Proceedings

1979
CALIFORNIA PLANT AND SOIL CONFERENCE

California Chapter
American Society of Agronomy

Holiday Inn at the Embarcadero
San Diego, California
February 7, 8, and 9, 1979

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Sponsored by the
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CONFERENCE REPORTS

Agronomists and Our Quality of Life

John Pesek

Two decades ago we in Agronomy would not have selected a theme such as yours--"Plant and Soil Conference: Improving the Quality of Life." The reasons are many but perhaps the main one was that we have been so close to the environment in our day to day association with crops, soils and climate that we took the quality of environment for granted. We may also have assumed that others understood the natural relationships, so much a part of our trade, that we overlooked checking, finding out that they did not, and informing them. Another reason is that we may have been so pre-occupied with the quality of life as it pertains to physical goods and comforts that we ignored the contribution of the wholesome environmental factors of air, water, food, fiber and landscape beauty.

We have made and we continue to make our contribution to the material well being by showing how a lesser number can produce ever more from our land, plants, water, atmosphere and light, thus freeing the preponderance of our population to provide the factors of a standard of living not ever before enjoyed by so much of the total of such a large population as ours. This shall continue because we have not exhausted our germplasm banks of superior genes for our crops; we have not learned about all the interactions in the mineral nutrition of plants; of all the effects which the soil has on these; of the factors which contribute to efficiency of water use; of the potential of the plant canopy to capture the energy of sunlight in compounds of reduced carbon derived from the carbon dioxide in the air; and so on. There are others and many of these shall lead to a greater production of our fields, pastures, ranges, forests and water bodies.

You in California have been in the vanguard of those who have selected plants, especially vegetables, for quality, durability and year around production and developed the crop, soil and water management practices to bring the rest of us wholesome, nutritious fresh fruits and vegetables whenever we want them and at a cost we are willing to pay. It is expected that there will be even more fresh foods which shall become less seasonal if not non-seasonal in availability. This has contributed and will add to the nutritional well being of all.

Once we have fixed the "type" (agronomic or horticultural) in our plants we will turn our attention more toward the internal properties of our crops so that they are even more nutritious. Positive factors such as vitamins, mineral and protein content and protein quality will be of major concern along with a pleasant flavor. But the absence of some negative factors such as excessive loads of heavy metals and other undesirable elements, reduction of alkaloids, etc. shall certainly come in for consideration, too. All these will contribute to a quality of life measured in terms of the general health and vigor of the population.

Crop production, soil management and water use practices have been blamed for a deterioration of our surface waters. Of course, there are other causes as well, but it is not our purpose here to enumerate these. And while some of our discoveries have made feasible the practices under indictment, it is also within our multi-disciplinary scientific profession where alternative, less damaging practices have been identified and more will be elaborated and demonstrated. It is we who will show how to lessen the salt and plant nutrient burden of our streams; manage the soil surface so that blowing dust does not choke us and eroded silts and sediments do not clog our water courses and destroy our impoundments; learn to handle crop residues efficiently without adding smoke and offensive odors to the atmosphere, or oxidizable solids to our streams rendering them unfit for out use and for higher forms of aquatic life. We know some of the answers already--acceptable and non-acceptable: adopted and not adopted--we shall learn and demonstrate others. Our extended profession, that of food production, can be dependable and effective and be a good neighbor in the environmental sense as well.

Soils, plants, atmosphere and surface water are everywhere. These parts of our physical and biological surroundings are effective sinks and dispersants for natural pollutants and those generated at an accelerated rate by civilized mankind. An understanding of the rate of these elements as sinks and sources of pollutants shall help deliver a better quality of life for everyone.

Our country is sorely in need of accurate values for the generation and the deactivation of undesirable environmental factors and their real effect on our lives. Only with these do we stand any chance of enlightened legislation and rational rules and regulations governing food, and fiber production. We have been late in entering this field of activity but we must if we are ever to be satisfied with the outcome.

The natural and cultivated beauty of our land surrounds us--we do not escape it if we have our senses of sight, smell, touch and hearing intact. Good or bad, we must live with our environment but we have not given it positive attention. Our quality of life can be enhanced by keeping our land, skies and waters productive and attractive and make our needs harmonious with these goals for our land. "This land is your land; this land is my land", the song writer has written. "From the mountains, to the prairies, to the ocean white with foam", wrote another: "This land is meant for you and me;" "From sea to shining sea."

Agronomists will help this land serve our quality of life in many ways. We shall do this by understanding your land and mine and making sure others do too. Your program this year is pointed in that direction.

RESEARCH, THE FARMER AND THE QUALITY OF LIFE

FRED HERINGER

California is the epitome of the farmer and the researcher working together for the betterment of the food production system. Nowhere else has the system worked better. Enlightened, bold research into the very beginnings of plant life and on through the production of high quality food and fiber in abundance has made California the hallmark of scientific development. With the enlightened, bold researcher there has been the modern California farmer-- willing to take the risk, willing to listen to the scientist while taking the scientific knowledge and putting it to practical application.

But along the way in the 60 or more years, things have changed. It is no longer the researcher and the farmer working by themselves. Others want something to say about what goes on in the laboratories and in the fields and orchards or our state. Narrow special interests want to restrict what is done. Honest but misinformed segments of our society want a say in how things are done. We must admit that they may have some good suggestions, some reasonable alternatives. Decisions in food production are no more exempt from political intrusion than any other facet of our lives in California.

If we accept the political and economic realities of life in the late 20th Century, what do we do to cope with them? We must work within the system of realities to solve the problems, face the issues with a minimum of rancor and a maximum of cooperation.

We will not solve the problems by caving in or taking the easiest way out. Bowing the critics and making the easy "political" decision to save a budget or a job or a program is not the solution. It must be a matter of education, of compromise and of enlightened leadership. The challenge is there and it can be met.

U. S. Agriculture in the Third World--

Is There Something Wrong?

R. H. Hancock

Points to be considered:

1. We should not promote U. S. versions of high technology agriculture as a solution to the world's food problems.

A. U. S. agriculture is characterized by more input of calories in terms of fossil fuels than is produced in calories for human food consumption

B. Capital intensive agriculture not adapted to surplus conditions of the Third World. Our process of agricultural developement moves people off the farm

C. Much of temperate zone agricultural technology not suitable for the tropics.

D. Agriculture cannot be treated as a separate entity. U. S. industrial development enabled Agriculture to develope by providing jobs for surplus farmers and immense purchasing power for agricultural products. If the third world follows this plan, life on our planet could be endangered.

Note: The oxigen content of air over the continental U.S. has declined since 1900. Oxigen attrition is replaced by oxigen from the oceans and from such areas as the Amazon basin. Should we encourage others to follow in our footsteps?

E. The vision of U. S. technologists tends to be culture bound. The few multi-cultural, humanities-oriented higher education courses offered in the U.S. reach mainly liberal arts students. Our students of technology are largely excluded even though they are the people that we expect to solve massive global problems. Compare this to other developed and developing nations where university graduates are almost universally expected to be fluent in several languages in addition to their own.

More than 200,000 foreigners are now studying in the U.S. attaining fluency in English and an expert knowledge of our culture. They are students of technology and constitute a major channel for the transfer of technology. The education of foreigners is becomming a major U.S. industry and a factor in our balance of payments.

F. U. S. technologists need too much pampering for successful overseas service. They are commonly paid more than the Minister of agriculture in most third-world nations. This constitutes a serious political problem which is largely hidden because its recognition threatens the privileges of the entire foreign service establishment including state departments of practically all nations, the United Nations, World Bank, etc., etc. It has been said that religious missionaries present our best image overseas. Nor has the Peace Corps been able to close this gap; it is strong on human relations but short on technology.

G. Too many U.S. programs are short-term in nature. Agricultural development in the Third World requires a career committment to workd in an overseas environment. The U.S. State Dept. policy of transferring employees every three years is incompatible with this. Most Ag specialists who go overseas must develope expertize in areas that are not in the mainstream in U.S. agriculture. When they return home they frequently lose out careerwise.

H. Too many U.S. programs have been influenced by politics. The need of politicians to produce quick results leads to distortion of development efforts, eg., Alliance or Progress.
I. Our medics are urging us to seek a Third World Life style: more exercise, more food with high fiber content, less super-saturated fats,less tension.

We have experienced many successes in foreign developement, but usually of a mission-oriented nature, eg., erradication of Foot and Mouth disease in Mexico, dumb rabies in cattle, tetse fly, screw worm, etc. These are easily defined goals of undisputed benefit where technology is readily transferrable. Long-term programs which require setting of national and international development goals are much more difficult, require brokering among various interest groups and intervention into domestic politics which is too easily characterized as imperialism. No foreigner can achieve this successfully; perhaps this is the lesson of Vietnam.

Recommendations:

1. We should support International Research Centers supported by Ford, Rockefellar, Kellog, and USAID. They perform a service similar to that of our Agricultural Experiment Stations. There are many of these centers abroad which function without U.S. support. In Mexico for example, there is no subsitute for the work that they are doing.

They are interested in relations with U.S. universities and this seems to be a fertile area for support. Perhaps the Fulbright Program can be useful in this regard. The Fulbright program could be more utilitarian in its goals.

2. We should attempt to provide high-quality programs especially-tailored to the needs of international students on our campuses. A warm welcome and a generous understanding of them and their cultures will have a vast future impact. Too many colleges and universities now look on them as an additional source of income which requires little or no investment. State legislatures are contemplating a higher rate of tuition exclusively for international students.

3, Language and cultural training for technologists first as students and later s adults. Any language can be learned quickly in an intensive format. The Foreign Service Institue in Washington trains State Dept. personnel in any of the modern languages to a high level in 16 weeks, ie., Spanish, French, German, Portuguese. Other more unfamiliar languages such as Russian require 34 weeks. Chinese, Japanese, Vitnamese, etc. require a full year. This is the shortest route to a successful transfer of technology. There is no subsitute for this type of effort. We are willing to send a person overseas for 3 to 5 years at a cost of $60-100,000/yr. but balk at making a one-time expense of $10,000 to prepare him adequately for this work.

