field of research with many facets. One of several practical problems is the hydrolysis of urea on the leaf surface after spray application of N solutions.

7. Comparative efficiency of N solutions and solid N sources
Very little basic soil chemical research has been done on N solutions other than anhydrous ammonia, despite their widespread and rapidly growing use. Their soil reactions are quantitatively and perhaps qualitatively much different than the soil reactions of solids.

8. N transformations of manures and municipal wastes in soils
Environmentalists argue without the results of definitive experimentation that organic wastes contribute less to nitrate pollution than soluble N fertilizers. The entire N transformations of such materials added to soil should be described using N tracer techniques.

9. N turnover in forest litter
A fundamental question to ask is whether it is more efficient to fertilize the tree crop or the forest litter. If the rate of turnover in the litter is sufficiently fast to provide nutrients for relatively slow-growing plants, then fertilizing the litter

would be an ecologically safer practice. Data are needed on transformation rates in forest ecosystems.

10. Field measurement of denitrification
Quantitative direct measurements of denitrification have never been made under normal field soils. Thus, 10-25% of the N balance account for soil-crop systems is based on indirect and presumptive evidence. Tracer N is indispensable for making direct measurements of denitrification.

11. Denitrification and soil water movement
Except for work in paddy soils, little work has been done in the field on the relationship between fluctuating water levels in soils and nitrogen deficits.

It is likely that other areas of research will be suggested as the work progresses.

REFERENCES

1. Hauck, Roland D., 1973. "N Tracers in N Cycle Studies - Past Use and Future Needs." Jour. Env. Quality. In press.

2. Kilmer, V. J. and Joyce, R. T., 1971. "Fertilizer Use in Relation to Water Quality with Special Reference to the Southeastern United States." Proceedings, 22nd Ann. Pacific N. W. Fertilizer Conference, Bozeman, Montana. 173 p.

3. National Academy of Sciences, 1972. Accumulation of Nitrate. Washington, D. C. 106 p.

4. Schreiber, E. R. (Ed.), 1971. Icons at LASL. Los Alamos Scientific Laboratory, Los Alamos, New Mexico. 18 p.

NITRATE ACCUMULATION IN VEGETABLES

O. A. Lorenz and B. L. Weir
Department of Vegetable Crops
University of California, Davis

Abnormally high levels of nitrate accumulation in plants have been noted for many years. New interest, particularly with vegetable and forage crops, has been generated since the 1950's due to the greatly increased use of nitrogen fertilizers. There is also public concern over possible health hazards as a result of nitrate accumulation in certain foods. Methemoglobinemia in infants has been associated with high levels of nitrates in water and foods. "Nitrate toxicity" is actually "nitrite toxicity" and the toxicosis results from nitrites produced after nitrate reduction by microbial action, either before ingestion or within the gastrointestinal tract. Nitrite oxidizes the ferrous iron of the red blood pigment hemoglobin to ferric iron producing a brown colored pigment called methemoglobin which is incapable of transporting or releasing oxygen to the body tissues. The nitrate content of foods is a potential index of the amount of nitrite that may be formed. Recently there is interest in the relationship of nitrates to nitrosamines and the subsequent carcinogenic and mutagenic effects.

Some of the effects of nitrates and nitrites on domestic animals are well-known. Less well-known is the effect on humans. Nitrate poisoning in livestock was reported as early as 1895. Beginning in 1940, there were numerous reports of cattle poisoning from nitrates in the Mountain States. In California there have been a number of cases of nitrate toxicity and reliable reports indicate that nitrate poisoning was responsible for the loss of 2000 to 3000 cattle in the Salinas Valley during the spring of 1952. Reports vary as to the levels of nitrate considered toxic to animals and several factors other than the actual nitrate content must be evaluated. Tucker et al. in California considered plants containing more than 0.20% NO_3-N on a dry weight basis as being potentially dangerous to livestock. Several workers have considered hay containing more than 0.40% NO_3-N to be toxic.

Although no authenticated cases of nitrate poisoning of human adults have been reported, there are a few reports of young babies being poisoned by eating spinach with a high nitrate content. The Public Health Service has not established standards relating to the nitrate content of vegetables. Standards have been set at 10 ppm nitrate nitrogen (NO_3-N) for drinking water and 200 ppm nitrate (NO_3) or nitrite (NO_2) for certain processed meats. Simon (19) has proposed that spinach for baby food should contain no more than 67 ppm NO_3-N based on fresh weight. Sollman (20) has estimated that a toxic dose for an adult might be 1 gram NO_3-N.

Nitrates are also important to the canning industry. Canned acidic vegetables such as tomatoes and beans which contain nitrates often result in excessive detinning of the cans, which can result in extensive economic loss. Under certain conditions, as little as 20 ppm NO_3-N, fresh weight basis, can cause serious detinning for canned tomatoes.

Vegetable crops in California receive high rates of N fertilizers. The rates continue to increase and, in many instances, are double those of 1950. We were interested in identifying the crops and plant parts that have the potential for accumulating high levels of nitrate, especially with high rates of N fertilization. Our principal concern was in assessing the part of the plant commonly eaten by man; but we also considered that part of the plant which may be trimmed away and have other uses, such as cattle feed; for example, the wrapper leaves of lettuce and the tops of radishes and turnips.

We surveyed about 25 of the important vegetables grown in California. Several distinctive cultivars were included in some of the crops. The plants were harvested at different seasons of the year to determine the influence of different growing conditions, particularly temperatures, on nitrate accumulation.

Samples were taken at prime edible maturity as well as at intervals before and after prime maturity. Nitrogen from NH_4NO_3 was applied at planting at rates of 0, 200, and 500 pounds N per acre. The 200 pound rate approximates a normal application, whereas the 500 pound rate is excessive and often several times that required for maximum yield. Most crops grew very poorly with the zero rate and nitrate accumulation was much less than that associated with or required for satisfactory yields.

What did we find? The particular crop, the part of the plant sampled, and the rate of fertilization all greatly affected nitrate accumulation. (Tables 1 and 2.) Some plant parts, such as pepper fruits or kernels of sweet corn, accumulated only negligible quantities of nitrate regardless of the rate of N fertilization. Others accumulated very high levels of nitrate; some by more than 10 times the level considered potentially dangerous for cattle feed. Some turnip petioles accumulated over 3% NO_3-N on a dry weight basis, the highest of any crop. Levels of about 2% NO_3-N were found in petioles of spinach, beet, and kale. The leaf blades of these crops were also high. Roots of radish exceeded 1% NO_3-N while turnips and beets were also relatively high. Carrot roots, potato tubers and onion bulbs were low. Practically all of the fruit vegetables were very low in nitrate and only a single harvest of summer squash exceeded the .2% NO_3-N level. Some workers have reported zero nitrate in a number of the fruit vegetables.

The wrapper leaves of cabbage were about three times higher in nitrate than were the head leaves of the same plants. Heavily fertilized Boston lettuce had .602% NO_3-N in the wrapper leaves and only .207% in the head. Crisphead type lettuce showed .496% NO_3-N in the wrapper leaves and .326% in the head. Thus, man's consumption of nitrate could be controlled considerably by observing some ordinary practices, such as discarding the older or wrapper leaves of lettuce and cabbage and the outer petioles of celery. Discarding the petiolar tissue of spinach and turnip and eating only the blade would reduce nitrate consumption by more than half.

As a general rule, nitrates accumulated at the highest levels in the leaf and stem tissues. Petioles and stems had more than did the leaf blades. There was considerable variation in the root crops; but, generally, the storage roots were lower in nitrates than were the leaves or stems. Fruits and floral parts accumulated only very small amounts of nitrate. Assuming 1 gram of NO_3-N to be toxic to man, an adult, to be poisoned, would have to consume some two pounds of spinach at a single meal, a quantity which is extremely unlikely. On the other hand all of the leafy vegetables and many of the others had nitrate levels which could result in detinning of the cans of processed vegetables.

Once we selected a plant part that accumulated nitrate, then N fertilization had considerable influence on the degree of nitrate accumulation. At levels of N where growth was restricted, accumulation of nitrate was very low. With increasing levels of N fertilization, the rate of accumulation increased. In a trial with table beets, fertilization with 500 lb N per acre as compared to none increased nitrate accumulation in the petioles of 70 times, in the blades 30 times, and in the roots 20 times. Equally significant was the increase in NO_3-N as related to total N, with the percentage of NO_3-N increasing from 3.7 to 88.4% in the petioles and from 2.4 to 38.2 in the blades. With practically all crops as nitrates accumulated, the proportion of NO_3-N to total N also increased.

While conducting these studies, we also made a thorough survey of the literature relating to the nitrate content of vegetables. The values we obtained agree very well with those reported by other workers. The crops which we found to accumulate high levels of nitrate were also found to be so by other workers. Our value for turnip petioles containing over 3% NO_3-N ranks as one of the highest values reported. One very significant point is that there has been no appreciable change in the nitrate content of vegetables since the earliest reported analyses of previous workers. This indicates that the increased usage of N fertilizers has not resulted in significant increases in the nitrate content of vegetables.

It should be emphasized that nitrate accumulation in plants, to a certain extent, is a natural and necessary process. Growers could not attain satisfactory yields without some nitrate accumulation in the product. Most of the samples analyzed had nitrate accumulation only slightly above the concentration required for maximum yield. There is a minimum level of nitrate associated with satisfactory growth. Nitrate accumulation beyond that level may be considered excessive, but, in some cases, is associated with greener color and increased succulence of the product.

The source of N fertilizer can have marked effects on nitrate accumulation. In our source of N studies with spinach and lettuce, nitrate absorption by the plants was higher from N applied in the nitrate form than from that applied in the ammoniacal forms. This agrees with workers in the East who found almost twice as much nitrate in spinach fertilized with nitrate as that receiving other forms.

In our studies there were large differences in nitrate content among species, but the differences among cultivars of the same species were small and inconsistent.

There was little effect of time of harvest on nitrate accumulation. Plant parts sampled at the time of prime edible quality varied only slightly and inconsistently from samples taken before or after this stage of maturity. Other workers have shown no consistent effect of maturity or nitrate accumulation.

Many cases of high nitrate accumulation in plants, and subsequent toxicity to animals have been related to growth conditions - particularly a sudden drought. Evidently, there is a cessation in growth which is not accompanied by a corresponding reduction in nitrate absorption; and, hence, the effect is that nitrates accumulate. It is doubtful if such drought conditions would be encountered in vegetable production; and they definitely would not occur with vegetables grown under irrigation.

Light very definitely effects nitrate accumulation. Plants grown with deficient light, such as during cloudy weather or under short days, are likely to accumulate more nitrate than those grown with ample light. Shading of plants greatly increases nitrate accumulation. Plants harvested in early morning often have higher nitrate content than those harvested near the end of the day. This is due to the fact that the enzyme, nitrate reductase, which is responsible for the reduction of nitrate, is light dependent, and is most active under high light conditions.

Temperature has also been shown to influence nitrate accumulation. Plants grown at temperatures where growth is restricted often accumulate nitrates. Tomato fruits grown at 20°C day temperature accumulated nearly five times the amount of nitrate as fruits produced at 30°C. Conversely, spinach plants accumulated much more nitrate when grown at 25°C than at lower temperatures.

Several tests investigated the effect of temperature and time on changes in the nitrate and nitrite composition of stored vegetables. These studies, conducted under aerobic conditions, showed no appreciable reduction in nitrates or increases in nitrites, even after extended periods of storage. A few reports show an increase in the nitrite content of stored vegetables.

SUMMARY

By way of summary, the following points are made. Leaf and stem tissues accumulated the highest levels of nitrate, followed by the roots. Fruits and floral parts accumulated only small amounts of nitrate. Some nitrate accumulation is a natural and necessary process and the levels of nitrate in the plants cannot be reduced much without reducing yield. The stage of maturity of the produce at harvest had little effect on nitrate accumulation. Differences in nitrate levels between cultivars of the same specie were small. Nitrate accumulation increased as the rate of nitrogen fertilization increased. Nitrate sources of fertilizer resulted in higher nitrate accumulation than did ammoniacal sources. There has been no significant increase in the nitrate content of vegetables since some of the earliest reported analyses. Even at the highest rates of nitrate accumulation observed, the possibilities of an adult consuming enough food to cause nitrate toxicosis are exceedingly remote.

TABLE 1. Range of Nitrate Content in Vegetables Grown at Davis, California Spring, Summer, and Fall, 1971.

Vegetable	Cultivar	Nature of Sample	NO_3-N % Dry Weight[1]
Bean	Contender	pods and seeds	.047 - .162
Beet	Crosby's Egyptian	blades	.011 - .866
		petioles	.031 - 1.891
		roots	.188 - .680
Broccoli	Calabrese	head	.018 - .232
Cabbage	Copenhagen Market	head	.014 - .207
		wrapper leaves	.002 - .543
Carrot	Imperator	roots	.058 - .183
Cauliflower	Early Snowball	head	.002 - .066
Celery	Tall Utah	petioles	.003 - .203
		blades	.004 - .224
Corn	Golden Cross Bantam	kernels	.008 - .016
Cucumber	Picklepak	fruit	.014 - .144
	Pepino	fruit	.001 - .143
Kale	Dwarf Blue Curled	blades	.002 - 1.564
		petioles	.008 - 1.967
Lettuce	Big Boston	head	.059 - .453
		wrapper leaves	.018 - .602
	Paris Cos	head	.141 - .303
		wrapper leaves	.119 - .613
	Great Lakes 659	head	.026 - .363
		wrapper leaves	.012 - .496
Muskmelon	PMR 45	fruit	.018 - .026
	Honey Dew	fruit	.043 - .161
	Persian	fruit	.024 - .103
Onion	Grano	bulbs	.020 - .034
		tops	.003 - .038
	Southport White Globe	bulbs	.068 - .097
		tops	.022 - .043
	Sweet Spanish	bulbs	.022 - .071
		tops	.015 - .210
Parsley	Paramount	tops	.032 - .358
Peas	Progress #9	pods and seeds	.019 - .033
Pepper	Yolo Wonder	fruit	.003 - .005
Potato	White Rose	tuber	.004 - .019
Radish	Crimson Giant	tops	.006 - 1.295
		roots	.046 - 1.086
	White Icicle	tops	.014 - 1.487
		roots	.173 - 1.280

[1]Each value represents the average of samples from two or more plots.