4. St. Paul says in Philippians II,12 "Work out your own salvation with fear and trembling for God is at work in you, both to will and to work for his good pleasure." We should keep this uppermost in mind and avoid going to foreign lands showing the flag of technology as the means of universal salvation. Moreover, we should not apply the test of whether a program constitutes a "free enterprise" or a "democratic" endeavor in order to qualify for our assistance. There are many roads to development and the American road is only one.

ROW CROP DRIP IRRIGATION

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INTRODUCTION

Row crop drip irrigation had its beginning in New Jersey and New York in the early sixties, although no commercial acreage developed until 1970 when growers Gerald Redon, Tosh Hasegawa and Robert Conforth had their first plantings of staked tomatoes. Since this first beginning, acreage on row crops has continued to increase where approximately 12,000 acres are annually irrigated in California with the drip method. Seven thousand acres of this total is in San Diego County. The crops that use this new method are mainly staked tomatoes, strawberries, cucumbers, squash and peppers, and with limited plantings of other crops.

Drip irrigation was explored in San Diego County due to limited available water supply, water costs, and generally a hope of increases in yields and quality for the off-season crops. Following the very favorable yields with drip compared to furrow application in the early trials, growers showed increased interest. Field trials where yield data was taken, good yields resulted and growers learned to use drip effectively in raising these crops with usually less water per crop.

PROCEDURE

Over twenty-five replicated field trials on several crops indicated yield increases over furrow irrigations. The first trial in 1970 on fall tomatoes resulted in the following data:

TABLE 1. 1970 FALL TOMATO DRIP VS. FURROW IRRIGATION
GROWER: COZZA BROS.- TOSH HASEGAWA, MANAGER

	Irrigation Method	
Yield Item	Drip	Furrow
Marketable in tons/A	33.70*	26.50
Ave. indiv. fruit weight	.39	.34
# Feet of water used/A	2.60	3.90

* Highly significant

RESULTS

The results from this early trial where yields were obtained resulted in very favorable tomato yield with drip irrigation. The seven ton yield increase with drip compared to furrow was a real stimulant to drip water application. Fruit sizes were also increased. One third less water was used to grow this increased crop compared to furrow application. Following this favorable drip irrigation trial, growers began to explore other crops such as strawberries, cucumbers, peppers and squash.

Cucumbers grown under plastic row covers were tested for crop response in 1972 on the Cacho ranch. Four replicates of drip versus furrow were compared, and yields were taken twice weekly from April 5 through June 15. Total yield is given in Table 2.

TABLE 2. CUCUMBER DRIP VS. FURROW IRRIGATION YIELD SUMMARY
GROWER: TONY CACHO, SAN YSIDRO, CALIFORNIA

Accumulated Marketable Yield #1 Fruit in Tons/A Through:	April	May	Total	Ave. Frt.Wt.	Water Used Per Acre
8-Mil Twin Wall Hose & Clear Mulch	3.2	21.1	28.8	.72	18.1
8-Mil Twin Wall Hose	4.4	18.8	27.7	.69	18.1
Furrow	5.3	16.9	26.3	.65	33.2

Drip irrigation increased the cucumber yields compared to furrow application. The clear mulch that was used to cover the drip line also tended to improve yields. This benefit was probably as much from the extra heat stored in the soil from the plastic cover as it was from water savings. The cucumber vines were larger and were more vigorous with the drip treatments. The spring crop is generally a higher yielder in contrast to summer and fall plantings. The water savings with drip were also appreciable.

Another potentially lower gross income crop, celery, was compared with furrow for yield response and plant size. A double row planting with drip line placed between the rows was compared with the standard single row furrow application. Three plant spacings, 8, 9, and 10-inch between plants were compared with two drip irrigation orifice spacings 12-inch and 15-inch. This gave two water regimes and plant spacings comparable to the single row as well as plant population above and below the usual furrow irrigation. This crop was grown for the winter harvest and plants were transplanted on September 19, 1977, and harvest was made on February 9, 1978. Yields and water use are shown in Table 3, along with drip line between double celery rows in Figure 1.

The drip versus furrow irrigation resulted in the highest yield and plant size with the 12-inch drip orifice spacing. This showed a need for slightly higher water requirement than the 15-inch drip orifice discharged. Rains supplied nearly half the drip water used,while it was a lower percentage with the furrow. Celery grown under drip resulted in a water saving of 9 inches as well as resulting in increased yields of 173 boxes of the three large sizes. Additional trials with a similar plant spacing and different fertilizer rates will result in further drip responses in this potentially lower income crop compared to staked market tomatoes, strawberries, and early cucumbers.

TABLE 3. 1977-78 CELERY DRIP VS. FURROW TRIALS
GROWER - LOUIS & RICHARD CACHO, CHULA VISTA

50 LB. CRATES/ACRE

	Furrow	Drip 12" Orifice	Drip 15" Orifice
TOTAL YIELD	1094	1224	1096
2 - 2.5 & 3 Doz. Sizes	843	1064	917
2 - 2.5 & 3 Doz. Sizes	976	1149	1003
3 Doz. Size	133	85	86
HEARTS	118	77	91
Ave. Plant Weight #	2.03	2.22	2.07
Water Applied + Rainfall	21.30" 8.60"	12.30" 8.60"	10.10" 8.60"
TOTAL WATER	29.90"	20.90"	18.10"

DRIP ADVANTAGES

These three trials are representative of the many trials conducted for yield, fruit quality and water use data. The commercial use of drip has given many evaluations as follows:

1. Crop improvement is standard with most plantings resulting in higher yields and good quality.

2. Water applied per crop results in savings of 10 to 50 percent, depending on the soil type and rains. This is especially important in districts with high water costs and limited supplies. This savings often pays all or a portion of the costs of drip over furrow application.

3. A very important advantage of drip over furrow is the ability of the growers to perform all cultural operations of the crop while the drip irrigation water is being applied.

4. The limited wetted pattern and especially the moist area wetted with drip results in far less weed development.

5. Another advantage of drip is the ability of drip to irrigate more acreage rapidly than can furrow or sprinkler application.

6. Labor saving of water application is usually half or less for drip versus furrow.

7. Drip irrigation wetted pattern is onion shaped which wets a small area on top of the soil. This keeps evaporation to a minimum in contrast to other irrigation methods.

8. Fertilizers can be applied as dry preplant or by liquid. Complete fertilizers such as liquids 7-7-7 and 12.5-5-5 may be applied in most waters. There is a trend to use less fertilizer with drip compared to furrow or sprinkler type. Liquid fertilizers are more expensive than dry mixes yet the application costs are practically eliminated in drip.

9. Run-off, especially with furrow application, is not a problem with drip.

CONCLUSION

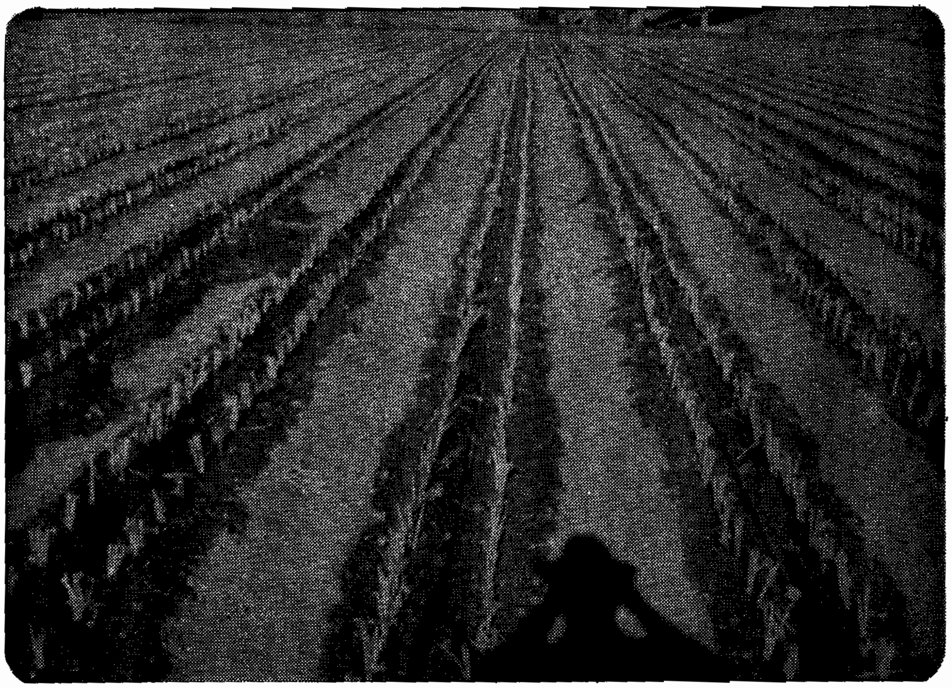
Drip irrigation will continue to expand, especially in areas where water may be limited and expensive.

Where food requirements are increasing, more acreage can be grown which will increase yield and total food supplies. Water is more evenly applied with drip compared to other methods.

Potentially lower income crops will continue to see drip acreage increased.

The technology of drip is continuing its development and the present knowledge is resulting in beneficial yield and crop responses.

FIGURE 1.



Double celery row drip irrigation planting in Chula Vista winter crop. Shows new transplants and wetted pattern.

DRIP IRRIGATION IN DECIDUOUS ORCHARDS

F. K. ALJIBURY
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Deciduous trees develop very extensive root systems when growing in deep, non saline, well-drained soils free of restricting layers on high water table. On the basis of water extraction studies in deep well drained soils, almonds and walnuts had numerous roots at depth of 10 feet while peaches and plums at 6 feet(2, 1). However maximum concentration of feeder roots are found in the top 3 feet and within the spread of the branches (8). Beyond the spread of the branches and at greater depths, the quantity of feeder roots per unit volume of soil generally diminishes progressively.

Water absorption by the roots of deciduous trees increases significantly with the advent of leaves in the spring. The initial water withdrawal is greater from the surface soils because of greater root activity under more favorable soil temperature near the surface (8). With the gradual warming up of the soil profile, the rate of water withdrawal by the trees become more proportioned to the feeder root population in any particular soil volume and those of the greatest root concentration are depleted of water most rapidly. Thus to delay irrigation until the moisture in the lower profile is depleted will expose the roots at the upper profile to moisture stress and water deficit within the tree.

Several irrigation researchers in the early 1930's, working mainly with perennial trees who used transpiration rate reduction as the only means to determine the effect of soil water potential on production concluded that crop production was unaffected by soil water stress until the soil moisture content fell below the wilting point (6). The fact that growth decreases at higher water potentials than does transpiration invalidates such a conclusion. It is now generally accepted that in most crops that crop yield is maximal only when water potential remains high thoughout the life of the crop unless water stress is required to initiate differentiation of maturation of harvested portions of the plant (7, 4). High water content soils also reduce the impedance to root penetration (3) and enhance the ability of the soils to supply nutrients to the plant roots (5). The soil water content should not be too high to disturb rapid diffusive supply of oxygen and removal of carbon dioxide. In most soils the air-filled pores should be at least 10 percent of the total pore space (11).

The above advantages of high frequency irrigation in addition to others (1) were the primary factors in the expansion of drip irrigation in deciduous orchards in the San Joaquin Valley. Previously these deciduous orchards were irrigated with the surface methods. Since each surface irrigation includes a fixed cost, it is economically advantageous to decrease the number of irrigations by increasing the time between them. As a consequence, orchard's irrigation management has focused on decreasing irrigation frequency by storing as much water as possible in the soil profile during an irrigation and using as much of this as practical before the next. Such practices often develop water deficit within the trees and cause reduction in fruit production and quality (9). In contrast, the use of drip irrigation systems which distributes water to the trees through emitters clipped on to hoses supplied with water from pipe systems reverse the economic picture. The capital cost of such system depends largely on pipe size which can be minimized by increasing the duration of each irrigation (6). Since it costs no more to use the system once it is permanently installed, the most efficient use is the near continuous operation of the system during peak water demand. The soil water potential of a drip irrigated mature Santa Rosa plum orchard planted 14 years ago in a Hanford fine sandy loam field at Parlier is presented in Figure 1. The numbers above the arrows represent the U. S. gallons per tree per day applied during the irrigation season. The effect of high frequency irrigation in this experiment on fruit size is shown in Figure 2. It should be noted that the fruit size of the drip irrigated plots were larger than the surface irrigated plots throughout 1978 season. The amount of water applied during the irrigation season was about 20 per cent less in the drip plots than those irrigated by the surface method.

High frequency drip irrigation of deciduous orchards in the San Joaquin Valley offers important savings in water, fertilizers and labor while maintaining high crop production. The record shows that in the San Joaquin Valley, farmers are making serious efforts to conserve resources and to maintain competitive production at least cost.

REFERENCES

1. ALJIBURY, F. K. 1973. Drip Irrigation Practices and Benefits Blue Anchor 50:32-35.
2. ALJIBURY, F. K.; and K. HENCH. 1971. Moisture Extraction of Almond trees in Kern Co. Cal. Agr . . . . . Nov. 1971.
3. GREACEN, E. L., and J. S. OH. 1972. Nat. New Biol. 235:24.
4. HSIAS, T. C. 1973. Annu. Rev. plant physiol. 24:519.
5. OLSEN, S. R. and W. D. KEMPER. 1968. Advan. Agron. 20:91.
6. RAWLINS, S. L., and P. A. C. RAATS. 1975. Prospects for High Frequency Irrigation. AAAS 188:604-610.
7. SLAYTOR, R. O. 1969. Physiological Aspects of Crop Yield. A.S.A., pp. 53-88.
8. URIU, K., and J. R. MAGNESS. 1967. Irrigation of Agricultural land. ASA Monograph 11: 686-703.
9. URIU, K., L. WERENFELS, G. POST, A. RETAN and D. FOX. 1967. Cling peach irrigation. Calif. Agr. 18:10-11.
10. VERHMEYER, F. J., and A. H. HENDRICKSON. 1938. Soil moisture as an indication of root distribution in deciduous orchards. Plant physiol. 13: 169-177.
11. WESSELING, J. 1974. Drainage for Agr. A.S.A., P. 7.

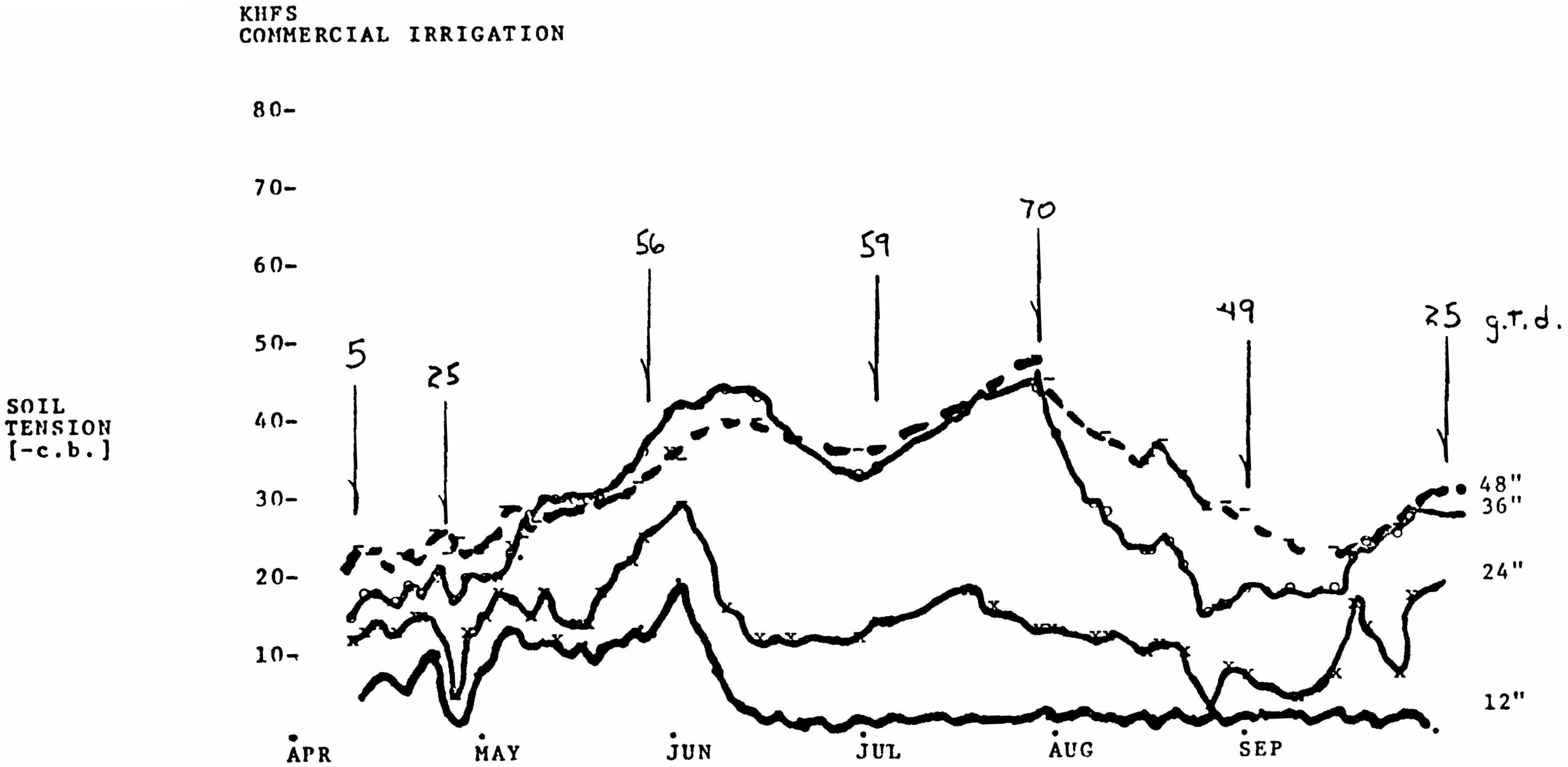

FIGURE 1. Changes in the soil water potential at different depths under high drip irrigation, 1978 season.