TABLE 1. (Cont.) Range of Nitrate Content in Vegetables Grown at Davis, California Spring, Summer, and Fall, 1971.

Vegetable	Cultivar	Nature of Sample	NO_3-N % Dry Weight[1]
Spinach	Viroflay	blades	.030 - .496
		petioles	.054 - 2.288
Squash	Hubbard	fruit	.003 - .496
	Early Prolific Straightneck	fruit	.062 - .446
	Zucchini	fruit	.054 - .298
Tomato	M. H. 145	fruit	.012 - .024
Turnip	Purple Top White Globe	blades	.039 - .870
		petioles	.022 - 3.109
		roots	.016 - .877
Watermelon	Striped Klondike	fruit	.018 - .047

[1]Each value represents the average of samples from two or more plots.

TABLE 2. Effect of Rate of Nitrogen Fertilization on Nitrate Composition of Edible Portions of Selected Vegetables.

Crop	Plant Part	NO_3-N % Dry Weight[1]			NO_3-N % of Total N[1]		
		N lb./acre			N lb./acre		
		0	200	500	0	200	500
Beet	petioles	.019	.712	1.598	3.7	61.5	88.4
	blades	.030	.238	.866	2.4	15.2	38.2
	roots	.187	.243	.384	14.6	13.6	15.7
Broccoli	heads	.114	.196	.232	3.6	4.6	5.0
Cabbage	wrapper leaves	.051	.316	.524	2.4	9.5	15.2
	heads	.077	.140	.154	4.3	6.0	6.7
Carrot	roots	.080	.183	.146	11.9	15.9	12.8
Celery	petioles	.004	.010	.203	1.0	2.2	25.3
	blades	.004	.007	.224	0.4	0.7	13.0
Kale	petioles	.009	1.095	1.396	1.3	38.1	31.9
	blades	.002	.095	.361	0.1	2.5	6.4
Lettuce, Boston	wrapper leaves	.029	.578	.602	1.3	19.3	17.2
	heads	.148	.212	.207	7.0	8.6	7.7
Lettuce, Great Lakes	wrapper leaves	.035	.229	.496	2.1	9.3	17.6
	heads	.026	.283	.326	2.4	17.2	19.6
Melon, Honey Dew	fruits	.099	.128	.161	38.7	29.1	30.7
Onion	bulbs	.023	.026	.020	3.8	2.9	1.9
	tops	.014	.014	.038	0.8	0.7	1.9
Parsley	tops	.032	.094	.267	1.6	3.9	8.9
Radish	tops	.700	.953	1.190	19.2	27.3	31.6
	roots	.802	.942	1.086	37.3	42.4	45.1
Spinach	petioles	.781	2.160	2.288	41.2	69.3	68.6
	blades	.153	.380	.496	4.1	9.2	11.9
Squash, Early Prolific	fruits	.186	.366	.446	6.2	16.6	18.6
Turnip	petioles	1.563	3.193	3.109	7.3	31.8	42.2
	blades	.050	.354	.870	1.8	9.1	16.2
	roots	.022	.066	.364	1.0	2.5	10.0

[1]Values are averages of samples from duplicate plots.

PANEL DISCUSSION ON WATER SUPPLY AND MANAGEMENT
THE PROBLEMS - AN OVERVIEW

Robert M. Hagan
University of California, Davis

In very simple terms, we don't have a water problem without people. The more people involved, the more difficult will be our problems of water supply and management. Even though we achieve a childbirth rate leading to zero population growth, we must still meet the water needs of increasing numbers of people in portions of California for some years to come. What man must do, then, is to develop water supply and management practices which will provide for more lives per gallon of water while still achieving an acceptable standard of living and preserving beauty and a desirable balance in our ecosystem.

Some say it is important to preserve our free-flowing rivers. Others say that precious water is being wasted and that we should continue to harness these rivers to meet man's needs for additional water, while achieving benefits of flood control, power generation, maintenance of stream flow in low-flow months, enhancement of some aspects of fish production, new recreational opportunities, etc. Some groundwater basins have been overdrawn and serious subsidence and/or salt water intrusion is being experienced. Increasing conjunctive use of surface groundwater storage may solve some of our problems. Possibilities for obtaining more water from surface and groundwater supplies will be summarized.

The changing value system of a changing society and the resultant rise in environmental concerns leads to demands that cities <u>not</u> continue to import water from distant watersheds, that our urban areas reclaim and recycle waste water and that man stop degrading the quality of our surface and groundwaters. This viewpoint requires that we find ways to achieve more lives per gallon of already developed water in California.

There are practical limits to recycling. On the average, each time water is cycled through the typical urban community, about 300 ppm of total dissolved solids are added. In the San Francisco Bay Area water from the Mokelumne and the Tuolumne Rivers contains less than 100 ppm of TDS. This water could be recycled about three times before reaching the U. S. Public Health limit for drinking water set at about 1,000 ppm. Waters containing greater TDS may still be acceptable for certain industrial uses. This use has been proposed for recycled waters in the Bay Area. In Southern California, the pressure to recycle has been greater, but the average salt content of the delivered water is much higher. Thus, the possibilities there for recycling are much more limited without desalting.

Man must now deal with both the quantity and quality aspects of water supply and its management. The loading of pollutants arising from the concentration of people and animals in urban areas, the intensification of agriculture, including the use of fertilizer and pesticides, society's desire to avoid or minimize disposal of waste to surface water, including the ocean, a growing concern about degradation of groundwater, and our reluctance to set aside sinks to receive our salts and other wastes - all are creating major problems of water quality management. Both state and federal legislation now require detailed studies of water quality control.

All planners, opinion-shapers, and decision-makers must deal with the problems of additional water supply, recycling, desalting, and water quality while facing the cross-currents of public opinion which often become highly emotional in dealing with the extremely complex patterns of water supply and use in today's society. No water project or water decision can be expected to satisfy everyone in today's crowded and interdependent society.

OBTAINING MORE WATER FROM SURFACE AND GROUND WATER SUPPLIES

John R. Teerink
California State Department of Water Resources
Sacramento, California

Since publication of the California Water Plan in 1957, the Department of Water Resources has been engaged in an intensive statewide planning program to maintain, supplement and update as necessary this long-range general plan for the management of California's water resources.

Alternative sources of water considered available for meeting future demands include surface water development by federal, state, and local agencies, increased use of ground water in conjunction with surface supplies, desalination, reclaimed waste water, weather modification, and geothermal resources.

Remaining sources of large quantities of surface water in California lie in the north coastal and Sacramento basins. Opportunity for storage to regulate these water supplies are also in the North Coast and Central Valley and in the extensive underground basins of the San Joaquin Valley and south coastal area. While surface water resources are ample to meet foreseeable statewide needs on an overall basis, they are maldistributed geographically with respect to areas of need.

The potential still exists for major on-stream storage development to regulate uncontrolled runoff and transport the available water supply to areas of need in large aqueducts. In addition, further conservation of winter flood flows may be accomplished by off-stream storage facilities within the Central Valley, particularly where excess capacity is available during the winter months in existing canals. Finally, groundwater storage capacity constitutes an extremely valuable resource at present, and its use will be expanded to provide additional regulation when operated coordinately with both local and imported surface water supplies to effect the most economical use of total available storage.

DESALTING SEAWATER AND BRACKISH WATERS[1]

Manuel Lopez, Jr.
Office of Saline Waters, USBR
Denver, Colorado

The program to develop the processes for desalting sea and brackish water is about 20 years old. Virtually all desalting processes occur naturally. The role of OSW is to optimize the processes, evaluate their potential to meet known and projected needs, and disseminate the information so that both suppliers and users have rational basis for decision-making.

Seawater desalting is already commercial. Numerous communities throughout the world currently receive all or a substantial portion of their water supplies from the sea. The most developed desalting process is distillation, in varying forms. Freezing has some important advantages over distillation and is being developed at a rapid rate.

Brackish water desalting has application both to augment water supplies and to improve the quality of existing supplies. Membrane processes are generally used for this application (list of communities using desalting of brackish water in the U. S.). Two main processes currently in use are electrodialysis and reverse osmosis. Costs for desalted seawater have gone from over $5.00 per thousand gallons in 1950 to less that $1.00 per thousand gallons today. Future costs will depend on energy costs, size of plants and cost-sharing arrangements with utilities. Costs for desalted brackish waters follow a similar pattern.

---

[1]Presented by Stewart F. Mulford

MANAGING WATER QUALITY

Dwight C. Baier
State of California Water Resources Control Board
Sacramento, California

In some respects, the traditional control measures for industrial waste discharges are not applicable to irrigation return flows. To this extent, innovative thinking is needed. To illustrate this point, one needs to look at the factors affecting irrigation return flows. These are evapotranspiration, soil additives, dissolved earth minerals and erosion. Ordinarily, evapotranspiration has the greatest effect of these and is the most difficult to control. Put simply, the problem is that all irrigation water contains some salt, and the plants use practically pure water, leaving the salt behind in the soil. Sooner or later, this salt must be flushed out of the root zone by leaching. Thus, the leachage is saltier than the irrigation water. The paradox is that the more efficient the irrigation, the higher the TDS of the discharge. Thus, the folly of traditional waste discharge requirements limiting the concentrations of minerals in irrigation return flows becomes apparent. Such requirements encourage inefficient irrigation and wasteful use of the resources of the State.

The second most important factor affecting the mineral quality of irrigation return flows is soil additives. The most maligned of these is manure. A normal application of manure contains about 300 pounds of salt per acre. This compares to 6,000 pounds of salt per acre in three acre-feet of Colorado River water or 1,500 pounds in a similar amount of State Project water.

In the category of soil additives, the precursors of nitrogen deserve special attention. First of all, of course, nitrates have special well-known qualities that make them undesirable. But, second, is their effect on the solubility of earth minerals. Every first-year chemistry student knows that oxidation of ammonia to nitrate releases an annion, nitrate, which demands a balancing cation. In calcareous soils, this cation is likely to be calcium. Suffice it to say that such chemistry is not damaging to the waters of the State if the nitrate is not leached.

The third factor affecting the mineral quality of irrigation return flows is the solution of earth minerals. Quite aside from the effect of nitrates, it has been shown that many irrigation waters dissolve earth minerals in their passage through the soil. Other things being equal, the quantity dissolved appears to be a function of the amount of leaching. So, overirrigation again becomes the villain.

The traditional approach to controlling discharges from cities and industries has been a numerical limit on certain constituents. To whatever extent such an approach would encourage overirrigation, it would be pushing the irrigator in the wrong direction and increase pollution rather than decrease it. Agronomists need to approach the problem of discharge requirements and devise an intelligent rationale that will truly reduce the pollution rather than increase it.

ENERGY REQUIREMENTS IN FOOD PRODUCTION

Perry R. Stout
Professor, Department of Soils and Plant Nutrition
University of California, Davis

Analyses of fossil-fuel energy being consumed on behalf of the USA's present-day farming operations show that the baseline of fossil-fuel energy expended for tillage, harvesting and fertilizer manufacture is equal to or greater than the energy content of foods consumed within the USA. Additional energy costs beyond the ones reported here must be added for transportation of goods to the farm and for distribution and pumping water where appropriate. Also, the non-solar energy costs for transportation, storage, packaging and food preparation must be evaluated before the full energy costs of food reaching the American Table can be accounted for in terms of fossil-fuel versus solar-energy components.

Nitrogen pathway tracing offers a convenient method of evaluating food-chain energy losses. The American dietary intake of 100 grams protein per capita day has a 70 gram animal-protein to 30 gram vegetable-protein mix. It requires 6 vegetable-protein units in animal feed for each animal-protein unit of meats, fish, eggs and dairy products consumed by humans. These latter food sources, with butter excluded, account for 34% or 1100 of the 3270 kilocalories per capita day available for human consumption in the USA. Therefore, the vegetable-protein fraction of the USA diet that supplies 30 grams of protein also supplies an average of (3270-1100)/30 = 72 kilocalories per gram of vegetable-protein consumed.

Agricultural production of the meat, egg and dairy components of USA diets claims by far the greatest share of solar-energy captured by USA crops. Assuming that animal rations have the same calory:protein ratios as the vegetable-foods consumed by humans, the per person share of daily feed for animals amounts to about (72 k cal/gm) x (70 gm. prot.) x 6 = 30,000 kilocalories per capita day.

The NPK fertilizer nutrient components of USA farming operations for 1969 were in millions of tons; 7.46 for N, 4.57 for P_2O_5 and 4.04 for K_2O. The corresponding energies consumed in production of these fertilizers in units of 10^{12} kilocalories were 62.3 for N, 14.7 for P_2O_5 and 2.4 for K_2O, respectively. This amounts to 940 kilocalories per capita day for the major fertilizers.

Tillage of USA's 287 million food-crop acres (assuming energy costs of making machinery and tires and burning fuels for a rain-fed wheat crop as the average) would have consumed 215 x 10^{14} kilocalories for the year. This prorates at 2920 kilocalories per capita day for tillage. Therefore, the combined energy for fertilizers and tillage was (2920 + 940) = 3860 kilocalories per capita day in 1969, versus a 3270 kilocalory per capita day available food supply.

Thus, the first-cut estimate of fossil-energy costs for fertilizers plus tillage is conservatively placed at 18% greater than the solar energy represented in unprocessed, undelivered foods made available to the USA public.

These figures do not include energy costs of transporting fertilizers from factory to farm nor of special farming operations, such as weed and pest control, pumping water, operating feedmills, redistributing animal-feeds, or transporting food to processors and distributors. Energy costs for packaging, transporting food to the home or restaurants and for food preparation are considered to be separate issues from the energy requirements for primary food production at farm-sites and animal-feeding facilities. It appears that coal or nuclear power can serve readily as energy substitutes for the natural gas being used at present for nitrogen fixation; but at greater energy costs because of thermodynamic losses sustained in converting fuel-energy into the electrical-energy needed to make hydrogen for nitrogen gas transformations into ammonia.

An independent approach to calculations of agricultural energy-needs can be made via nitrogen pathways where knowledge of fertilizer production figures is not required. Assuming the same 70/30 mix of dietary protein, a 2800 kilocalory daily food intake and nuclear power for fixing nitrogen; a figure of 3700 kilocalories per capita day was obtained for tillage and nitrogen fertilizer for USA farming conditions.