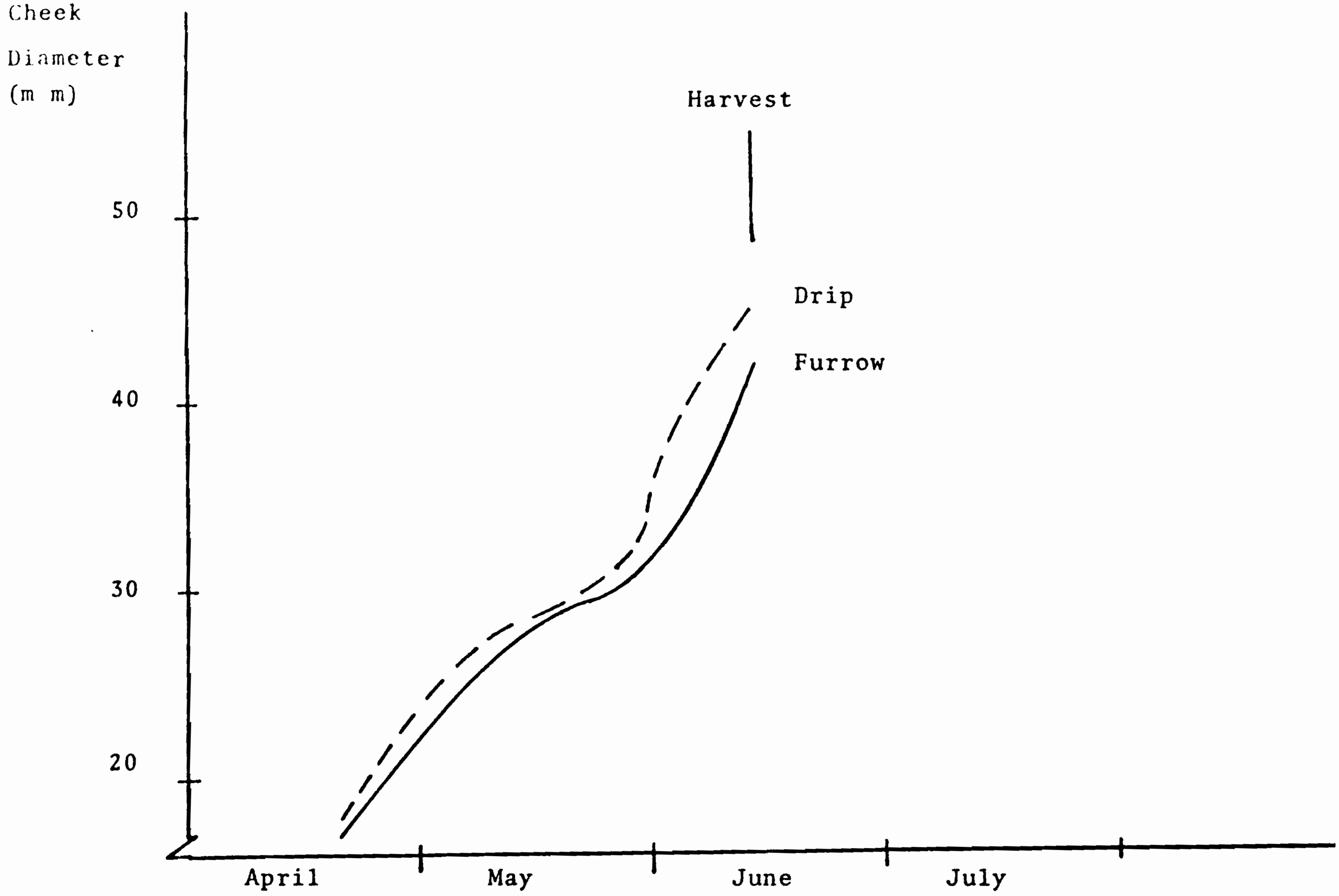

FIGURE 2. Affect of irrigation methods on Santa Rosa plum size, 1978.

WATER USE BY CROPS UNDER DRIP/TRICKLE IRRIGATION

by Albert W. Marsh

California American Society of Agronomy
San Diego February 7, 1979

SUMMARY

Crop water use is an important item in California at the present time. The recent drought coupled with social concerns has directed attention at the large quantities of water used by agriculture for irrigation. Society in general is inclined to view the large uses by agriculture as a ripe ground for curtailment of use through conservation. This would be done to stretch present supplies to meet rising demands for water in nonagricultural uses without resorting to new water developments. This has lead to considerable talk about reduced water use with drip irrigation as a viable means to achieve the desired conservation. It suggests the need to examine more closely the water use with drip irrigation.

Crop water use is usually defined as consumptive use, (C.U.) or more commonly in recent years as evapotranspiration (ET). ET includes the water combined chemically in the plant structure, a very small amount, plus that transpired from the leaves of a growing crop (T), plus evaporation (E) from the surrounding soil in which the crop is growing. These are unrecoverable losses since liquid water is transformed to a vapor and lost to the atmosphere. It does not include deep percolation or surface runoff losses from irrigating the field since they remain as liquid water that is potentially recoverable for reuse locally or elsewhere. It does not include delivery losses that are related to the method of delivery and not to the crop and may be recoverable.

ET of a crop depends primarily on climatic factors such as solar radiation, air temperature, wind and humidity. It also depends on the nature of the plant, its size, leaf resistance and health. Plant size affects ET, not only by the leaf area available for transpiration, but by the amount and density of shading of the soil affecting water evaporation from the soil.

With drip irrigation we begin to separate ET into E and T. Transpiration from a crop will be about the same with any method of irrigation if the crop is not shorted. Evaporation from the soil can be reduced to a small amount with drip irrigation, particularly when plants are small and very little of the soil surface is wetted during irrigation. When compared with equal sizes of plants that are grown in soil more or less completely wetted at each irrigation by surface or overhead methods, the E value can be closely approximated. The E value is the main potential saving with drip irrigation.

The title assigned for this talk did not say water application, but I think we should discuss the difference between water application and water use or consumptive use. Water application covers not only consumptive use, but also the other items mentioned previously that ET did not include, such as deep percolation and surface runoff. Real efforts to conserve water in California agriculture should aim at reducing ET, because this is where the great unrecoverable losses occur, and should not become entangled in expensive efforts to curtail water application where most of the excesses are recoverable.

Water application can be reduced greatly by drip compared to an inneffi- cient method of irrigation. But it is the savings in E that are important rather than the savings in water application. The latter saving can be important to a grower if water is expensive or the energy of application is high. It can be important to society if deep percolation is unrecoverable which is true in some parts of Southern California. It is a questionable saving to society if deep percolation is recoverable as in much of the Central Valley.

Our experiment with a newly planted avocado orchard in San Diego compared drip irrigation with good sprinkling. Use of water by drip was very small at the start and was only 30 per cent of the conservative application by sprinklers. It increased as the trees grew but when the trees reached nearly full size the application by drip did not exceed 76 per cent of that applied by sprinklers and was just slightly above 24 acre-inches per acre (610 mm). The water applied by sprinklers was 32.6 acre-inches per acre (828 mm). This was a year that 10.5 inches (267 mm) of rain was received at the experiment.

USE OF DRIP-TRICKLE IRRIGATION IN GREENHOUSES

Seward T. Besemer, Farm Advisor
University of California, San Diego

The use of drip-trickle irrigation is gradually increasing for the production of greenhouse and field-grown floral crops. Only two systems continue to be used for irrigating potted plants. Both are high flow delivery. A true pot dripper system has potential but is not economical.

Some gradual increase of drip-trickle irrigation is taking place in field-grown cut flowers and cut foliage. At least five systems have been used commercially for crops such as eucalyptus, daisies, gypsophila, and statice.

Only slight adoption has taken place using drip irrigation systems in high-density cut flower beds in greenhouses. One or two double-wall ooze tube systems appear to irrigate satisfactorily in beds of roses, carnations, and chrysanthemums.

ALFALFA BREEDING - IS MULTIPLE PEST RESISTANCE SUFFICIENT?

I. I. KAWAGUCHI

Alfalfa workers have contributed and achieved much in multiple pest resistance in recent years. Multiple pest resistance may be defined as a cultivar (variety) or genetic line possessing resistance to two or more diseases, insects, nematodes or any combination thereof. Multiple pest resistance is essential for high forage production of perennials.

Some of the major pests that have received wide attention in breeding programs are bacterial wilt, Phytophthora root rot, anthracnose, downy mildew, spotted alfalfa aphid, pea aphid, blue alfalfa aphid and the alfalfa weevils.

Most of the cultivars and lines have been evaluated for resistance with each pest taken singly. This is essential in varietal characterization but offers little indication of the role of pests in pest-host and pest-pest interactions. Evidence indicates that such interactions are important in stand longevity, persistence, forage and seed production and general vigor. In several instances a new alfalfa cultivar or line having several resistances can demonstrate yield superiority only in the presence of a specific pest while some alfalfas with few resistances perform well over diverse areas and conditions.

Additional information is needed on the effects of pest susceptibility or resistance on water and nutrient uptake, metabolism, photosynthesis and other physiological processes. Such studies are necessary since an increase in resistance to as many as 6 or 7 pests has not consistently given a proportionate increase in performance.

Breeding for Pest Resistance in Oilcrops

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Oilseed crops are attacked by many pests and damage varies with the pest and the crop. Two examples in California are red spidermites (*Tetranychus* species) on soybeans, and sunflower moth (*Homoeosoma electellum* Hulst.) on sunflowers. These two pests represent different types of damage, different colony maintenance problems, and require different testing procedures.

A colony of spidermites is relatively easy to maintain on plants in a greenhouse. They are easily distributed over test plots, but may fail to develop damaging populations because of predators or other reasons. Results of tests conducted in the greenhouse or in the field are usually consistent, but plant-to-plant variation makes studies on inheritance of resistance difficult.

On the other hand maintenance of sunflower moth colonies is tedious and time consuming. Distribution of eggs, larvae or adults is difficult and results of different tests are erratic. However, since the sunflower moth larvae will grow on artificial media, it is possible to compare individual plant substances which have been separated from susceptible and resistant plants. This may enable us to determine different sources of resistant germplasm with chemical tests.

At present the biggest problem in breeding for pest resistance in oilseed crops is the development of techniques for accurate, precise, and reliable tests.

TIMING AND PLACEMENT OF VEGETABLE FERTILIZERS

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Timing and placement of fertilizers for vegetable crops are fully as important as rates and sources. There is no single recommendation for placement that fits all crops, soils or environments. Two general recommendations can be given: First, place the fertilizer deep enough in the soil so that it remains in an area where the plant roots can reach it; Secondly, place the fertilizer as close as possible to the young seedlings without causing burning.