The conclusion is that food demands of the USA have progressively brought USA agriculture to a point in time where agriculture's fossil-fuel energy expenditures now exceed the captured solar energy represented by foods consumed by the human population. The time has also come for agriculturists to bring these facts to public attention - particularly in view of the general concern about available energy resources for the future.

ENERGY SOURCES FOR THE FUTURE

Craig B. Smith
Private Consultant
Los Angeles, California

We hear much today about an "energy crisis." In this discussion, I would like to comment on four aspects of it:

- Is the energy crisis real?
- Why is it a crisis?
- What are our alternatives?
- What should we be doing about it?

Because of time and space limitations, I shall confine this discussion to the question of electricity generation in California; (30 to 40% of all energy is consumed as electricity) however, similar remarks apply to other energy forms.

The energy crisis exists because our society has become increasingly dependent on energy over a long period of time, yet only recently have economic and environmental factors become of sufficient importance for public concern. The crisis has arisen because, at a time when energy consumption appears destined to increase rapidly, our supplies of low cost fuel are diminishing, the multiplication of power plants is thought by some to be a potential threat to public health and safety; and we are concerned about siting of power plants and land use conflicts.

To cite some specific numbers: the present installed generating capacity in California is 35,000 Mwe. Some estimates indicate that if present trends continue, between 80,000 and 90,000 Mwe of new capacity must be added during the next 20 years. Continuing this trend to the year 2000, and placing all plants along the coast, we could have as much as one power plant for every ten miles of coastline, if such sites were available.

There are three basic alternatives and some variations on them:

1. Do nothing except continue as we have in the past.
2. Find new or alternative sources of power.
3. Reduce energy consumption by improving use efficiency.

Because of public concern, it seems unlikely that the first choice will be selected. The legislature is examining the question of power plant siting and California's energy needs, and studies are underway at municipal and federal levels as well. While it is important to encourage efforts at locating new sources of energy, such as fusion, geothermal, and solar energy, it is unlikely that these can be brought to bear on California's needs in any substantial way before the year 2000. The third possibility, that of reducing energy consumption by increasing the efficiency with which we use it, has promise. It will reduce the magnitude of the problem, but not solve it.

Although public acceptance to date has been "lukewarm", nuclear energy is one of the most important sources of non-polluting power, and one that will be important in California's future. There are disadvantages as well as advantages to nuclear power, but, on the whole, I feel it is a promising source of future power for the State.

PROGRESS IN ANIMAL WASTE MANAGEMENT

W. C. Fairbank
Extension Agricultural Engineer
University of California, Riverside

Our livestock industry no longer ignores the pleas of a concerned public nor the demands of environmental protection agencies for an improved level of waste management. Directly and indirectly producer groups are raising funds for more basic and applied research, as well as expanded Extension programs which are able to translate laboratory findings into practical solutions. This is producer progress.

Many research agencies here and abroad are studying the problem, its causes and controls. We hear about the new concepts of pyrolysis, fluid-bed oxidation, gasification, conversion to fuel or protein or building blocks; but these disposal processes will all cost the producer more than simple soil-plant recycling. These processes are probably some years away yet. This is research progress.

Extensive manure research has brought to my realization that our livestock producers have not really applied the technology that has been long available. This technology is aeration, natural drying, and soil-plant recycling. Any manure nuisance problem can be controlled through proper use or management of these concepts. Economics of manure disposal is another matter and is not dismissable; but is so intertwined with politico-socio considerations as to be beyond the purview of us technologists.

Aeration is being used for both liquid and dry manure handling systems as a means of realistic odor control and drying. It is also the essential component of biodegradation or bioconversion.

Natural drying by thin-bed spreading, under-cage windrowing, open stacking and manipulations, and natural composting processes is gaining popularity.

Soil-plant recycling by using manure as the major fertilizer source in an intensive cropping system is regaining acceptance. Crop selection, irrigation practice, and fertilizer management are more exact than before. For the present, soil-plant recycling offers the greatest opportunity for beneficial manure management consistent with environmental protection. This is Extension progress.

MANAGEMENT OF FOOD PROCESSING WASTES

George K. York
Agricultural Extension
Department of Food Science and Technology
University of California, Davis

Wastes from processing foods is rather arbitrarily divided into four categories: (1) liquid wastes - primarily water containing solids; (2) solid wastes - primarily solid materials containing various amounts of water; (3) trash - dry, slowly degradable materials; and (4) gaseous wastes. The techniques for managing these wastes differ. This paper will be limited to liquid and solid wastes.

Methods to conserve water have been instituted in most food processing facilities. These range from simple automatic shut-off valves on hoses to complex systems for the re-use of water in unit operations. Re-use of water requires screening and the use of germicidal agents which, in most cases, are chlorine compounds. The volume of fresh make-up water added depends upon the use of the water and the amount of solids dissolved or suspended on it.

Reducing the amount of water used in processing is also accomplished by modifying or completely changing processing procedures. For example, evaporative cooling using small volumes of water applied as fine mists and moving air has replaced submersion and large volume sprays of cold water for cooling foods after cooking or blanching. Pneumatic transfer of foods and mechanical belts have replaced fluming in water. It has long been a practice to re-use cooling water and spent treated boiler water. Dry caustic peeling utilizing infra-red lamps and rubber fingers has replaced immersion, hot caustic peeling of potatoes and some fruits. A method of peeling tomatoes which freezes then warms the skin causing it to crack and removes the skin with rubber fingers is currently being studied to replace peeling with hot caustic. This method not only significantly reduces water usage, it also simplifies the recovery of the skins since neutralization of caustic is no longer required.

Other changes in waste management consist of reducing pollutants by changes in processing technology. An example is the non-salt storage of olives and cucumbers developed by Dr. R. H. Vaughn, University of California at Davis. This method consists of acidification of the covering liquid, addition of a microbial inhibitor, and the maintenance of strict anaerobic conditions.

Segregation of wastes having high BOD and solids concentrations, such as blancher water, slaughter room wastes, and fermentation lees, allows them to be treated separately from the main flow of wastes. Since these highly organic wastes are generally a small portion of the total volume yet contribute the bulk of the pollutional load, the segregation system leads to both efficiency and economy in treatment.

Recovery and re-use of all water in a food processing operation is the goal of waste management. This will mean there will be no discharge of waste water from a processing facility or the discharge only of water of the same or better quality than the water before use. This will entail biological, chemical, and physical treatment and will require a high degree of sophistication of equipment, operation, and personnel.

Liquid wastes presently discharged from a food processing plant can no longer be disposed of in streams, rivers, or lakes without treatment to remove turbidity, color, solids, and organic matter. In the food processing industry, treatment, in almost all cases, is microbiological and is undertaken either at the facility itself or in a municipal treatment system or both.

Lagooning or ponding wastes is still widely used and this system depends upon diffusion of oxygen from the air to enable aerobic microorganisms to stabilize the waste. Although economical, this system is slow and inefficient since the lagoons often become anaerobic and undesirable odors are generated. To reduce odors and increase oxidation, air is often mechanically introduced into the ponds either by floating aerators or pumping over a series of baffles.

Other systems employing microbial oxidations consist of trickling filter and activated sludge units, with settling basins before and after oxidation. This is termed secondary treatment and forms the basis for most municipal treatment plants. There are numerous modifications and types of equipment available for these basic systems. Because of the removal of relatively large volumes of unstable solids by gravity, these solids must also be treated before disposal. This unstable "sludge" is treated anaerobically and the treated sludge is dried and discharged to land.

A few anaerobic techniques using closed systems are also employed for treatment of liquid wastes. These systems appear to have merit in treating the highly organic wastes which can be segregated at the processing plant since a major cost in construction of the closed system equipment is the size of the unit.

Solid wastes are collected separately during processing and as much solid material as possible is removed from the liquid wastes by screening and occasionally by centrifugation. The amount of by-product recovery from solid processing wastes depends on the type of food being processed and the method of processing. For example, practically all solid waste from meat packing is utilized: hides for leather, bones for meal, offal for fertilizer, and tallow for soap. Conversely, little solid waste is used as by-products from fruit canning operations. A major problem in utilizing solid wastes from fruit and vegetable freezing and canning is the presence of large amounts of water. Thus, such waste is unstable and drying is expensive. Presently, most such solid wastes are put back on land, either in landfill operations or by discing into the soil.

With changes in processing methods, it appears inevitable that more attention will be given to recover usable by-products from solid waste materials from the food industry.

NITROGEN MOVEMENT BELOW CROPS

Robert S. Ayers
Extension Soils and Water Specialist
University of California, Davis

Nitrogen pollution potential increases greatly as the application rate of nitrogen exceeds the true crop need for near maximum yield. At rates of N needed to produce near maximum yield measured pollution is relatively low. Many good field trial results showing yield data are available. Very few data, though, are available where actual pollution potential has been measured. Hopefully, if the nitrogen-yield-pollution potential relationship holds, fertilization guidelines as presently used will protect water quality of drainage waters moving to underground water supplies.

We should emphasize, this report deals only with nitrogen. The salt pollution problem is still with us.

COMPREHENSIVE WATER QUALITY CONTROL PLANNING [1]

Bill B. Dendy
Executive Officer, State Water Resources Control Board
Sacramento, California

The overall purpose of the Board's basin planning effort is to determine the future direction of water quality control for protection of California's waters. There are few constraints on this comprehensive planning effort.

The purposes for development of these plans are as follows: First, they are required by the Federal Environmental Protection Agency to meet federal requirements for grants to construct wastewater treatment facilities. Second, they fulfill the requirements of the Porter-Cologne Water Quality Control Act for water quality control plans. Third, they provide a basis for disbursement of state grant funds for wastewater treatment construction. Fourth, they will provide a basis for evaluating the water quality control plans of other agencies. The plans will affect the future water quality control decisions of the State Water Resources Control Board and the nine regional water quality control boards. The 16 basin plans will provide the framework for comprehensive water quality control for the State.

The plans will set forth a definitive program of actions designed to preserve and enhance water quality and to protect beneficial water uses in a manner which will result in maximum controllable environmental and socio-economic benefits to the people of the State. Present and future land use, population growth and economic development which result or may result in significant water demand or water quality degradation will be identified.

The scope of the planning effort is intended to be broad and an attempt will be made to give consideration to all factors which affect beneficial water uses. Water quality-quantity interrelationships will be considered.

The plans will establish priorities and time schedules for upgrading and expanding existing waste treatment facilities and constructing additional facilities as required for effective water quality control over a 30-year planning period.

The plans will set forth the institutional arrangements and governmental structure needed for implementation. The detailed financial and repayment arrangements for plan implementation will be determined by the implementing agency. Where research is needed to understand adequately the true impact of proposed solution of water quality, such research requirements will be identified.

This broad planning base is needed if we are to plan and build for the future and abandon the inefficiencies of reacting to our day-to-day needs.

---

[1] Presented by Thomas Bailey

APPLICATION OF THE LIVING FILTER IN REGIONAL WASTEWATER MANAGEMENT

W. E. Vandenberg
U. S. Army Corps of Engineers
San Francisco, California

The Corps of Engineers is studying methods of using the land application process for treating and disposing of wastewaters in the San Francisco Bay and Delta region. This work is being conducted as input to the State of California's Basin Planning process, in accordance with an agreement between the State, the Corps and the Environmental Protection Agency. The Corps' task is to identify feasible methods of using the soil and its vegetative cover as a living filter to provide a high degree of removal or immobilization of the polluting constituents of wastewater. This process can provide associated benefits by removing effluent discharges from the Bay-Delta estuary and by reclaiming the wastewater for beneficial use.

The Corps study covers the twelve counties of the Bay and Delta, which had a 1970 population of 5.7 million. This population and the industry in the area generated a total of 690 million gallons per day of wastewater, a potential reclaimable resource of 1 million acre-feet of water per year, projected to rise to 1.6 million acre-feet by the year 2000.

The concept is simple. Raw wastewater is treated to the secondary level, either in conventional treatement plants or by lagooning, and the resulting effluent is used for irrigation. The water is renovated by the biosystem of the soil and its cover crop by four basic mechanisms operating within the soil: filtration, plant uptake, cation exchange and fixation, and volatilization. The renovated water is then collected by a system of drain tiles or drainage wells and returned to the surface for reuse. The drainage system is designed to maintain an aerated, unsaturated condition in the upper soil layer, protecting the root zone and insuring control of surface and subsurface water flows.

The factors governing system design are:

1. The crops grown should be adaptable to the area's climate and to irrigation and should have a relative worth as an income or cash crop to provide a practical basis for individual farmers to participate.

2. The volume of water applied must be based on the cover crop's uptake capability of the critical nutrient, nitrogen. However, sufficient water must be applied to avoid excess concentrations of dissolved salts in the recovered water. This necessitates a carefully controlled interaction between water balance, nitrogen balance and salt balance for each site.

3. The amount of land required must be determined by comparing the volume of water to be treated with the amount of nitrogen which can be applied for the selected crops. Allowances must be made for rainfall and for necessary physical facilities.

An example of the expected performance of the land application method: The applied water is secondary treatment effluent, with a nitrogen concentration of 16.8 ppm and a dissolved solids concentration of 550 ppm. Assuming volatilization of 20 per cent of the applied nitrogen, and crop removal of 150 pounds of nitrogen per acre, the application rate is set so as to insure no more than 2.0 ppm of nitrogen in the leachate. The salt content of the leachate would be 1350 ppm. Increasing the application rate would dilute the salt concentration slightly, at the cost of increased nitrogen carryover.

Tentative conclusions of the Corps studies: The Corps will report on alternatives which, if fully implemented, would call for land application of up to one million acre-feet of wastewater annually by the year 2000. About 250,000 acres of agricultural land would be required. The recollected land-treated water would total about 250,000 to 300,000 acre-feet per year, with a net treatment cost about the same as conventional advanced waste treatment. The Corps does not recommend land application as a single best solution for the treatment of all of the region's wastewater. However, the process is recommended for use in selected areas, with proper controls and management. It can assist in solving some of the critical problems of water quality and water supply in Northern California.

CALIFORNIA PESTICIDE PROGRAM AND PROGRESS REPORT

David J. Bingham
California Department of Agriculture
Sacramento, California

The California Department of Food and Agriculture administers a comprehensive pesticide regulatory program. This program is comprised of six integrated parts as follows: (1) registering all products sold and used in this State; (2) licensing of firms applying pesticides (pest control operators); (3) licensing of firms selling pesticides for agricultural uses; (4) licensing of persons making recommendations for agricultural uses; (5) restricting sale, possession and use of particularly hazardous materials to man and the environment; and (6) testing of fruits, vegetables and other raw agricultural commodities for unlawful pesticide residues.