Based on many experiments conducted throughout the U.S., the National Plant Food Institute in 1958 published recommendations for placement of vegetable fertilizers. For most crops it was recommended that the fertilizer be placed 2 to 3 inches to the side and 2 to 3 inches below the seed. This recommendation remains satisfactory for relatively low rates of fertilizer and particularly for fertilizers low in N but high in P and K. These general recommendations do not fit our California conditions where we are dealing with high rates of N and where crops are grown on beds and receiving furrow irrigation. Furrow irrigation often moves the fertilizers inward toward the seed row where plant injury may occur. When sprinkler irrigation is used the fertilizer can be placed closer to the seed than when furrow irrigation is practiced. For potatoes the recommendation is to place fertilizer 2 inches below and 2 inches to each side of the seed piece.

With the high rates of fertilization commonly used in California, the practice of applying fertilizers broadcast and then incorporating them in the plant bed is a good and safe method of application. It results in the fertilizers being localized in about half of the land area. Some of the fertilizer is in close proximity to young seedlings but the total salt concentration is dilute enough that plant injury rarely occurs. It is expected that this method of fertilization will increase as growers build up the P levels in the soil so that there is less need for heavy P fertilization near the seed.

Timing of fertilizer application is very important. Delayed application can actually eliminate the benefits of fertilizers. Seedlings show great response to P fertilization. Consequently for California vegetables it is suggested that all of the P and K and one-third to one-half of the N be applied at planting or transplanting and placed about 4 inches to the side and 4 inches deep. This is usually safe but if N rates are high the placement should be even farther away from the seedlings. The remaining N can be sidedressed or applied in the irrigation water.

Tomatoes, lettuce and onions and some other vegetables have shown phenomenal response from a small amount of P placed about 2 inches deep directly below the seed. This results in earlier and more uniform plant maturity. The fertilizer is often a neutral liquid mix such as 8-24-0 or 10-30-0 in which the N is low enough that it does not cause burning. Over 100,000 acres of canning tomatoes in California receive fertilizer this way. The original application supplies the P needs of the crop and additional N is supplied as a sidedressing after the plants are established.

With tomatoes and lettuce, P fertilizers placed 4 inches below the seed were not nearly as beneficial as placement only 2 inches below the seed. Also placement of P 2 inches to the side was not as good as placement directly under the seed. Localized placement when to far from seed or roots can result in retarded growth until the roots reach the supply of plant food.

The source of N very definitely influences where fertilizers can be applied. Aqua and anhydrous ammonia cannot be placed as close to the plant as ammonium sulfate, and they should be applied several inches deeper and several inches farther from the plant than ammonium sulfate.

Numerous tests have shown that foliar application of the major nutrients is not efficient. Concentration of most salts in the spray cannot exceed 10 to 20 pounds of salt per 100 gallons of water without causing burning of the foliage. This results in a very small amount of N, P or K being applied and an even less quantity being absorbed and utilized by the leaves. Unless many repeated applications of fertilizers can be made there is little possibility of foliar feeding of the major nutrients. Some of the trace elements such as manganese, iron, zinc and molybdenum can be applied very effectively as foliar sprays.

OPTIMUM RATES OF N FOR VEGETABLE CROPS

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Determination of optimum rates of N for Vegetable Crops is becoming more important as environmental concerns are raised and present fertilizer practices are challenged. Energy conservation and escalating prices for N fertilizer also play a role. Growers of vegetables have long used generous rates of N for very good reasons. First, these crops are extremely expensive to produce and fertilizer costs in the past represent a relatively minor production expense. In addition, the nature of rapidly growing vegetables is such that any slowing or temporary cessation of growth and development often results in irreparable damage and loss. For this reason, extra N is commonly applied as insurance against N deficiency in many vegetable fields.

To more accurately determine proper rates of N for vegetable crops there are a couple of tools or techniques that will assist. One of the first things is to sample and analyze the soil. In the past there has been much skepticism as to the value of soil samples for N. Recent studies, in which nitrate-N is used as an index of N availability, have been encouraging. With our present limited information, we are experimenting with soil NO_3-N deficiency ranges for several vegetable crops which might indicate whether or not N application is needed for a given crop. Perhaps later, the information may be refined to the point where rates of N can be indicated based on soil NO_3-N levels, the crop to be grown, and the managment conditions.

Plant tissue analysis is another technique that can and should be used, in combination with soil analysis. To be of practical value to a currently growing crop, analysis and interpretation of analytical results must be very rapid to permit timely application of fertilizer N, when indicated, in order to avoid N deficiency. Tissue analysis alone for the current crop is generally useless during the period of stand establishment and early growth since there may be insufficient plant tissue for sampling. Perhaps the best use of tissue analysis is in monitoring a crop's nutrient status to insure sufficient N through the "grand stage of growth" and for gaining fertilizer management information for future crops.

Recognizing that fertilizer use must be adjusted according to each crop and each set of management practices, plant tissue and soil analyses should logically be used by growers as management tools for establishing, ammending and/or verifying optimum rates of N for their crops.

Getting Potassium into Prunes

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Potassium deficiency is a serious problem in the prune growing areas of Central California and the Sacramento Valley. K deficiency results in pale, chlorotic leaves, scorch of leaves in midsummer, shoot dieback, sunburn fruits, low fruit soluble solids and reduced fruit size. The usual method of correction is soil application of massive doses of K fertilizer (e.g., 20 lbs. K_2SO_4 per tree) concentrated in bands. The K fertilizer is drilled along the tree row in several bands down to a depth of 6 to 8 inches. In non-tilled orchards the K is applied on the soil surface in bands. However, these soil treatments do not always result in correction. The K is usually "fixed" by the soil at the point of application and the K does not move down to the root zone where it can be picked up by the tree.

A second method to get K into the tree is to spray KNO_3 to the foliage at a concentration of 8 lbs. KNO_3 per 100 gals. water in early to midsummer. However, repeat applications are necessary, sometimes up to 3-5 applications depending on the severity of the deficiency.

A third method which was found to be effective and efficient in getting K into the tree is the application of K by drip irrigation. K_2SO_4 was dissolved in a tank and continually injected into a drip irrigation system to give a K concentration of 200 ppm in the drip irrigation water. This concentration was applied all summer beginning about May. The uptake of K by the trees was monitored by frequent leaf samplings for K determinations. These trees were compared with a) trees drip irrigated but receiving no K and b) trees that had been banded with 20 lbs. K_2SO_4 per tree and sprinkle irrigated (grower type treatment).

An increase in K concentration in the leaves was detected within a month after the drip-K treatment was begun whereas it was 4 months before uptake was detected in the "grower" treatment. When uptake in the leaves was detected in the drip-K treatment, only 2 lbs. of K_2SO_4 per tree had been applied up to that time.

Another experiment was conducted in which dry K_2SO_4 was placed on the soil directly underneath the emitter and compared with dissolved K_2SO_4 injected into the drip irrigation water. The rapidity and effectiveness of uptake was the same in both treatments.

Soil analyses showed that when K was applied in the drip irrigation water or placed underneath the emitter, the K had moved down into the soil about 30 inches. This is deep enough to be within the main root zone for ready uptake of K by the prune tree.

THE USE OF SOIL AND PLANT ANALYSIS

IN

PRECISION FERTILIZATION

BY

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AGRONOMIST

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The science of providing plant nutrients to growing crops has been improving over the years, however growers are still following rot practices on many crops. High cash value crops have been traditionally over-fertilized as on insurance against any possible deficiency which might affect harvestable produce on good markets.

Because of variability in soils, farm practices rotations, and environmental conditions, standard area wide practices do not guarantee satisfactory results.

Research work done on timing of fertilizer applications in accordance with information derived from soil and plant analysis has proven to yield equally as good crops and of sometimes better quality.

This presentation will deal with summaries of several crops indicating how soil and plant analysis can provide a guide for better fertilization practices that will be also more consistent with environmental concern for energy conservation and minimal pollution.

Crops discussed will be lettuce, sugar beets and cotton.

SOIL AND PLANT ANALYSES AS GUIDES TO NITROGEN FERTILIZATION OF SUGARBEETS

R. L. Sailsbery and F. J. Hills[1]

The precise use of fertilizer N for sugarbeets requires just enough N to achieve maximum sugar yield, and no more. When this is achieved the farmer maximizes net income, the processor obtains quality beets for processing, fertilizer is not wasted, excess N is not left in the soil as a potential groundwater pollutant, and the production of needed food calories is maximized.

Estimating the N Requirement

Soil nitrate per acre 3 feet, determined at the start of the growing season, accounted for more than 60 percent of the variability in root yield of nonfertilized crops in 21 trials conducted throughout California from 1971-1975. This relationship is shown in Figure 1. Considering the many factors which affect crop production, this correlation is evidence for the fact that the variation in NO_3-N between fields is an important factor affecting production.

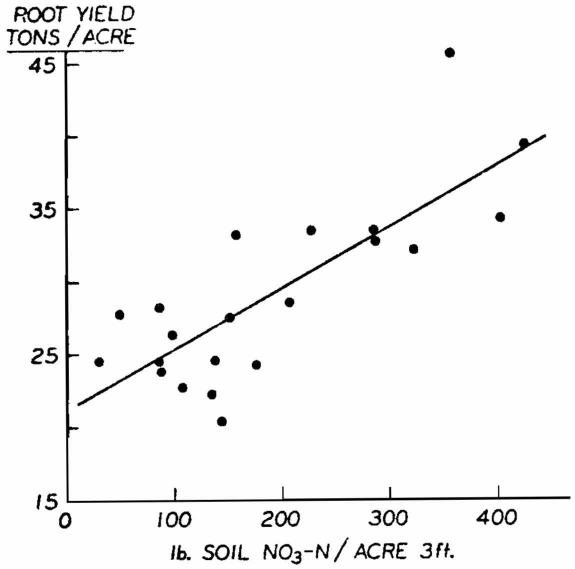

Figure 1. Relation of sugarbeet root yield to soil nitrate-nitrogen determined early in the growing season for 21 locations, $Y = 21.1 + 0.042X$.