California has long been recognized as being the leader in the nation and in the world in pesticide regulatory enforcement work. Our success and accomplishments in this work are closely linked to the cooperative role carried on at the local level by County Agricultural Commissioners and their trained staffs.

If we were to choose one word to typify this program, perhaps the most fitting would be "progressive" - "progressive" in the sense that significant program changes have occurred in recent years and are occurring at an accelerating rate.

These changes were to meet needs and concerns expressed by many different segments of our society. These needs and concerns can be categorized into several major groupings: (1) application of new technology by an everchanging, dynamic agricultural industry; (2) safety of food and feed products; (3) health and safety of man; and (4) conserving and enhancing the environment.

Currently, this Department is developing regulations and enforcement procedures to implement recent legislation directed towards:

1. Providing increased protection to the environment.

2. Classifying pesticides into restricted and general use categories.

3. Strengthening agricultural pest control operations.

4. Examining and licensing pest control advisers.

5. Strengthening the pesticide permit system administered by County Agricultural Commissioners.

6. Providing for safe storage of all pesticides by requiring locked closures and placards.

7. Implement statewide a program for pesticide container and waste pesticide disposal.

8. Providing increased protection from pesticide illnesses to workers applying pesticides and to agricultural field workers.

9. Subventing counties to partially reimburse local costs of pesticide use enforcement.

10. Cooperating with the Department of Public Health and the Environmental Protection Agency in implementing a nationwide pesticide illness reporting system.

11. Completing staffing and reorganizing of the Agricultural Chemicals and Feed Unit with particular emphasis on pesticide registration, environmental protection and worker safety.

It is gratifying to note that many of California's "progressive" pesticide program activities are being incorporated into Federal laws and regulations.

As we look to the future, our direction should be to provide practical and meaningful pesticide enforcement which will serve the best interests of the people of this State. Our goal is to assure a program in balance to assure adequate supplies of safe and wholesome food, protection of public health and safety and protection of the environment.

TESTING SOILS, PLANTS AND WATERS

H. M. Reisenauer
Department of Soils and Plant Nutrition
University of California, Davis

Soil, plant and water samples are analyzed for a variety of purposes and by a variety of methods. The usefulness of these analyses is determined by our ability to interpret them into meaningful management recommendations. In the past, these recommendations were concerned almost entirely with improving the yield and quality of crops and with conserving our natural resources. This is no longer true. These tests have important roles in preventing the build-up of residues from fertilizers and of other potentially harmful compounds in our soils and groundwaters.

ZINC FERTILIZATION OF RICE

D. Marlin Brandon[1] and D. S. Mikkelsen[2]
[1]Agricultural Extension, University of California, Colusa and
[2]Department of Agronomy and Range Science, University of California, Davis

Zinc fertilization is important in the economical production of rice in California. Zinc deficiency in rice is rather widespread and its importance as a needed fertilizer material is exceeded only by nitrogen and phosphorus. The so-called "alkali disease" of rice which causes rice seedling chlorosis and partial to complete loss of plant stand is zinc deficiency. Rice production may be a partial to complete failure in problem soils depending upon the severity of the zinc deficiency. Zinc deficiency in rice may occur in irregular patterns throughout a field, or the entire field may be affected in some cases.

Diagnosis of soil zinc deficiency before seeding rice is important so that fertilizer needs can be anticipated and rice zinc deficiency avoided. Field research shows zinc deficiency to be more common in sodic and calcareous soils that have a pH greater than 7.2. Removal of topsoil during land leveling usually intensifies zinc deficiency in rice because of the exposure of low zinc calcareous subsoils. Field and laboratory research show that extraction of soil with a DTPA solution gives excellent soil test results which correlate well with rice plant and yield responses. The critical soil level under California conditions is 0.4 to 0.5 ppm of zinc. A knowledge of rice plant zinc deficiency symptoms also is valuable in diagnosing zinc deficiency in established rice crops. Zinc deficient rice plants usually exhibit a general chlorosis approximately three to four weeks after water seeding. The intensity of rice seedling chlorosis caused by zinc deficiency usually increases with time and eventually irregular dark necrotic spots develop in the older leaves of severly deficient plant seedlings. Plant vigor is reduced and severly deficient plants die and decompose in the water. Consequently, areas in fields barren of plants at mid-season are characteristic of severely zinc-deficient soils.

Economical correction of zinc deficiency in rice is possible through soil surface application of commonly used zinc fertilizers. Field and greenhouse experiments indicate that commercial zinc fertilizers, such as zinc sulfate, zinc oxide, zinc EDTA chelates and zinc ligno-sulfonate provide good correction of rice zinc deficiency. However, the data indicates these materials differ in their relative efficiency of correction. Experiments indicate that zinc ligno-sulfonates have a higher efficiency factor in water-sown rice. Zinc sulfate and zinc oxide are slightly less effective and zinc EDTA is least effective based upon plant utilization of applied zinc, plant growth and grain yield. The effectiveness of zinc EDTA is reduced probably because of its high mobility in flooded soils. Laboratory experiments indicate that zinc EDTA moves below the root zone of young seedlings with the waterfront at flooding and, consequently, is too deep for utilization by young rice seedlings under California conditions.

The method of zinc application is important in that it influences the effectiveness of zinc fertilizers. Experiments indicate that zinc is more effective per unit of zinc applied when it is broadcast and unincorporated than when it is soil incorporated or placed below the soil surface. Surface placement is critical at relatively low rates of zinc application, but at higher application rates, the placement effect diminishes. Experiments indicate that zinc application rates of 8 to 16 pounds per acre are sufficient to correct zinc deficiency in rice. Since zinc deficiency occurs in the seedling growth stage of California's water-sown rice, it is important that zinc fertilizers be applied and maintained on the soil surface.

THE N, K, AND P NUTRITION CHARACTERISTICS OF SESAME: A PROMISING ROLE FOR CALIFORNIA

George Mitchell and Frank Bingham
Department of Soil Science and Agriculture Engineering
University of California, Riverside

Sesame (Sesamum Indicum L.) was grown under sandculture conditions in separate studies with varying substrate concentrations of N, P, and K, respectively. Petiole and leaf blade samples of recently matured leaves were analyzed. Leaf samples were collected at three different growth stages of the plants. Nutrient calibration curves were constructed to determine the tissue concentration associated with optimum seed oil and vegetative yields. In addition to yield, consideration was given to seed quality including protein content, fatty acid composition and distribution of amino acids.

In addition to the greenhouse studies, a field nitrogen experiment was conducted to determine diagnostic criteria of sesame under these conditions.

MINERALOGICAL AND CHEMICAL CORRELATIONS WITH
PLANT ACCUMULATION OF POTASSIUM

[1] O. R. Lunt and R. L. Branson[2]
[1] Professor, University of California, Los Angeles
and [2] Agricultural Extension, University of California, Riverside

Though soils in the arid and semi-arid parts of California are generally well-supplied with potassium, some deficiencies of this element are appearing and more can be expected in time. Eight Southern California soils with a wide range of exchangeable potassium were cropped intensively with alta fescue (Festuca arundinacea) under greenhouse conditions to study their potassium-supplying ability, and to evaluate various means of characterizing the potassium status of these soils. The soils selected were the following, listed by series name:

Bettaravia sandy loam	Elder loam
Garey sandy loam	Coachella very fine sand
Pleasanton sandy loam	Metz sandy loam
Pleasanton very fine sandy loam	Sorrento sandy loam

The first four soils listed above gave yield responses when fertilized with potassium. All of the potassium-deficient soils were obtained from terrace locations whereas soils with sufficient potassium were younger, valley soils.

Potassium accumulation in the alta fescue tissue came from both non-exchangeable and exchangeable sources, and in some cases, the non-exchangeable potassium appeared to be the exclusive source. Soils that released substantial quantities of non-exchangeable potassium contained relatively large amounts of illite and chlorite.

Since ammonium-acetate-extractable potassium was not a reliable indicator of the soils' ability to supply potassium, boiling nitric acid was also used to extract potassium from samples taken prior to cropping. The acid-extractable potassium appears to be satisfactory for characterizing soils regarding potassium supply. Values of approximately 1400 mg. of potassium per 1500 grams of soil were associated with adequate supply while values of about 1000 or less were associated with deficiency.

AGGREGATE EFFECTS OF NUTRIENTS AND GIBBERELLIN ON ORANGE CROP VALUE

Tom W. Embleton, Winston W. Jones, and Charles W. Coggins, Jr.
Department of Plant Sciences
University of California, Riverside

Four years of Valencia orange experimental fertilizer data showed that the greatest monetary return (15% greater than the poorest combination) was associated with the combination of 2.55% leaf N and 0.85% leaf K. The lowest return was from the combination 2.54% leaf N and 0.62% leaf K. Intermediate returns were associated with the combinations 2.35% leaf N and 0.72 leaf K, and 2.32 leaf N and 1.06 leaf K. Factors which contributed favorably to the monetary return were: the individual and additive effects of increased N and K in increasing yield and reducing creasing, and the increase in fruit size by the addition of K. The adverse effects that limited the return were: the reduction in fruit size with increased N, and the large influence of the high rate of N, plus the small influence of the addition of K on the amount of green color on the fruit at harvest.

A five-record-year experiment, in which N was not limiting for yield and in which the increase in leaf K from 0.47 to 0.66% did increase yield, showed that the addition of K fertilizer, gibberellic acid (GA) spray, and increase in N rate each reduced creasing and increased green color on the fruit and the effects of all three were strongly additive. An increase in N reduced fruit size and K addition increased fruit size. Packinghouse statements for lots of fruit, in which N effects were masked, showed that monetary return was increased by about 75% by K additions; 17% with GA alone; 61% with GA + soil-applied K; and 42% with GA + foliar-applied K.

SALT TOLERANCE OF MEXICAN WHEATS

F. T. Bingham[1] and C. Torres[2]
[1] Department of Soil Science and Agriculture Engineering,
University of California, Riverside
and [2] Mexico, formerly University of California, Riverside

A sandculture experiment consisting of 3-short and 1-long season wheats under variable substrate NO_3 and NaCl was carried out to grain maturity stages. Leaf samples were collected at flowering stage for chemical analysis of Ca, Mg, Na, K, P, NO_3, N, and Cl. This experiment showed that the long-season variety was markedly more tolerant than any of the short-season varieties and that leaf NO_3 concentrations decreased to deficiency levels with the higher NaCl treatments. The second phase consisted of evaluating short-, intermediate-, and long-season wheats (8 in all) under variable substrate NaCl. These plants were grown to grain maturity also. This experiment showed salt tolerance (grain yields) to be a function of the growth period - the longer season wheats were about 3-fold more tolerant than the short-season varieties. Leaf NO_3 decreased to values considered deficient under the high NaCl treatments. Although marked differences occurred in vegetative growth and in grain yields due to variety under test, no consistent effects were found with germination.

IRRIGATION WATER APPLICATION OF SOLUBLE AGRICULTURAL CHEMICALS

Albert W. Marsh
Extension Irrigation and Soils Specialist
University of California, Riverside

Since there are other ways by which agricultural chemicals have been traditionally applied to soils and crops, one might question why should they be applied in the irrigation water. The answer would be that there are cost-reducing possibilities plus certain other advantages that might be gained.

Instead of sending a power-driven machine up and down the field, it is a relatively simple procedure to insert the chemical in irrigation water at a single point along one side of the field and have it distributed without further effort over the entire field. This eases the effort and lowers the cost of application. There is also a potential advantage to be gained with respect to timing of the application. By applying in the irrigation water, the operator is not restricted to certain times relative to other cultural practices with a crop or to the condition of the soil surface. It is also possible at relatively low cost to make repeated application of small amounts during the life of the crop rather than applying the entire needs at one time. This increases the possibility for improved efficiency of uptake of the applied chemical with less losses. As times change, it may be that such an improved efficiency will not only be desirable, but required.

The possibility for successful application of chemicals in irrigation water depends upon several things, one of which is the method of irrigation. Surface irrigation by flooding or furrow application is still the most widely used method, but has the least potential for satisfactory injection of agricultural chemicals. Irrigation efficiency by this method remains relatively low in most instances, frequently less than 50%. It is unlikely that the efficiency of application and distribution of chemicals in the water will be any better than the efficiency of the water distribution and probably will be somewhat worse.

Sprinkler irrigation presents the best opportunity for distribution of agricultural chemicals and the method by which the greater proportion of it is likely to be applied. Sprinklers can be designed and managed to give a rather high efficiency of application, as well as uniformity of distribution. Sprinklers also provide the possibility for application of chemicals that must be applied to the leaves of plants.

Drip irrigation is a new method recently entering the picture. It seems evident that any fertilizer applications needed by crops grown with drip irrigation will have to be applied in the irrigation water.

Not all types of chemicals can be successfully distributed in the irrigation water. The chemical must be in solution and liquid chemicals are much to be preferred since they will be least likely to cause blockage of the orifices of either sprinklers or drip irrigation emitters.

There are three basic methods of injection available for sprinklers or drip irrigation systems. If a pump is used, the solution dissolved in a pressurized tank can be drawn into the irrigation system on the suction side of the pump with replenishment of water in the pressure tank made possible by a connection on the pressure side of the pump. A Venturi-type device can be used on pressure lines where there is no pump or it is desired to inject at some distance downstream from the pump.

A third type of device is used in a pressure line where a separate small pump injects the chemical solution into the irrigation line with a pressure greater than that existing in the line.

Whichever method of injection is utilized, it is desirable to have the entire irrigation system operating and filled with water before injection is initiated, then followed by injection for 30 minutes or more. Finally, there should be a period of operation with only irrigation water for at least 30 minutes after injection to complete the distribution and flush the system.

Uniformity of distribution must be emphasized. For many chemicals, there is a relatively narrow range between an amount that would be too little and another amount that might be too much. Since the chemical uniformity is no better than the water uniformity of distribution, the latter must be good if the limits are to be met for chemical distribution.

Irrigation application of soluble agricultural chemicals can be an effective way of applying many types of chemicals, but several conditions must be met satisfactorily before it can be a generally acceptable procedure. These include good control on the injection and a high degree of uniformity of distribution of the water.