From these same fertilizer trials it can be shown that a sugarbeet crop requires, on the average, about 16 pounds of fertilizer N per ton of increased root yield resulting from fertilization.

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[1] Farm Advisor, Glenn County and Extension Agronomist, University of California, Davis, respectively.

The regression of Figure 1 can be used to estimate root yield if no fertilizer is used. For example, with 100 pounds NO_3-N/acre 3 feet, root yield without fertilizer N can be estimated as 21.1 + 0.042(100) ≈ 25 tons/ acre. Anticipating a 30-ton root yield, fertilizer N for the 5 ton increase is 5(16) or 80 lb N/acre.

If soil NO_3-N is 225 pounds per acre or more, the best procedure is not to apply N at all unless petiole analyses indicate a deficency will occur more than 10 weeks before harvest. As Figure 2 indicates, there was a response to fertilizer N in only 1 out of 7 trials where soil NO_3-N exceeded 225 pounds per acre 3 feet.

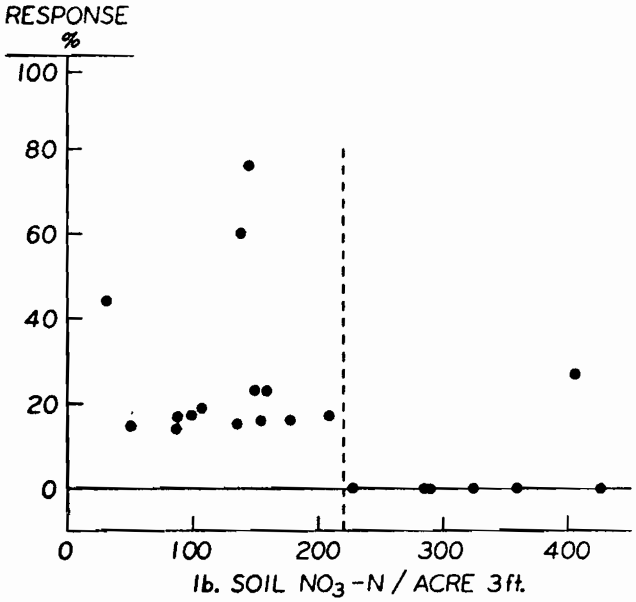

Figure 2. Soil NO_3-N related to crop response at 21 locations. % response = $100[(YN_m-YN_o)/YN_o]$, where YN_m = root yield with fertilizer N giving maximum sugar yield and YN_o = root yield without fertilizer N.

One additional caution, if the previous crop involved turning under a large amount of high nitrogen crop residue, for example following field beans or alfalfa, there may be an unusual amount of nitrogen in this organic matter which, with irrigation and warm temperatures, will soon be released. For this situation it may be wise to be conservative with initial N application and rely more heavily on plant analysis to determine if additional fertilizer N is needed.

Soil samples should be taken as close to the start of the active growing season as possible. A good time to sample is just after emergence with the major fertilizer N application to be made by thinning time. If seedlings will need fertilizer N prior to thinning, their needs can be met by 10 to 20 pounds of N per acre in a starter fertilizer.

Assessing the Adequacy of the Initial Estimate

To decide whether additional fertilizer N is needed, start taking petiole samples early in the grand growth period of the crop. The samples should be promptly analyzed and plotted in a graph similar to Figure 3. If the rate of decline of petiole nitrate indicates that the plants will be below 1000 ppm NO_3-N for more than 10 weeks prior to harvest, then 40 to 60 pounds of N per acre should be applied at about mid season to prevent the impending deficiency. For overwintered sugarbeets, November 1 can be considered the effective date of harvest in determining the length of the deficiency period prior to harvest.

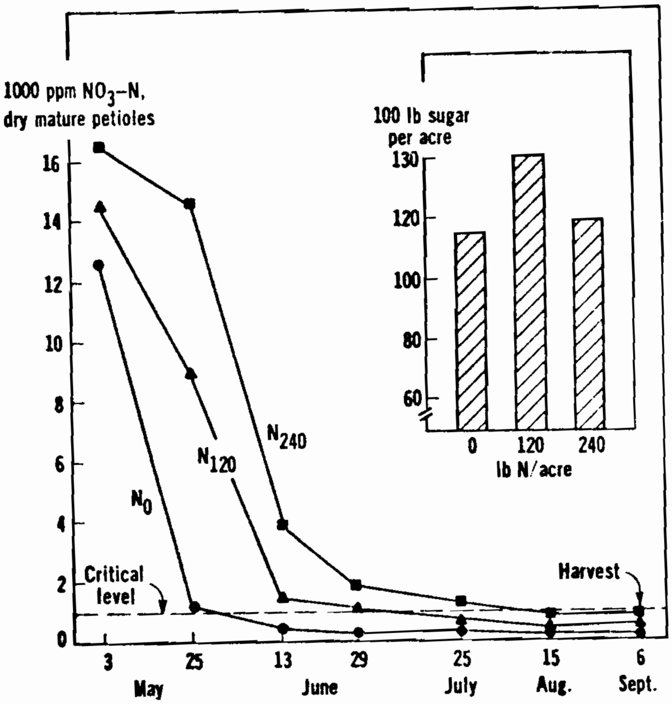

Figure 3. Nitrogen deficiency prior to harvest is essential for maximum sugar production. For this field maximum production resulted when petioles of plants fertilized with 120 lb N/acre were less than 1000 ppm for about 9 weeks prior to harvest.

Implementation--Putting the Program to Work

A system to allow farmers to use scientific aids such as those we have proposed must include: 1) the collection of the proper samples; 2) laboratories to quickly and accurately perform the correct analyses; and 3) proper interpretation of the results to allow farmers to make a sound management decisions. The development of such a system has been under test the past two years in Butte, Glenn and Tehama counties where the farm advisor has provided opportunity for growers to participate in a cooperative program using soil and plant analysis to determine and/or monitor nitrogen fertilization. The participating grower selects and obtains the cooperation of an agricultural fieldman to collect the proper samples and submit them for analysis to a laboratory selected by the grower and the fieldman. The fieldmen are trained by the farm advisor to take the necessary soil and plant samples. The samples are delivered to the local laboratory where they are analyzed by approved methods at the grower's expense. The laboratory reports the results to the grower and farm advisor. The farm advisor, in cooperation with the fieldman, interprets the samples and suggests the indicated action to the grower. Through this "on the job training" the agricultural fieldman becomes a vital link and enables him to better serve his client. His frequent presence in the grower's field permits him not only to monitor the field for nitrogen nutrition, but exposes him to the evaluation of many other potential pest and cultural problems while carrying out his sampling assignments. The laboratory provides an important service to agriculture in providing accurate analyses that can be interpreted with confidence.

During the past two years, some 25 growers, 9 different fieldmen and 4 different laboratories have been involved in fertilizer recommendations for more than 60 different fields. It is hoped, that with the kind of assistance outlined above, fieldmen and laboratories will soon be able to conduct such programs on their own and thus increase and improve the precise fertilization of sugarbeets.

Citrus and Avocado Varieties and Rootstocks--Climate

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The correct choice of variety for any specific area plays an important role in the successful commercial production of citrus and avocados in California with its many variables of climate. Some varieties have a wide adaptability while others are limited in the areas where maximum production and high fruit quality can be attained.

In citrus, the variety situation is well established for commercial production. Two orange varieties, the Washington navel, with a winter and spring harvest, and the Valencia, with a summer and fall harvest, are the principal varieties grown. Valencia oranges have a wide range of climatic adaptability while navel oranges are more restricted in their requirements for high fruit quality and production. Two lemon varieties, the Eureka and Lisbon, are confined to the warmer locations of the state. In addition to limiting the area of production, climate markedly affects the season of lemon maturity. Two varieties of grapefruit, the Marsh, and a pigmented selection, the Redblush, comprise the majority of production in California. Again, the climate of the location dictates where grapefruit can be successfully produced as well as its season of maturity.

Numerous varieties of the so-called "exotic" citrus, the mandarins, tangelos and tangors, make up a relatively small portion of the California industry. They vary considerably in their adaptability to different climates but one or more varieties can be and are grown in most all the citrus-producing areas. Lime production in California is very small and because of its frost sensitivity is limited to areas of minimal frost hazard, primarily in coastal areas. The Bearss is the principal variety.

In contrast to the long time stability of citrus varieties, the avocado variety situation has been one of change. With hundreds of varieties to choose from, all varying in production and fruit quality, the problem has been to select a few which together provide adequate production of high quality fruit year round. There is a continuing search for new varieties which will surpass or supplement those now in use. Avocado production is more severely restricted by climate than is citrus and frost hazard, as well as extreme summer heat, limits the areas where they can be successfully grown. Climate also influences the season of maturity of any variety.

Currently, the recommended varieties for commercial planting are: Hass, the predominant variety but frost sensitive with a spring to fall maturity; Fuerte, once the predominant variety, tolerant to a few degrees of frost but an inconsistent producer with a winter and spring maturity; Bacon and Zutano, more cold tolerant varieties with a fall maturity but of somewhat lower fruit quality than Hass or Fuerte; and Reed, a newer variety, frost sensitive but very productive with a summer maturity.

The selection of rootstocks in citrus and avocados is generally less dependent on climate than is the choice of scion variety. In citrus, however, the influence of the rootstock on scion frost tolerance is important in cold areas. Some rootstock selections make the scion more susceptible while others impart added cold tolerance. Of equal or often greater importance in the selection of citrus rootstocks have been their characteristics of disease tolerance; effect on production, fruit quality and size; tolerance to salinity and poor soil drainage; compatibility; tree size; and longevity. With their various characteristics, rootstocks for citrus may be selected for specific situations and needs but often compromises must be made.

In avocados, less is known about rootstock characteristics and performance due, in part, to the heterogeneity of avocado seedlings. Observations and experience have led to the general use of several Mexican race varieties. Of primary importance in avocado rootstock research has been the effort to select and develop rootstocks tolerant to the avocado root rot disease. Other areas needing investigation are stocks to provide salinity tolerance and tree size control.