Table 1. Uniformity of Chemical Distribution in Irrigation Water

Coefficient of Uniformity	Chemical Factor* (90%)
90	1.15
85	1.25
80	1.35

*The pounds of chemical that must be applied to a treated area to obtain at least one pound to 90% of the area.

NUTRITIONAL PROBLEMS WITH HYDROPONIC GREENHOUSE EXPANSION IN CALIFORNIA

H. Johnson, Jr., W. L. Berry and J. Davidson
Agricultural Extension
University of California, Riverside

The recent rapid expansion in the use of hydroponics for greenhouse vegetable production in California has brought with it a problem in nutrient solution waste disposal. The wastes contain from 50 to 100 ppm nitrate nitrogen and constitute a possible hazard to the pollution of groundwaters when disposed of by ponding on the greenhouse property. In order to avoid this problem, the waste solutions could be transported to Class I dumps for disposal at considerable cost and inconvenience to the greenhouse operator. Alternatively, the nutrient solution could be managed so as to maintain its quality over an extended period of use, possibly for the life of the crop.

A study on long-term nutrient solution maintenance, initiated at the University of California at Riverside in 1970, provided confidence in the feasibility of such a system, and it is now in current use at some commercial hydroponic installations. Plant growth, yields, and fruit quality on both tomatoes and cucumbers have been comparable to that obtained under previous practices involving short-term use of solutions prepared from premixed salts.

In practice, a nutrient solution modified from Hoagland's formula is prepared at the beginning of the crop and maintained by adding small amounts of concentrate to replace the nutrients removed by the plants. Concentrate additions are estimated by monitoring the total salt level of the solution as measured by the EC of daily samples from the tank, using the EC of the original solution as a reference. Statistical analysis of data obtained through a four-month period at Riverside showed that EC values were very well-correlated with concentrations of individual ions, paricularly the macroelements. When this procedure was first tested on a commercial hydroponic tomato crop, the increasing concentrations of Ca^{++} and Na^{+}, from the make-up water, caused interference in interpreting EC readings. As a strategy in overcoming this difficulty, it was found that the use of an increasing EC standard, roughly paralleling the extraneous cation increase, was satisfactory and produced no adverse effects.

Adjustments in the levels of phosphorus and minor elements were also found to be necessary. The phosphorus concentration in the original solution was apparently inadequate for the plant density employed (18,700 plants/acre). Typical phosphorus deficiency developed, but disappeared within two weeks when the quantity of KH_2PO_4 in the solution was doubled. Minor element levels became excess early in the crop, and even though no toxicity symptoms developed, supplies of these elements were restricted to avoid adverse effects, as well as to determine more suitable concentrations.

When nutrient concentrate was withheld, just before terminating the first crop, the plants depleted the solution to near zero levels of nitrate, phosphate, and potassium in less than a two-week period. The resulting solution, while high in calcium and sodium, could be disposed of on the greenhouse property with less hazard to the underlying groundwaters.

From the standpoint of plant nutrition, the current and continuing studies indicate that a nutrient solution can be successfully maintained for extended periods. Water quality is extremely important to the success of the practice; the length of successful maintenance being inversely proportional to the salt content of the water used. While EC can never be a precise measure of nutrient solution status, it appears to be a practical tool for the hydroponic farmer if used in conjunction with periodic monitoring of individual elements, such as calcium and sodium. The benefits of the practice are reduced operating costs and greatly reducing the possibility of groundwater pollution when disposal becomes necessary.

A LOOK AHEAD AT FERTILIZER SUPPLIES

John R. Douglas, Jr.
Staff Economist, Agricultural and Chemical Development
Tennessee Valley Authority
Muscle Shoals, Alabama

Farmers of California and the Nation are facing a new supply-demand situation for fertilizers for the next two to three years. The past five years have seen surpluses of fertilizers. These surpluses in some cases have already vanished. Supplies of many fertilizers will become increasingly tighter.

Low prices of the past led to low profitability in the industry and a lag in building new plants. Current price controls on domestic sales of fertilizers, in conjunction with a firm, strong export demand for fertilizers at higher prices, has led to tightness in domestic supplies.

Essentially no new nitrogen plants have been built in the past three years. Supply of natural gas has become short, leading to curtailed production. Existing plants are operating at full effective capacity. Total demand for nitrogen now approaches maximum supply capability. Shortages of solid nitrogen products can be expected with increasing pressure on total nitrogen supplies.

Sharply increased export demands have siphoned off much of the solid P_2O_5 fertilizers from the U. S. market. Liquid ammonium polyphosphate supplies are especially tight with less electric furnace acid being available and little new high-quality wet-process acid becoming available.

The supply-demand situation for potash fertilizers has been brought into effective balance by governmental action of the Province of Saskatchewan.

Farmers of the Nation and of California, then, are facing a completely new set of circumstances in so far as their fertilizer supplies are concerned. In the past five years, supplies have been more than adequate; prices and terms have been highly favorable. With the supply-demand situation dramatically reversed, farmers may well expect prices to firm up rapidly. With such conditions existing, there will be a premium on advance planning - since only by careful advance planning will fertilizers be available at the time they are needed.

GETTING THE MOST EFFICIENCY OUT OF FERTILIZERS

R. S. Rauschkolb
Extension Soils Specialist
University of California, Davis

Several changes have occurred in recent years which are of great concern to us as agriculturalists. The principal change has been for the general public to become more critical of agriculture and the cultural practices it employs; we are in the position of having to conform to public demands for improvement of agricultural practices to minimize unwanted environmental changes. Along with this shift in public attitude toward agriculture and general lack of understanding of agricultural methods of plant production, there have been other equally dramatic changes. They are the possibilities of a lack of energy, or at the very least, a more costly form of energy for production of some fertilizers and the knowledge and concern that we do not have inexhaustible supplies of others. These last two factors will manifest themselves in the form of increased cost of fertilizer to the producer.

All these factors combined present a challenge for us to become more efficient in the use of fertilizers. Fortunately, in agriculture we already have many tools to help us meet that challenge.

Intelligent and efficient use of fertilizer has been the goal of agricultural research in plant nutrition from the very beginning. Such tools as soil and tissue testing have been developed for some crops to assist in the decision-making process for determining the amount and timing of fertilization. In some instances, reliable aids are not available; as a result, those decisions are made on the basis of experience and desire to be assured that yields would not suffer from a lack of plant nutrients. While, for the most part, this approach has been working, there have been occasions when excessive fertilizer has been applied.

For the reasons enumerated, we can no longer afford to be generous with our fertilizers. We will have to rely more heavily on a combination of soil and tissue testing, coupled with experience to guide us in making fertilizer recommendations. The challenge for us is to develop and improve these techniques and to encourage and assist in their proper application so we can attain the greatest fertilizer efficiency. To do so is in the best interest of agriculture and of benefit to us all.

SOME FACTORS TO CONSIDER IN USING ANIMAL MANURES FOR FERTILIZER

K. B. Tyler
Extension Vegetable Specialist
University of California, Parlier

Aside from cost factors, the nutrient content of manures and the availability of these nutrients to crop plants are, perhaps, the most important factors in considering the use of animal manures for fertilizer. Additional factors, which may also be important in some cases, include: (1) The effect of manure application on the total salt balance and on the sodium status of soils; (2) The possible introduction of weed seeds, disease organisms and other undesirable materials with the application of manures; (3) Problems related to the storage, transportation and application of manures due to their bulk.

California surveys have shown that manures are highly variable in their content of plant nutrients. For instance, nitrogen in dairy and feedlot manures varied from 0.5 to 3.5%; phosphorus from 0.1 to 0.8%; and potassium from 1 to 5%. Poultry manures vary within similar ranges although they are usually higher in N and P and lower in K than dairy and feedlot manures. Thus, unless nutrient analyses are made, users cannot be certain of the potential fertilizer value of manure.

It has long been a matter of conjecture as to how rapidly nutrients in manures become available to plants and as to what proportion of the total nutrients are made available for plant use during a cropping season. To better understand the availability of plant nutrients in manures, a series of incubation experiments were conducted using three California soils to which either poultry or feedlot manures had been added. After application, mixing and moistening the soil-manure samples, they were incubated for various time periods under conditions of temperature and aeration favorable for rapid decomposition of the manures. Samples were removed periodically from the incubation chambers, extracted and analyzed to determine their concentration of available nutrients. By comparing analyses of manure-treated and control soils incubated for comparable periods, the net changes in nutrient availability were estimated.

Experimental results indicate that the availability of plant nutrients in manures varies considerably with soil type, kind of manure, and nutrient element in question. Potassium, which was high in feedlot and low in poultry manure, was about 80% available immediately after the manures had been applied. Additional K release, however, was very slow. About 25% of the total P in poultry manure was immediately available and nearly 60% of the total P in feedlot manure. Further releases of P were slow.

Unlike P and K, the availability of N from manures was extremely low initially - about 8% of the total N in poultry manure and 4% of the total N in feedlot manure. Subsequent release of N from poultry manure proceeded rapidly such that nearly 40% had become available after 12 weeks and about 50% after 36 weeks. The pattern of N mineralization from feedlot manure differed considerably from the poultry manure. Immobilization predominated and at the end of 12 weeks, about 25% of the total N in feedlot manure became available in one of the soils with lesser proportions in the others. Less than 1/3 of the total N of feedlot manure had been mineralized after 36 weeks of incubation.

SOIL PRODUCTIVITY IN RELATION TO HIGH LOADING RATES WITH MANURE

Burl Meek
Soil Scientist, ARS, USDA
Imperial Valley Conservation Research Center
Brawley, California

In the past manure has been used at rates of 5-20 tons/acre because of its nutrient values. The greater number of cattle in confined feedlots and the concentration of dairies in small areas require high loading rates because of the limited farmland available for disposal. It will require special management practices and crop selection to maintain high soil productivity under high loading rates of manure.

In the western states, high loading rates of manure cause problems with salinity and ammonia toxicity which may limit crop production. The salt content of manure is variable according to the ration which was fed so this problem will be more serious in certain areas. The salinity problem can be alleviated to a certain extent by applying one or two irrigations before planting. High rates of manure application, usually above 100 tons/acre, cause serious ammonia toxicity problems. This toxicity can be reduced by allowing time for the manure to partially decompose before planting.

Advantages of applying manure at high rates are increased crop growth and earlier maturity. Research in the western states has shown an increase in yield due to the application of manure with proper management practices. In most of the experiments, it was necessary to go to rates above 100 tons/acre before there was a yield reduction. It has been shown that the application of manure can result in an earlier maturity as much as two weeks. This effect has been observed under a wide range of climatic conditions.

With proper management, it should be possible to apply manure at high rates without a reduction in soil productivity.

PROCESS AND PRODUCT DEVELOPMENT RESEARCH IN FERTILIZERS

Warren J. Sharratt
Field Representative, Tennessee Valley Authority
Department of Soils and Plant Nutrition
University of California, Davis

In considering new fertilizers, one should be mindful that when a new product is developed, it will not necessarily move directly into production by the fertilizer industry and widespread adoption by the farmer. Fertilizer materials that are now popular did not become so as soon as they were recognized as potential fertilizer materials. For example, diammonium phosphate, today the most popular dry fertilizer compound, was manufactured for fertilizer use in Germany about 1930. It did not become popular until the 1960's. Similar histories could be related about urea, triple superphosphate, and many other materials.

Forecasting what material will become popular is not easy. Perhaps the outstanding factors that influence a fertilizer material's desirability are (1) an improved technology - producing a material at minimum cost; (2) a material that lends itself to low cost and ease of transportation; and (3) perhaps most important, a material that readily fits into a marketing and distribution system.

No completely new fertilizer materials are foreseen for the 1970's, although some mentioned below will come into commercial use.

<u>Sulfur-coated urea</u>: Urea-based products having controlled release of nitrogen are of considerable interest. The approximate analysis in production to date has been 38-0-0-12S. The cost is estimated to be 25-50% higher than uncoated urea.

<u>Ammonium polyphosphate</u>: Granular ammonium polyphosphate, 15-62-0, is the highest analysis dry material on the market. This material is very versatile. It can be used as a straight material, bulk blended, or dissolved in water to produce a liquid 10-34-0.

<u>Nongranular monoammonium phosphate</u>: This material is being developed primarily for use in fertilizer granulation processes. It has other potential uses, such as the production of low-cost suspension.

<u>Exotic fertilizers</u>: Process and agronomic studies are under way on ultrahigh-analysis materials, such as phosphonitrilic hexaamide (55-92-0) and phosphoryl triamide (44-74-0). These products will require elemental phosphorus for their production.

<u>Potassium phosphate</u>: At least one commercial firm is working on production of a commercial potassium phosphate, although it is not yet available in the marketplace.

<u>High polyphosphate liquids (11-37-0 and 12-44-0)</u>: Liquids of high polyphosphate content (75-85% P_2O_5) can be combined with wet-process phosphoric acid to sequester the impurities normally present in the acid. The pipe reactor process for production of high-polyphosphate 11-37-0 from all wet-process superphosphoric acid is in the pilot-plant stage. It shows considerable promise.

<u>Suspensions</u>: Use of suspensions is increasing. The latest TVA base suspension, 13-41-0, derives as much as 40% of its total P_2O_5 from wet-process acid.

Through use of superphosphoric acid in formulations, several granulation plants have controlled dust emissions that otherwise would have forced closure of the plants.

NITRIFICATION INHIBITORS

Cleve A. I. Goring
Director, Ag-Organics Research
Dow Chemical U. S. A.
Walnut Creek, California

The adverse consequences of the nitrification process in soil, as well as its inhibition by chemicals, has been studied for over 50 years. In the last decade, the development of commercially available inhibitors and the increased emphasis on better nitrogen fertilizer management has sparked a resurgence of research on this problem.

Practical control of nitrification under field condition is being achieved with soil fumigation in a variety of situations, but is only incidental to the primary goal of pest control.

The first specific inhibitor of nitrification made available for study was 2-chloro-6-(trichloromethyl)pyridine in 1962. Subsequently, other inhibitors, including 2-amino-4-chloro-6-methylpyrimidine, sulfathiazole, thiourea, and dicyandiamide were evaluated, and some were commercialized in Japan. Practical use of nitrification inhibitors has not yet occurred in other countries, although 2-chloro-6-(trichloromethyl)pyridine is being registered in the United States for use on corn, wheat, sorghum, cotton, sugar beets, and potatoes.