Both citrus and avocados are ideal for home and family orchard planting in many areas of California. Not only are they beautiful evergreen trees but they can provide substantially to the family food supply. In addition to the several varieties mentioned, there are others, not grown in commercial quantities, that are excellent for home orchard or landscape use. Both these subtropical fruits can improve the quality of life.

AVOCADO & CITRUS CULTURAL PRACTICES

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INTRODUCTION

Avocados

San Diego is the leading county in California in acreage and production of avocados. Total state acreage is between 45-50,000 acres. The 1977 San Diego County acreage of avocados was 22,000 acres. Of that, 5,000 were non-bearing acres. Commercial avocado production is concentrated in an area bounded by the Riverside County line on the north; Bonsall and Vista on the west; Rincon Springs and Pauma Valley on the east; and Poway on the south.

Citrus

The present acreage of citrus in San Diego County is approximately 15,000 acres. Of that, about 1,300 acres are non-bearing. The over-planting and over-production of citrus of all varieties throughout the world has slowed down plantings considerably in the County.

Citrus is grown mostly in the North County, which includes the districts of Pauma Valley, Rincon Springs, Fallbrook, Pala, Valley Center, Escondido, Vista and Rancho Santa Fe. These areas are characterized by relatively mild climate.

VARIETIES

Avocados

Five main varieties are grown in San Diego: Fuerte, Hass, Reed, Zutano, and Bacon. The Fuertes are marketed from November to April. The Hass can be marketed as early as February, but the usual harvesting period if from April to August. The Bacon and Zutano, which are planted primarily in cold areas, are harvested from October to January. The Reed is marketed from July to September. New varieties being tested are Jim, Santana and Pinkerton.

Citrus

The citrus varieties grown in San Diego, with their respective acreages, are:

Valencia Oranges	8,260 acres
Lemons	3,110 "
Grapefruit (summer)	1,385 "
Navel Oranges	1,145 "
Tangerines & Tangelos	950 "
Limes	350 "

The main varieties grown in the County are Eureka Lemon, Marsh White or Pink Grapefruit, Bearss Lime, Washington Navel Orange, Valencia Orange, Minneola Tangelo, and a number of Tangerine-Mandarin varieties such as Clementine (Algerian), Satsuma, Kara, etc. Rootstocks used are usually citrus macrophylla with lemons and limes; troyer citrange with oranges, grapefruit, tangerines, tangelos and limes; and citrus trifoliate on orange, grapefruit, mandarin and tangelo.

Harvest season for the varieties can be listed as follows:

Valencia Oranges	April to November
Navel Oranges	December to April
Grapefruit	June to October
Tangerines & Tangelos	January to April
Limes	October to January
Lemons	Year-round harvesting, bulk of crop coming November to May

CULTURAL PRACTICES

Irrigation

Imported Colorado River water is used on most avocado and citrus orchards. Water quality is fairly good. The only exception is the relatively high level of chlorides. The avocado tree is sensitive to this specific ion. Less leaf damage would result if the chloride content were lower. With proper irrigation, however, the tipburn of the leaves can be kept to a minimum. Quantity of water should be sufficient for the future with the addition of water from the California Aqueduct, even with the present restrictions placed upon growers by water agencies. Water costs range from $100 to $300 per acre foot, the highest priced water in the State, if not in all the U.S.A.

Irrigation in San Diego is a must—a way of life. Any rainfall is a bonus. Irrigation methods used vary, depending upon the water supply, type of tree, age of tree and growers' preference. These methods include basins, spitters, sprinklers and drip/trickle.

Normal irrigation intervals for avocados are about once a week. Citrus, usually planted on soils holding more moisture, frequently can be irrigated at two to three week intervals. Where alternate irrigation is used, two to four week intervals may be possible before irrigating the same soil again.

Trees require about 3 acre feet (about 980,000 gallons per acre) per year, including rain. Extra water is applied periodically (in avocados, every six weeks during summer and fall) to leach salts to lower levels and prevent buildup in root zone.

Dry soils tend to result in tipburn, sunburn, and dieback the following season, especially when mite, scale, heat, and wind damage occur too. Dryness also reduces fruit growth, and increases fruit drop. Avocados can be permanently damaged by sunburn when the soil is too dry.

Salinity

The salinity problem is created by the use of irrigation water containing large amounts of dissolved salts. When these salts are deposited in the soil by irrigation and are not leached by winter rainfall, the accumulation in the root zone may become harmful to avocados.

Much of the common "tipburn" that occurs is due to an accumulation of chloride salt in the leaves. Sulfates, sodium, or boron can also be injurious, depending on the amounts and proportions present.

The general effect of high salt accumulations is to make more difficult the normal functioning of trees. Some accumulations prove quite toxic and cause serious leaf burn, premature defoliation and even shoot dieback.

In some cases various leaf patterns appear, indicating that there has been a disturbance of nutrition in the plants.

Sufficient rainfall on a saline soil helps remove salt accumulations below the root zone. Where drainage is good, liberal use of irrigation water will prevent the excessive accumulation of salts in the root zone. Attempts to leach salts should not be made on soils with impaired drainage.

FERTILIZATION

On young trees, adequate nitrogen is provided for vigorous growth, but not enough to burn the roots. Following are approximate rates per tree:

Avocados

1st year	1 tablespoon of commercial fertilizer, each 3rd irrigation.
2nd year	1/8 lb. nitrogen each year.
3-4 years	1/4 lb. nitrogen each year.
5-7 years	1/2 lb. nitrogen each year.
8-9 years	3/4 lb. nitrogen each year.
10-14 years	1 lb. nitrogen each year.
15+ years	1-1/2 lb. nitrogen each year.

Citrus

1st year	1 tablespoon of commercial fertilizer, 3 or 4 times.
2nd year	1/4 lb. nitrogen each year.
3rd year	1/2 lb. nitrogen each year.
4th year	3/4 lb. nitrogen each year.
5th year	1 lb. nitrogen each year.
6th year	Amount indicated by leaf analysis.

For producing trees, major nutrients should be maintained at the following levels in the leaves:

Avocados	Maintain 1.6 - 2.0% nitrogen in August-October leaf samples. Leaf nitrogen for Hass should be 2.0% plus and will probably need more fertilizer than Fuertes to obtain this level.
Lemons	2.25 - 2.5% nitrogen in leaves from mature spring flush samples in August-October period.

Oranges	2.4 - 2.6% nitrogen in an August-October leaf sample. Increase or decrease nitrogen as indicated. Apply January or February.

Apply fertilizer in the early spring (February) so nitrogen will be in the trees before bloom and fruit set on mature avocado and citrus trees. Another application is made in July. For better orange fruit quality, apply more nitrogen in February than in July. Young citrus from the second through the fourth year should have the fertilizer divided into three or four applications during the season. Phosphorus and potassium should be applied when a deficiency is indicated by leaf analysis.

MINOR ELEMENTS

Avocados

Zinc may be sprayed on trees anytime, but spring is best when spring-cycle leaves are expanded. Soil application of zinc can be made anytime during the year. This treatment should last about five years. Place zinc sulfate in two foot bands around the trees at the drip line.

The following amounts of zinc sulfate containing 36% metallic zinc may be used for soil application:

Age tree - years	Pounds per tree
2	1/2
5	2
10	4
15	5
20	7

Citrus

Zinc, manganese, copper, and iron may become deficient. Spray zinc when the new growth is near full expansion for best results. More than one spray annually may be needed, especially if treatment is combined with pest control spray. One formula that can be used by itself for correction of a deficiency is 1 lb. of 36% zinc sulfate per 100 gallons of water.

PEST CONTROL

Pest control is usually not as much a problem in San Diego County as in other areas. The mild climate favors biological control by par-sites and preadtors. NO PEST CONTROL SPRAYS ARE RECOMMENDED FOR AVOCADOS. Avocado brown mite is serious in some years, but biological control does occur, and damage has been less where no treatment is given. Loopers occasionally cause leaf and fruit damage, and biological control is the best pest control.

Biological control of several citrus pests is effective. Total control can better be called "integrated pest management." Complete dependence on biological control does not usually maintain an adequate level of control, because fruit and tree damage will be excessive, and some pests have no adequate predators. On the other hand, complete chemical control will result in elimination of beneficial insects. Also, if there are no host insects at all, beneficial insects may disappear.

The solution, then, for effective integrated pest management, is to use pesticides only when necessary and those that result in minimum damage to beneficial insects. Stay on top of the pest situation so fruit damage will not result in excessive gradeout.

Ant Control

Elimination of ants is the most effective way to encourage biological control of harmful insects.

Major Pests

	Pest	Major Damage
Avocados	Snails	Foliage, blossom, fruit damage
	Brown mite	Leaf, fruit damage
	Looper	Leaf, fruit damage
	Rats	Fruit loss
	Thrips	Leaf, fruit damage
Citrus	Bud mite	Crop reduction, grade loss
	Rust or silver mite	Grade loss
	Red spider	Weakens tree, leaf drop, dieback
	Scale	Weakens tree, leaf drop, dieback
	Thrips	Fruit scarring, retards growth
	Aphids	Retards growth
	Orange worm	Fruit drop, grade loss
	Snails	Fruit damage, foliage loss

DISEASES

Avocados	Root Rot (fungus)	Sunblotch (virus
	Cankers (fungus)	Verticillium wilt (fungus)
Citrus	Fruit rot	Stylar end rot
	Rind rot	Brown rot, foot rot, dry rot
	Scaly bark	Virus diseases

WEED CONTROL

Weed control is done by mowing, chemical contact killers, and pre-emergence herbicides.