The advantages of controlling nitrification include more efficient use of ammonium and urea fertilizers because of reduced leaching and denitrification. Improved uptake of phosphorus applied with the ammonium also occurs. Nitrite formation in alkaline soils is reduced or eliminated, and seedling injury due to nitrite or nitrate is mitigated.

Yields may be increased, especially if insufficient nitrogen was used to achieve maximum possible yields. Plants may also grow better on a diet having a higher percentage of ammonium. The quality of the crop may be improved as a result of increased protein or reduced nitrate content. In a number of situations, the crop is less susceptible to disease.

Control of nitrification also permits more flexibility in the application of nitrogen. Split applications can be combined into a single application. Nitrogen can be applied in the fall or winter under conditions where unacceptable losses of nitrogen would ordinarily occur.

Nitrification inhibitors are not a panacea for all problems in nitrogen management. However, they will eventually provide the most economical way of nitrogen management and will find utility on many crops in many agronomic situations.

UREA-FORMALDEHYDE AND IBDU

O. R. Lunt
Director, Laboratory of Nuclear Medicines
and Radiation Biology
University of California, Los Angeles

The special purpose nitrogen fertilizers, urea-formaldehyde and 1,1-diureido isobutane are finding increasing use on turfgrass, nursery and ornamental crops, and in fertilizer formulations for home grounds and similar markets. A feature of both materials is that only a fraction of the nitrogen is immediately available for plant use, while the remainder becomes available over a longer period. The basic mechanism for action of the two materials differs. In U-F, biological mineralization is required to produce plant-available nitrogen; while the rate-limiting step for IBDU is the dissolution of the compound.

Commercial fertilizer grade U-F is composed of a series of polymers of condensed urea and formaldehyde. Obviously, commercial preparations may vary, but, in general, the mixture contains unreacted urea molecules and straight chain polymers of urea and formaldehyde containing up to six urea residues. There seems to be no extensive ring structures, but the higher polymers show branching. The mixture can be characterized, based on solubility, into three fractions which may represent about equal proportions. The most readily available fraction is about as available as urea or NH_4NO_3. The most slowly available fraction has been estimated to mineralize at about 10% per year under favorable conditions. The intermediate fraction mineralizes at about 15% per week in the first week or two, but drops to about 1.5% per week by the fourth to sixth month. Methylene-diurea, the simplest polymer, is apparently not available to plants until it is hydrolyzed.

The rate-limiting step in the conversion of IBDU appears to be the dissolution of IBDU. This rate is not mediated by microbial activity. Hydrolysis of soluble IBDU to urea and then to NH_3 occurs readily under most soil conditions. Particle size strongly influences dissolution rates. The hydrolysis rate is rapid under acid conditions, but much slower under alkaline conditions. This effect does not appear to present a practical problem in soils up to pH 8.3. Depending on particle size, very high levels of nitrogen can be applied safely to supply nitrogen for several months.

CONTROLLED RELEASE FERTILIZERS: COATED MATERIALS

Hollis M. Barron
Technical Director, Sierra Chemical Company
Newark, California

A considerable amount of work has been done in coating soluble fertilizer granules or prills with various water-resistant substances including polymers, waxes, asphalts, silicates, sulfur, etc., as well as combinations of such substances. In order for such a controlled release fertilizer material to offer potential in providing improved, more efficient nutrition of crops, it must release nutrients in a reasonably predictable manner. Also, the manufacturing process must be sufficiently flexible to allow the production of materials with various release patterns to meet the nutrient uptake requirements of the various crops.

Two coated fertilizer processes which have been developed and their products widely tested are the TVA sulfur coating process and the Osmocote plastic resin coating process. These two processes are described and characteristics of the products discussed. Factors external to the products which affect release characteristics are outlined. Current and potential utilization of these controlled release fertilizer materials are discussed.

IS THE GENE THE UNIT OF SELECTION?

R. W. Allard
Department of Genetics
University of California, Davis

Multilocus analyses of enzymatic variants in natural populations of *Avena barbata* revealed striking gametic phase disequilibrium for both linked and unlinked loci in this species. This disequilibrium is associated with two balanced five-locus gametic types, one associated with mesic conditions and the other with more xeric conditions, held together by selection acting on two coadapted combinations of alleles.

The rate at which such coadapted units can develop will be discussed in terms of the dynamics of gametic frequency change in two experimental populations of barley. These populations were in gametic phase equilibrium at synthesis, but both soon developed near maximal correlations in allelic state. The results provide evidence that selection acting on correlated multilocus units, including unlinked loci, is an important determinant of population structure.

COTTON BREEDING

Hubert B. Cooper, Jr.
U. S. Cotton Research Station
Shafter, California

Methods and procedures generally used in breeding upland cotton will be reviewed. Special emphasis will be placed on problems involved in developing upland varieties with improved yield, high fiber quality, disease resistance, improved fruiting characteristics, strain evaluation, and variety maintenance in the San Joaquin Valley program.

FLOWER BREEDING

Glenn A. Goldsmith
President, Goldsmith Seeds, Inc.
Gilroy, California

The Breeding of the Garden Petunia (Petunia hybrida)

The Petunia is by far the most important garden flower in the United States, measured by the dollar value of the seed. Although open-pollinated field grown Petunia seed is marketed largely in pictorial retail packets, the majority of the seed sold to professional growers and marketed to the public as bedding plants are F_1 hybrids.

Three United States companies and one Japanese company have extensive breeding programs with this crop. In addition about half a dozen companies in the United States and Europe have limited breeding programs. The breeding work is almost entirely devoted to the development of F_1 hybrids. The F_1 hybrid seed is produced by hand, mainly in Japan and Central America.

The major factors considered in Petunia breeding are flower color, form and size; earliness and freedom of bloom; and disease resistance. A major consideration, although not important to the acceptance or popularity of a variety, is the ease of the production of the hybrid seed.

A NEW GENUS OF CEREALS

Earlene A. Rupert
Department of Agronomy and Range Science
University of California, Davis

Increasing public sentiment for improved environmental and nutritional quality has compounded the urgency of extracting additional resistance and variety from the natural gene pools.

Since 1876, when the first wheat-rye hybrid, Triticale, was described, more than 2400 interspecific and intergeneric crosses have been reported among the grasses. Most of these have served only as a means of determining familial relationships and few have been explored sufficiently for a valid estimate of their economic and agronomic potential. Outstanding among these are Triticum x Secale (Triticale) and Agropyron x Triticum (Agrotricum).

Triticale combinations are possible between all species of wheat and rye, and thus provide an unlimited source of gross variation from which to select range, forage or food varieties. Amino acid and total protein ranges are greater than for either wheat or rye. After less than ten years of intensive effort, yields approach those of the best wheats; and the new genus is adapted to marginal terrains unsuited for either parent. Once complete floret fertility has been combined with multiple tillering, yields should surpass all other related cereals.

Hexaploid and octoploid triticales now included in international nurseries are intentional and accidental combinations of rye with both tetraploid and hexaploid wheats in varying proportions. Fertility and endosperm development seem directly related to the plant breeder's success in combining lines in which the reproductive cycles of wheat and rye are synchronized, and the rye component is either heterozygous or self-compatible. Many failures among inter-triticale crosses can be avoided by pedigree comparisons of parental lines which have been carefully guarded from outcrossing.

Triticale now stands as a striking example of imaginative gene pool diversification. Infinite numbers of such innovative hybridizations may be expected among our plant sources of food, shelter and clothing as additional laboratory procedures are evolved for embryo culture, cell-plant culture and parasexual fusion.

PROBLEMS, PROGRESS, AND PROMISE IN CITRUS BREEDING

R. K. Soost
Professor, Department of Plant Science
University of California, Riverside

As with all long-life-cycle, large-sized organisms, progress in breeding citrus has been and continues to be slow. The presence of a long period of juvenility not only delays fruiting, but also introduces long-term non-genetic changes. The presence of nucellar embryony seriously interferes with hybridization. However, it provides a mechanism for the study of juvenility, the production of uniform rootstocks, and an alternate method of asexual propagation. The development of triploids and the use of self-incompatible varieties provide mechanisms for overcoming the disadvantage of seediness, a major barrier to variety acceptance. The effective use of these two mechanisms is dependent on the incorporation of a high level of parthenocarpy, not generally present in citrus. Studies to correlate seedling vigor with field performance have been initiated to permit early reduction of seedling populations. Breeding for specific characters for rootstock and scion use continues to be the major means of progress for varietal improvement.

Breeding for resistance to soil-borne organisms is being emphasized because of the severe effects of these organisms and the potential for reducing the need for chemical control. Inheritance of low acidity from at least one source is relatively simple and is providing a means of consistently producing early maturing varieties.

Attempts to introduce precocious bearing, present in the related genus Fortunella, are being made. Initial efforts are being made to utilize somatic hybridization and in vitro fertilization. The successful development of these techniques would increase the range of available genetic variability and remove the barriers imposed by nucellar embryony.

GENETIC VULNERABILITY

David J. Thompson
Research Director, Ferry-Morse Seed Company
San Juan Bautista, California

The 1970 epidemic of Southern Corn Leaf Blight in the United States illustrated potential risks of genetic uniformity. Technology assessment has been in vogue since the epidemic. The tragic consequences of substantial or complete losses of major food crops are obvious.

Major crops of the United States will be considered as regards their genetic vulnerability to epidemics, and non-exclusive alternatives for minimizing risks will be presented. Economic, social, and legislative factors will be outlined.

THE MISSION OF PUBLIC INSTITUTIONS AND PRIVATE FIRMS IN THE TRAINING AND EDUCATION OF PLANT AND SOIL SCIENTISTS AN ADMINISTRATOR'S POINT OF VIEW

L. D. Whittig
Department of Soils and Plant Nutrition
University of California, Davis

Training and education of agricultural scientists are today, more than at any time in the past, being influenced by forces outside agriculture. Highly successful in meeting needs for more food and fiber on less land with less effort, agriculture is increasingly faced with need for continued higher output, as well as for consideration of secondary effects of intensive production and societal demand on limited resources. Demands on agriculture dictate close communication between component elements of the industry, educational institutions, and the general public and mutual understanding of problems and roles of each. Educational institutions must provide the educated, not merely trained, individuals equipped to deal with needs and problems of the present and to anticipate needs and problems of the future. Graduates of our agricultural institutions must have a working understanding of science related to their specialties, as well as ability to think through problems and deal with complex systems. Curricula must provide opportunity for interdisciplinary training, balance between general education and technical training, and flexibility for change. In harmony with educational institutions, private firms associated with the agricultural industry can and must continue to provide a component of leadership in marshalling natural resources, identifying problems of the industry, and supplying services to maintain a healthy society. In-service technical training programs provided by private firms for the graduate agriculturist, internship programs developed between the educational institutions and the private firms, and open lines of communication between the two provide avenues for accomplishment of mutual objectives and maintenance of the strong traditional leadership role of agriculture in its service to society.

LEARNERS ALL LEARN

Marinus Van Elswyk
Professor of Agronomy
California State University, Fresno

The recent publication of the Journal of Agronomic Education is an indication of the interest plant and soil scientists have in educational concepts. Other professional journals include significant contributions on educational concepts, too. The interest displayed by professional organizations comes at a time when changes in educational concepts, as well as attitudes toward learning, are at a peak. It is no longer possible for all necessary learning to take place in a schoolhouse and in a specified time period, indeed if it ever was.

Traditions in agronomic education, as elsewhere, are breaking down. There is talk of changing degrees, changing time in school, changing requirements for employment; and, in agriculture perhaps a bigger change is in the number of students who come from non-farm backgrounds.

In addition to the changes affecting the structure of education, the attitudes of young people in particular and society in general indicate a need for review of the respective roles of public institutions and private firms in the education and training of plant and soil personnel.

In order to review our respective missions, the education and training process can be divided into three functions: formal education; on-the-job-training; and retraining. These three functions are not mutually exclusive and appear to call for a larger interacting role (partnership) between the public institutions and private firms. In the recent Journal of Agronomic Education, the learning environment was discussed. Since learners all learn, it seems natural to expect that improvements in the learning environment will benefit all.

INDUSTRY'S NEEDS FOR TRAINED PERSONNEL

I. J. Johnson
Research Director, Cal/West Seeds
Woodland, California

Changing times in the agricultural economy cannot help but have their impacts upon job opportunities for college-trained personnel. It is not possible to make a comprehensive report on the changes in personnel needs in more than a small segment of the industry.

Personnel needs can be conveniently divided into four major categories: those whose duties primarily are in mail and processing operations, those in field services to customers, those in sales and those in research or new product development. Information from a survey conducted by member firms in the National Council of Commercial Plant Breeders showed that, as a result of the enactment of the Plant Variety Protection Act, there would be an expansion of research expenditures in plant breeding. These needs will include Ph.D. trained staff, as well as supporting technicians. Industry needs in agronomy for other classifications of employment have not been surveyed; and, hence, only generalized conclusions can be made. From all indications, the needs for a major increase in personnel will not be great since there has been no dramatic change in the kind and nature of services provided by these industries.

An alarming trend in employment opportunities for college and university graduates has been summarized in Business Week, September 23, 1972. This national analysis showed that more young people are going to college annually (over 10 million by 1975), more people are graduating with a BS degree (1.0 million annually by 1975) and more graduates are completing doctorate degrees (over 40,000 annually). These numbers are exceeding the demand in nearly every field of specialization. Fifteen years ago, U. S. colleges granted fewer than 300,000 BS degrees and fewer than 10,000 doctorate degrees. The trend will continue to rise, in keeping with the increased birthrate in the mid-1950's.

Although these disturbing trends are for the U. S. A. in general, their impacts also can and are being felt in agriculturally-trained graduates, who, in some fields, face competition for employment by graduates in closely related fields.

UNIVERSITY-INDUSTRY COOPERATION IN GRADUATE EDUCATION

M. L. Peterson
Department of Agronomy and Range Science
University of California, Davis

Changes in public attitudes, governmental support of research, finances of universities, and the job market for graduate students, suggest new approaches are needed to graduate education. One of these approaches is greater university-industry cooperation in the graduate education system. Numerous reports and experiences indicate a shrinking market for talents of basic scientists, but an expanding one for persons to work in a much broader range of positions.

The traditional bases for university organization, teaching, and research are the disciplines. The graduate student is, in a sense, a scientific apprentice to a major professor with whom he chooses to serve. Although the professions, agriculture included, have been exceptions to strict adherance to disciplines, at graduate level, the disciplines prevail as the system of offering graduate degrees.

The problems of society usually have scientific components, but they cut across disciplinary lines. Universities will never have the capacity and resources to solve more than a few of these kinds of problems. They do have, however, a particular obligation to educate those who will be able to solve multidisciplinary problems. The apprenticeship scheme of graduate research provides limited opportunities for solving multidisciplinary problems. The internship plan used in medicine could be adapted to serve the needs for practical experience in problem solving in graduate agriculture.

Following are some of the opportunities for introducing or expanding university-industry cooperation in graduate education:

1. Sponsorship of graduate research assistantships for students pursuing problems of interest to the sponsor.

2. Employment of graduate students through a part or all of their graduate studies to provide supervised practical experience in problem solving as an agricultural intern.

3. Use of agricultural industry laboratories and facilities for off-campus research of graduate students doing thesis research of mutual interest to the industry and the university.

4. Graduate instruction by agricultural industry scientists for graduate students in fields not covered or within the area of competence of available university scientists.

5. Conversely, the offering of graduate courses to industry scientists and technicians, as well as enrolled graduate students, at times and places mutually convenient.

6. Industrial representation on thesis committees in fields of special competence of industry laboratories or industrial scientists. This arrangement is similar in purpose to the extramural examiners used in higher education in British Commonwealth countries.

Most, if not all the above suggestions, have been used somewhere within the University system. The university, the general public, and agricultural industries all will benefit by greater exchange of people, ideas, and mutual use of facilities for problem solving.

FUTURES UNLIMITED

John J. McCabe
Vice President, Ferry-Morse Seed Company
San Juan Bautista, California

The title, "Futures Unlimited", refers to the direction of education to which consideration may be given in the selection and presentation of particular subject matter which will prepare agriculturally-oriented students for positions in research, production and administration. The author questions the purpose of education as a vehicle to teach a way of living or a way of earning a living.

Author presents a composite of viewpoints concerning the kind of education that will be needed. The composite represents opinions of several individuals holding positions of responsibility in the seed and grower-shipper industries.

The author challenges educators to create new kinds of educational criteria and thresholds, new ways of presenting course work at a more efficient level through a technique of conceptual communication as the primary precursor of understanding before establishing the working hypothesis.

Consideration is given to establishing recognized achievement and proficiency levels rather than present levels of academic attainment through a specific degree.

PROFILE OF A SUCCESSFUL COMMERCIAL AGRONOMIST

Malcolm H. McVickar
National Manager, Agronomy
Chevron Chemical Company, San Francisco

There are at least ten areas of proficiency that can materially contribute to the success of a commercial agronomist. These areas, not necessarily in the order of importance, are:

1. Technical Training
2. Profit Orientation
3. Integrity
4. Communications
5. Analytical Ability
6. Personality
7. Growth
8. Creativity
9. Public Relations
10. Sales Ability

A sound technical training is a solid foundation on which all other areas of proficiency must be built. The successful commercial agronomist must have the ability to put his technical knowledge to work in a practical manner. He must be a professional and remain a professional throughout his career. His recommendations, although made in terms of his company's products, are always sound and of value to the user.

The art to communicate clearly and objectively, both orally and in writing, is a "must." Simple language is used to explain the technical. The commercial agronomist has the ability to weigh all evidence and then reach a sound decision. He must be willing to make decisions and they must be sound.

Most commercial agronomists work with other people. A good personality is a valuable asset. If a commercial agronomist likes people and others like him, his chances of success are greatly increased.

Technological changes are coming fast. The half-life of agronomic knowledge is probably no more than four years. Today's recommendations will be obsolete in a few years. The commercial agronomist continues to keep abreast of new developments. The commercial agronomist with a flair for creativity can use this ability to help him convey his ideas to others.

In many cases, the commercial agronomist relies on others for much of his new information; he, therefore, must maintain good public relations with his associates, both in the commercial and academic fields. When it is all said and done, most commercial agronomists are actually salesmen. They sell ideas, concepts, etc. They must, therefore, be at least proficient in the five steps of a successful sales presentation: (A) Attention, (B) Generous, (C) Desire, (D) Conviction, and (E) Close.

Commercial agronomists who are proficient in these ten areas will very likely be highly successful.

THE ROLE OF COMMUNITY COLLEGES IN AGRICULTURAL EDUCATION

J. D. Axtell
Agricultural Instructor
Reedley College

The community college has become a very important cog in the educational system of California. Some of the objectives of the community colleges are: to prepare students to transfer to the state university and state college systems, education of the general public in an adult school system, and to provide vocational-technical training leading to direct employment. Community services are also provided by the community colleges for the purpose of supplying cultural activities.

There are over 850,000 students enrolled in the community colleges in California. Three hundred and thirty thousand of these students are attending school full-time while 525,000 are part-time students only. A projected enrollment predicts that by 1975 the California community colleges will enroll over 1,000,000 students. This enrollment is over twice as large as that of the university and state college systems combined. Community colleges enroll over 85% of all entering freshmen. About 85% of the entering freshmen students indicate that they have four-year degree aspirations. Only 25% of those indicating baccalaureate objectives actually transfer to four-year institutions, and some statistics indicate that only a small portion of those transferring to a four-year college actually complete the baccalaureate requirements. Another interesting fact is that 30% of the freshmen who enter the community colleges are qualified to enter the state university system.

Statistics indicate that 60% of the entering students do not return for the second year. Many of those who do not return have completed a one-year certificate program and have found employment. There are students who drop out because of lack of incentive or for other reasons and who come back later in life after they find a reason for becoming an educated person. Another reason contributing to the high attrition rate of students entering community colleges may be that too many students are undecided in terms of a life objective. It has been estimated by several staff members at Reedley that 50% or more of the students are undecided on their major when they enter college.

A typical vocational-technical program at Reedley College is the natural resources program which is serving a multiple role in training students for transfer toward a professional forestry career, training technicians for immediate employment, and, at the same time, providing a general educational thrust for the many undecided students who are attracted to the natural resources program because of its current vogue.

What are the Natural Resources? Dr. Oliver S. Owen, Department of Biology, Wisconsin State University, defines them as "any portion of our natural environment - such as soil, water, rangeland, forest, wildlife, minerals or human population - that man can utilize to promote his welfare." This includes atomic energy, wind, precipitation, tide power, sun, atmosphere, streams, scenery, lakes, soil fertility, agricultural products, forests, forage land, wild animals, ocean gems, metals, fossil fuels (potential pollutants) and mineral salts. Some students not too familiar with the program, think of it as hunting and fishing.

Reedley College offers 42 units in Natural Resources with the main objective of providing the student with enough knowledge and experience to obtain and hold a position in the field at the technician level. A transfer option is also available.

Some of the technician jobs are log scaling, cruising and marking timber, campground aide, firefighting, patrolmen, park maintenance man, mill work, tree felling, road building, surveying, bookkeeping and public relations.

We feel that we should use the work experience program to the fullest extent possible. A problem of timing has been encountered since the work starts in April or May and goes until October or November and the school year is September to June.

It would appear that many students could benefit from a year or two working in the field of Natural Resources before they start to college; however, custom and the fear of not returning deter most students from following such a course of action.

AGRONOMIC EDUCATION IN THE COMMUNITY COLLEGE

Byron E. Harrison
Chairman, Agricultural Department
West Hills Community College, Coalinga

1.0 Introduction

1.1 A brief statement regarding the role of agronomy education in community colleges.

2.0 Content

2.1 A brief explanation of the courses and programs that are offered in the community colleges that I am familiar with.

2.2 A description of the programs that are offered in Agronomy, such as a one-year certificate program, a two-year certificate program, and third, a program that leads to continued education necessary at a four-year college or university.

2.3 Discussion and presentation of the conception of a one-year certificate program, the students that enter this program, the need for the program (how it was drafted), and most important, the placement of students who have completed the one-year program.

2.4 A description and explanation of the two-year agronomy program, in other words, A. A. Degree; the difference between this and the one-year program; a discussion of the specific skills presented to the students, and again most important, the placement of these students.

2.5 A presentation regarding the transfer student who has majored in agronomy, the difference between his program while attending a two-year college and the one and two year programs, the ease with which he can transfer to a state college or a university, and again, what happens to him when he is ready for employment.

2.6 A plea for guidance for instructors in agronomy at community colleges - we need organizations, resources, people who are employers to direct us and identify the type of an educational program we should be offering in the community college.

2.7 I would like to identify ways and truly call for help for directions and procedures in keeping the staff informed and involved with the skills and knowledge that is needed for our instruction. In other words, in-service training programs, etc., for instructors of agronomy.

3.0 Conclusion and Summary

3.1 A brief overview of the highlights of this discussion.

NATURAL RESOURCES OFFERINGS IN THE CALIFORNIA STATE UNIVERSITY AND COLLEGES SYSTEM

D. W. Hedrick
Dean, School of Natural Resources
California State University, Humboldt

Among the nineteen campuses of the California State University and Colleges, Humboldt is the only one offering degree programs in all of the natural resources disciplines. Degree work in some phases of natural resources is available at several campuses. For example, Park Administration curricula are available at two locations - Cal Poly, Pomona and Sacramento; natural resources management at Cal Poly, SLO; range management at Chico and Fresno; and Recreation Administration in eleven of the nineteen institutions. Environmental studies are offered at Sacramento and San Jose.

Some data on objectives, instructional resources, numbers of majors and degrees offered during the past five years are presented for the six undergraduate programs - Fisheries, Forestry, Natural Resources, Oceanography, Range Management, and Wildlife - and the Master of Science programs in Fisheries, Forestry, Wildlife and Watershed Management at Humboldt. At California State Polytechnic University, San Luis Obispo, enrollment data are included for the five-year period in the Natural Resources Management major.

UNDERGRADUATE EDUCATION IN AGRICULTURE AND NATURAL RESOURCES IN CALIFORNIA

O. J. Burger
Dean, School of Agricultural Sciences
California State University, Fresno

The California system of higher education is huge and complex and has many facets. There are more than ninety-three community colleges that are "fed" by more than 1,477 high schools. There are nineteen institutions in the California State University and Colleges system which draw students from the community colleges and high schools. From these institutions, students may also enroll at nine campuses in the University system or at one of the fifty-one private four-year colleges.

Of the nineteen institutions in the State University and Colleges system, there are four state universities that present programs leading to both the baccalaureate and master degree in Agriculture. They are, from north to south, California State University, Chico; California State University, Fresno; California Polytechnic State University, San Luis Obispo; and California State Polytechnic University, Pomona. The number of students enrolled in Agriculture at these four institutions is nearly 5,000.

These four state universities have dedicated nearly 8,000 acres of land for use in their agricultural instruction programs. On this land, students, through appropriate student projects, may learn to put into practice the theories they learned in the classroom. Although firmly based on professional agricultural programs, the students are presented opportunities to "learn to do by doing." The thrust of the educational programs could be classified as applied science. This presents the opportunity for students to receive some vocational training to qualify them for the first jobs. Moreover, the program contains enough science and academic work to provide the basis for continued educational growth.

Each of the four state universities have credentialling programs to prepare students to teach vocational agriculture in high schools. At present there is a grave shortage of qualified vocational agriculture teachers in California.

There are more than 185 faculty members at the four state universities that service the nearly 5,000 professional agricultural students and teach courses in which thousands of non-agriculture students are enrolled.

The four state universities are dedicated to provide educational opportunities to help prepare young men and women for the ever-increasing number of career opportunities in the Industry of Agriculture in California and the world.

THE CONSERVATION OF NATURAL RESOURCES PROGRAM AT UNIVERSITY OF CALIFORNIA, BERKELEY

Arnold M. Schultz
Professor of Ecology
University of California, Berkeley

The Conservation of Natural Resources major at Berkeley is just starting its fourth year. While administered jointly by the College of Agricultural Sciences and the School of Forestry and Conservation, it is a broad ranging program which has two hundred fifty students who come from all over the campus.

The essential features of CNR include the following:

1. Core course requirements are minimal: two quarters of IDS-10 (Man and His Environment - Crises & Conflicts); CNR 49 - a field trip course; and CNR 149 - a senior seminar.

2. From there on it is an individual major. The students must concentrate with at least ten courses in an "area of interest" which does not constitute a conventional major.

3. Advising is intensive. The student "shops" for his own advisor when he first comes into the program. Faculty members are restricted to eight advisees.

4. The curriculum is interdisciplinary. Students investigate the interfaces between disciplines - the space that usually goes unstudied at academic institutions.

5. The program is holistic, that is ecosystem oriented. Ecosystems are considered not only biogeochemical systems, but socio-cultural systems as well. The aim of the core courses is to get students into the habit of systems thinking.

AGRICULTURAL ENVIRONMENTAL EDUCATION

Harry O. Walker
Associate Dean
College of Agriculture and Environmental Sciences
University of California, Davis

Reference is made to the place of the University of California system in agricultural instruction, statewide. Tentatively, the plan is as follows:

1. An attempt to place in perspective the meanings conveyed by "agricultural education," i.e., traditional vs. current concepts.

2. Trends in the curricula now being made available in colleges and universities; the influences of those changes in enrollments, majors available, instructional relevance.

3. Agricultural education within the University of California (UCR, UCB, UCD) - present and proposed programs.

4. Instructional activities in the College of Agricultural and Environmental Sciences, UCD - 1967-1972.

5. Opportunities for cooperative action in agricultural education among the community colleges, state colleges and universities, and the University of California.

MAINTAINING THE ENVIRONMENTAL QUALITY OF CALIFORNIA WILDLANDS

R. Merton Love
Professor, Department of Agronomy and Range Science
University of California, Davis

Ten thousand years ago, or even less, the whole world was a vast wilderness. We don't know whether people were happier then than they are today. But we do know that every man, woman and child spent all his waking hours searching for food, and all his sleeping hours trying to be comfortable - whatever the elements.

It has been said that nature was in balance then. But was it? Man has never been satisfied with his environment. He has always tried to change it to suit his needs, and very early he started domesticating plants and animals. Over the millenia, man has learned a great deal about how to overcome the limitations of nature in order to grow and harvest his crops. The interrelated factors involve climate, soil, plants, and management. Management includes the selection of species of plants, seeding, fertilizing and irrigating where necessary, control of pests, and harvesting the crop. Now he has a more efficient agriculture, which may be defined as man's attempts to overcome the limitations of nature so he can grow and harvest the desired crop. In intensive agriculture, the plants are the crop. On wildlands the plants are usually referred to as the vegetation, and the "harvest" is the use, whether it be timber, water, or outdoor recreation.

The lessons and the principles man has learned in agriculture can be applied to the "management" of wildlands because, here too, within the restrictions imposed by climate, the soil and the vegetation must be cared for intensively.

Once the domain of the sportsman, the livestock owner, the lumberman, the miner, the naturalist, and nature lover - with their many conflicts, today the wildlands have to bear with a new dimension - the outdoor recreationist. That is why there is such extreme pressure on the wildlands today.

For today's symposium, four knowledgeable men have agreed to discuss the problems, responsibilities, and solutions that society is now undertaking to maintain the environmental quality of California wildlands.

NATIONAL PARK SERVICE

Howard H. Chapman
Director, Western Region National Park Service
San Francisco, California

The principal limiting consideration in maintaining the environmental quality of California wildlands is fast becoming the impact of human use. Thus, public use is limited by the need to preserve the quality of the areas in question. A noteworthy example is increased use of the Colorado River as a result of construction of Glen Canyon Dam. Since boats can now use the river at almost any season of the year, annual visitor use has increased fairly rapidly from a few hundred to about 12,000. Plans are to cut present use about in half by 1977. Concurrent with this limitation are movements to determine the carrying capacities of the backcountries of all national parks.

Quite obviously, research should be expanded on the ability of the environment to withstand human impact. Additionally, land use may be limited not by the land itself, but by visitors' limits of tolerance of the numbers of other visitors. Educational programs on responsible behavior in the wilds will also be needed.

UNITED STATES FOREST SERVICE

William G. Graham
Chief, Multiple Use Planning Group
U. S. Forest Service, San Francisco, California

America has a history of long and continued effort to conserve its natural resources. Earlier planning was rough, but demands on those lands in those days were equally simple. As the Forest Service developed the concept of multiple-use management, the problems of management became necessarily more complex - and in time, the growing pressures for more varied and optimum use made them more complex yet.

Today, although much land is close to areas of population, and, therefore, subject to air pollution and people pollution, great areas remain comparatively isolated and unchanged. The Forest Service has the goal of minimizing permanent changes, allowing them only to the degree justified by benefits.

Land capability is one of the first considerations of land planners in these complex times. Then comes the search for a balanced program of protection and development for the objectives agreed upon.

Those objectives are often clear in remote high-altitude lands that seem ideal for wilderness recreation. But even then, there may be competing uses: mineral claims, watershed considerations, winter sports, summer grazing, off-road vehicle recreation. The optimum balance, determined in cooperation with the public, will almost certainly evolve over time.

A measure of the size of the management problem is found in the California National Forests. They annually provide over 50 million visitor-days of recreation and almost two billion board feet of wood. Each year about 29,000 acres are planted or seeded with trees, and about 30,000 acres receive stand-improvement treatments. Nearly 350,000 domestic animals graze under special permits. Millions camp, hike, picnic, hunt, fish, or simply drive through these forest homes of countless species of plants and animals.

MULTI-USE MANAGEMENT OF PACIFIC GAS AND ELECTRIC COMPANY'S WILDLAND

R. E. Hayden
Supervisor of Recreational Planning
P. G. & E., San Francisco, California

Developing and distributing power has involved the Pacific Gas and Electric Company in the management of 176,000 acres of wildlands in California. An important aspect of that management is P G & E's involvement in outdoor recreation. Thus, the power company's 133 reservoirs involve 450 miles of shoreline that attract freshwater recreation to various degrees. Management may thus involve maintaining levels to the end of the season, maintaining stream flows for fish and wildlife, helping flood control, and conserving water for domestic and agricultural uses.

Under multiple-use concepts, such areas are also managed for livestock forage, forests are managed for sustained yields, and campground facilities are maintained. Included today are 202 picnic units at 23 locations and 27 compgrounds with 483 overnight units. Carrying capacities determined for the more popular spots are still greater than today's use.

Concurrently, P G & E is involved in fish and wildlife conservation, cooperating with the Fish and Game Department in spawning fish in P G & E reservoirs and placing gravel to expand spawning areas. Press releases inform anglers during the trout season. In cooperation with state agencies, a barrier was built to keep rough fish from a 3½-mile length of Hat Creek, and the stretch is managed as a wild-trout fishery, with continuing evaluation of several trout management schemes.

Waterfowl and other birds are fostered, particularly through protection of nesting areas, providing nesting platforms, and improving habitats. Deer crossings provide access to reservoirs and canals. Transmission lines are constructed and routed to minimize environmental impact, and construction and maintenance roads are given esthetic and erosion-control treatments. Rights-of-ways are cooperatively developed with cities for use as parks and playgrounds.

MAINTAINING ENVIRONMENTAL QUALITY IN THE PUBLIC DOMAIN

E. J. Petersen
Associate State Director, Bureau of Land Management
Sacramento, California

Early attitudes toward lands in the public domain were consistently as expressed in legislation for their management: "pending final disposition." In time, however, the attitude developed that public ownership should be continued, with management for public use. Today there is layered on that general responsibility the publicly-expressed mandate that the environment must be protected while the public is served.

Multiple-use concepts complicate the problem for the Bureau of Land Management (BLM), so that today the BLM is busily developing umbrella statements as guides covering oil and gas leasing, timber management, geothermal steam, wildlife habitat, brush conversion, etc. Pressures for full multiple use along with full protection of the resource coincide with growing awareness of the uncertainty about possible long-range consequences of any actions taken. Thus, today: (1) more and more people are aware of the immense importance of public lands; (2) resource managers are more aware than ever that managing resources involves managing people; (3) besides foresters, range ecologists, wildlife biologists, soil scientists, and engineers, the management of resources needs interpreters, naturalists, archaeologists, public-information specialists, rangers, economists, and regional planners; and (4) intensified management under the conflicts of various needs will involve still more disciplines: sociologists, human ecologists, anthropologists, and psychologists.

Additionally, since environmental impacts don't stop at boundary lines, greater cooperation will be mandatory among areas and groups.

Trends in the public domain are exemplified in specific examples: waste disposal must become environmentally more sound - and in a hurry. What new systems should be considered with the explosive nature of demands on recreational use of public lands? BLM uses an interdisciplinary approach to identify potential uses of public land and resolve conflicts for use. Management frameworks for all BLM lands in California are planned by the end of 1979, so that projected needs can be met while giving the environment full protection.

THE ROLE OF FIRE IN MAINTAINING FOREST WILDERNESS QUALITY

Harold H. Biswell
Professor of Plant Ecology
University of California, Berkeley

Surface fires are an important component of forest wilderness systems in a state of nature. Set by lightning or by man, such fires can benefit the forest by keeping fuel loads at minimum levels that do not induce flaming of the forest crown - thus, maintaining parklike open conditions with an understory of pine needles, burrs, and wildflowers; speeding nutrient cycling; destroying pathogens and phototoxic substances; and allowing more water to penetrate the soil because debris and duff are minimized.

Crown fires were practically unknown in such balanced and stable wildernesses, favorable habitats for wildlife. Frequent surface fires thinned the trees, favoring broad spacing and large specimens. Man's early management of California forests naturally aimed at controlling wildfires. Two theories contended for dominance: excluding fire altogether; or controlling burns to keep brush, etc., at a minimum, so that fires would be naturally limited, crowning only locally at most. The former theory prevailed, with the result that underbrush fuel and consequent hazards continue to mount, not only endangering mature trees, but replacing vegetation, wildflowers, and animal life with impenetrable thickets of dry and dangerous fuel loads. One area has been measured to have about 22 tons of debris per acre, plus hundreds of dead and small standing trees available for creating fierce fires that can crown.

Experimental programs of surface fires in Lake County and the Teaford Forest have confirmed that natural conditions, restored by man, yield the benefits theorized. Three or four surface fires in successive years, each under progressively drier conditions, easily reduced fuels to the point where any wildfires thereafter could do little or no damage and were easily controlled. Such "prescribed" burning nearly always gave benefits outweighing any possible damage. The areas in the various experiments are now taking on open and parklike qualities, and shrubs and wildflowers are returning. The National Park Service is having similar success in introducing controlled fires and naturalness in King's Canyon, Sequoia, and Yosemite National Parks.

CARBOHYDRATE RELATIONSHIPS IN TURFGRASSES

V. B. Youngner
Professor, Plant Science
University of California, Riverside

Adequate carbohydrate reserves are important for turfgrass management in the following ways:

1. They are necessary for the regrowth of leaves following mowing;

2. They aid in recovery from injury;

3. They promote initiation of new tillers;

4. They help the turf survive during periods of heat, cold, and drought;

5. They promote initiation of new roots and growth of old roots.

Recent studies have shown that levels of carbohydrate reserves are affected by temperature, light intensity, nitrogen fertility, soil moisture, and mowing intensity. Varieties differ in their ability to accumulate carbohydrate reserves under identical conditions.

Kentucky bluegrass varieties grown at three different Southern California Climate zones responded differently within each climate in accumulation of reserves. They also differed on a seasonal basis among the three zones. In general, a mild coastal climate is less favorable to the accumulation of reserves than is a climate with colder winter temperatures.

USE OF WASHED DAIRY MANURE MULCH AS AN AID IN SEED GERMINATION UNDER A SALINE CONDITION

Richard L. Baldwin, Ervin L. Bramhall and Vic A. Gibeault
Agricultural Extension
University of California, Ventura

Washed dairy manure used as a mulch over a seeding of Seaside creeping bentgrass, Agrostis palustris, permitted germination in an area of high soil salinity that precluded germination with normal practices. The presence of a high water table made leaching ineffective. Washed dairy manure was applied as a mulch in 0, ¼", ½", and 1" depths. No germination took place without the mulch, and only a scattered stand in the ¼" mulch. A fair stand was obtained in the ½" mulch, and a dense stand germinated in the 1" application. Soil incorporation of the material did not effect germination.

TURF COLORANTS - A METHOD TO PRESERVE WINTER GREENNESS WHILE REDUCING COSTLY WINTER MAINTENANCE

Kent W. Kurtz[1] and John Van Dam[2]
[1]California State Polytechnic University, Pomona
and [2]University of California Agricultural Extension, Los Angeles

Turfgrasses throughout the United States, whether cool season or warm season species, exhibit a discoloration during certain phases of their annual growth cycles. In most instances, this discoloration is attributed to either summer or winter dormancy, which may last a few weeks to several months in duration. Various techniques are employed to alleviate discoloration, including overseeding with cool season grasses and spraying with turf colorants. Studies conducted in 1972 evaluating the use, value, and cost of overseeding compared with colorizing culminated three years of preliminary research utilizing various turfgrass colorants. A comparison of the two methods indicates lower per-acre costs and several advantages to the use of turfgrass colorants.

COMMON BERMUDAGRASS OVERSEEDED WITH COOL SEASON TURFGRASSES FOR AN EVERGREEN LAWN IN COASTAL SOUTHERN CALIFORNIA

S. E. Spaulding and V. B. Youngner
Department of Plant Sciences
University of California, Riverside

Problem, Research, and Practices

Poor quality turf, fall and spring, is associated with customary overseeding for provision of active winter cover over resting bermudagrass.

Materials and Methods

A common bermudagrass lawn was fall renovated, and overseeded with four cool season turfgrasses at two densities. (Other treatments were presowing growth retardant, mowing height, nitrogen fertilizer, and vertical mowing.)

Results

Qualitative evaluations and density data give differences between grasses and cultures after three years.

Discussion

Results are interpreted for application.

Conclusion

Infrequent overseeding with certain cool season turfgrasses is indicated for an evergreen lawn in coastal Southern California.

NITROGEN SOURCE IN RELATION TO TURFGRASS ESTABLISHMENT IN SAND

Kenneth D. Gowans and Edward J. Johnson
Agricultural Extension
University of California, Halfmoon Bay

Nine different sources of nitrogen were used to establish and maintain Manhattan perennial ryegrass in sand for eleven months. All materials, with the exception of ammonium sulfate, were applied at rates of 3, 6 and 9 pounds of nitrogen per 1000 sq. ft. at the time of establishment. Ammonium sulfate was applied at the same rates, but in six equal applications at two-month intervals. The quality of the turfgrass in the ammonium sulfate and plastic-coated nitrogen source was above the acceptable level during the eleven-month period. Urea formaldehyde, I. B. D. U., sewage sledge and chick manure provided enough nitrogen for establishment, but the quality of the grass decreased below an acceptable level after three months.

ANNUAL BLUEGRASS CONTROL IN HYBRID BERMUDA TURF

Stephen T. Cockerham
Agronomist, Cal-Turf, Inc.
Camarillo, California

Two years of testing at Cal-Turf has shown both Casoron and Kerb will successfully take Poa annua out of hybrid bermudas with little effect on the turf. Casoron under certain conditions will bronze the tips of the blades of the bermuda, but this will mow off. Considering the excellent weed control, the phytotoxicity is well within commercially acceptable limits. Kerb has shown the same control with no phytotoxicity. Rates are critical with 1.5 lbs. active per acre the optimum for Casoron and 1.0 lbs. active per acre optimum for Kerb. An overlap with a sprayer where double rates of Casoron occur does cause unacceptable injury to bermuda, but even this does not kill turf. Both chemicals, in addition, provide pre-emergent control of Poa annua for up to ten weeks. There has been no observable injury to turf roots or rhizomes; no effect on rooting of transplanted sod; and no effect on rooting of stolons which would inhibit sod formation or recovery on golf tees and fairways.

EVALUATION OF COOL SEASON TURFGRASS SPECIES AND VARIETIES THROUGHOUT CALIFORNIA

Vic A. Gibeault
Extension Turf Specialist
University of California, Riverside

Numerous varieties of cool season turfgrass species have recently been released from various breeding programs throughout the world. The new varieties, as well as existing cultivars, were established in fifteen locations to observe their performance characteristics under representative plant climate zones of California. The species and varieties thereof, being evaluated include Kentucky bluegrass, perennial ryegrass, red fescue, Colonial bentgrass, and tall fescue.

The trials are planted in use conditions (golf course, park, athletic field, lawn, etc.) and are maintained at a comparable level to surrounding turfgrass areas. They are evaluated at standard intervals using a uniform rating system. Particular interest is being given to characteristic disease resistence/susceptibility of the various varieties.