ORCHARD OPERATIONS CALENDAR

	January	February	March	April	May	June	July	August	September	October	November	December
Irrigation	▨	▨	▨	▨	░	░	░	░	░	░	▨	▨
Fertilization		░					░					
Minor Elements			░	░					▨	▨		
Pest Control				▨	▨			░	░	░		
Replanting	Fumigate soil		░	░	░							
Ant Control				░	░	░	▨	▨	▨	▨		
Disease Control		Check for gummosis									Paint trunks spray skirts	
Rodents	Check Monthly		░	░	░					░	░	
Weed Control:												
oil spray			░	░	░	░	░	░	░	░		
Simazine			░								░	
mow		░	░	░	░	░	░	░	░	░		
Frost Protection	░	░							Check Equipment	Test thermometers	░	░
Topworking			░	░	░							
Orchard Thinning	AVOCADOS - AFTER HARVEST											
Pruning	░	░	░									
Harvest	Fuertes Navels	Fuertes Navels	Fuertes Navels	Fuertes Valencias	Hass Valencias	Hass Valencias	Hass Valencias	Hass-Reed Valencias	Lemons	Zutanos Lemons	Bacon-Zut. Fuertes Lemons	Bacon-Zut. Fuertes
Equipment Repair	AS NEEDED			▨ Frost Equipment					Check frost Equipment			
Material Orders	▨ New Trees	▨ Pest Control		▨ Frost Equipment			▨ Pest Control			▨ Fertilizer		▨ Sprinklers, Pipe
Record Keeping	Plans									░ Yield		░ Summaries Inventory

░ Recommended Time

▨ May be necessary

Some Diseases of Avocado and Citrus in California

Howard D. Ohr

AVOCADO DISEASES

A native of Mexico, Central and South America, the avocado, Persea sp. has been used as food for centuries. Selections from those native trees are the basis of the avocado industry.

Avocado trees were introduced into California during the last half of the 19th century, but it was not until after 1930 that development began in earnest. Today there are an estimated fifty thousand acres of avocados in the state.

Several diseases affect avocados in California with varying degrees of severity. Most of the diseases are caused by fungi, one is suspected to be caused by a virus and one is of unknown cause.

Avocado Root Rot

The most serious disease of avocado in California is root rot caused by the fungus Phytophthora cinnamomi. This fungus has a large host range and was first reported on avocados in California in 1942. Undoubtedly, it was present for some time before detection. At present it is estimated that root rot infests over 5000 acres of avocados in the state.

In California root rot occurs mainly on heavy soils and on shallow soils with underlying layers such as rock or clay that prevent water passage. In both instances water drainage is poor and moisture conditions favorable to the fungus may develop. On well drained soils the fungus may be present but rarely causes damage.

Symptoms of root rot are best described by G. A. Zentmyer (1) as follows:

> A gradual deterioration sets in on the above-ground parts of the tree affected with root rot. The general appearance indicates root destruction. Early symptoms include a lighter green color than is normal for leaves, a tendency for leaves to wilt in the presence of an amply moist soil, and a lack of new growth. As the disease progresses, branches die back, many leaves are shed, newly formed leaves are generally small and yellowish green, and fruit does not reach normal size. Frequently an abnormally heavy set of fruit happens soon after symptoms of the disease first appear-evidently a reflection of the fact that much of the root system is rotted and food material has accumulated in the top.
>
> The gradual decline in vigor and productivity of the tree usually goes on for several years, although occasionally the deterioration is more rapid. Many of the small feeder roots on affected trees are blackened, brittle and dead; healthy roots are difficult to find.

Control of avocado root rot is difficult. Because the disease is favored by excess water and diseased trees take up less water than healthy trees, water management is important. Soil moisture should be monitored and the diseased trees watered only when necessary.

In recent years several rootstocks have been found that offer resistance to the disease. Rooted cuttings of rootstock are in commercial use while other selections are still under evaluation.

Testing of chemicals for root rot control has a long history with very few success stories. Until recently few chemicals had been found that were effective enough in controlling root rot to warrant their wide spread use. In recent developments several chemicals have been tested that show promise of providing some control. One of these chemicals has recently been approved for use in controlling root rot and is now being used in a number of groves. In the future the most feasible control may well be a combination of rootstock resistance, cultural and chemical controls.

Verticillium Wilt

Another fungal disease of avocado is *Verticillium* wilt, which has been known to occur on avocados in the state since 1948. When *Verticillium* wilt occurs, leaves on all or part of the tree suddenly wilt and rapidly die. After death the leaves turn brown and remain attached to the tree. Brown streaks typical of the disease may be seen in the wood of the branches or roots after the bark is removed. Occasionally trees die from the disease, but if only a few branches are affected, the tree may recover with vigorous growth and never be affected again.

The disease can often be avoided by planting in land that has not been planted to other hosts of the fungus, and by avoiding intercrops of these hosts.

Other Fungal Diseases

Other fungal diseases affecting avocado in California are *Armillaria* root rot caused by *Armillaria mellea*, trunk cankers caused by *Phytophthora citricola,* and a fruit rot caused by *Dothiorella gregaria*. These along with the *Verticillium* wilt discussed previously are of relatively minor importance in the state.

Sun Blotch

Avocados are affected by one virus like disease. Described in California in 1928, Sun Blotch is characterized by yellow streaking on green stems and branches and yellow or red streaks on the fruit. Affected trees may have a recumbent, stunted growth pattern and checked bark on mature branches and trunks. Sun blotch is transmitted by budwood and grafting. Seed transmission occurs with low frequency and some varieties may be symptomless carriers of the disease. Control of sun blotch can be accomplished by careful selection of disease-free seed sources and scion wood. All seedlings showing symptoms should be removed from the nursery and destroyed.

Black Streak

The last disease of avocados to be discussed is of unknown cause. Black streak was probably noted as long as forty years ago, but has only recently become a major problem in the state. Affecting trees of the Guatamalan varieties such as Hass and Reed, the disease is found from San Luis Obispo to San Diego counties.

Black streak causes leaves to be more yellow than normal, with trees becoming stunted in growth. The disease is progressive and the tree defoliates and dies. The diagnostic symptom is the presence of lesions on the trunk or branches. Usually beginning on the lower part of the tree or on the underside of a lower branch lesions may progress to many parts of the tree. Although there are many of these lesions on the tree, most are shallow and do not penetrate to the active phloem. In dry weather the lesion is covered with a white powder that consists of the sugary remains of sap that oozes from the tree.

Black streak is increasing and could become a serious problem in the industry and an active research program is underway to determine its cause.

CITRUS DISEASES

Citrus diseases are numerous in California. To attempt to discuss all the diseases present would require many pages and much time. This summary will cover the following selected diseases. The *Phytophthora* complex, stubborn, tristeza and blast.

Phytophthora Diseases - Root Rot

Diseases of citrus caused by *Phytophthora* sp have been known in the state since 1865 and many of the citrus groves in California are infected with one or more of four species of the fungus *Phytophthora* that cause root rot, trunk gummosis or brown rot of the fruit. The four species involved are *P. citrophthora*, *P. parisitica*, *P. syringae*, and *P. hibernalis*.

A tree infected with root rot generally suffers a decline and debilitation along with a reduced size of fruit and crop. Often a general twigginess is present due to the inability of the roots to transport sufficient water. Trees in low wet areas or in heavy soils are more severly affected than trees in well drained soils.

The use of resistant rootstocks such as Troyer citrange or trifoliate orange, along with improved drainage helps to reduce the effects of the disease.

Phytophthora Diseases - Gummosis

Gummosis can occur on the trunk of a susceptible scion even if resistant rootstocks are used. Initiated by spores splashed on the bark gummosis is characterized by dead, firm areas of bark, exudation of gum in large or small amounts depending on variety and weather, infiltration with gum and a brown staining of a thin layer of wood, a yellow gumming zone at the cambium beyond the invaded area and a longitudenal cracking of the bark. Severe gummosis can girdle and kill a tree.

Phytophthora Diseases - Brown Rot

The third phase of the *Phytophthora* complex is known as brown rot. This rot occurs during prolonged wet weather when spores are splashed on to the lower fruit where they incite a firm, leathery decay. Loss to brown rot can become severe when prolonged wet weather prevents spray applications in the groves.

Stubborn

Stubborn is a major disease of navel oranges and grapefruit in warmer areas of the state. Trees infected with stubborn tend to look more compact and bunchy than normal trees due to multiple buds and shorter intermodes. Trees affected by stubborn bear less and less fruit. Fruit that is present often is more irregular in size and paler in color. Fruit from infected trees is often lopsided or acorn shaped with a thinner skin toward the blossom end. Excessive abortion often occurs in seeds from those varieties having seeds.

Stubborn is caused by *Spiroplasma* citri which is also present in a large variety of weeds and ornamentals from which it can be transmitted by insects to citrus.

Control methods for stubborn have not been developed.

Tristeza

Tristeza is an insect transmitted disease caused by a flexuous rod virus. Of worldwide importance, the disease has killed over 3 million trees in southern California. Affecting sweet orange trees budded to sour orange rootstocks, the disease is characterized by a general deterioration in the top resulting in a gradual curling and wilting of leaves and dying back of twigs.

Below ground the roots are starved and gradually die from the smaller roots inward. During periods of low humidity, the tree may suddenly collapse and die. Trees that do not die may continue to live for several years producing poor crops. The effects of tristeza may be avoided by the use of rootstock-scion combinations unaffected by the disease.

Citrus Blast

Citrus blast is of relatively minor importance in California, occurring mainly in Butte County. It is of interest because it is a bacterial disease caused by *Pseudomonas syringae*. The disease occurs during the wet cool weather of late winter and early spring when the bacterium enters wounds in leaves, petioles, stems or fruit. From there it can invade and girdle twigs and can disfigure fruit causing considerable damage. Conditions for blast do not occur every year, but during long wet periods every three to five years. Some control of citrus blast is achieved by the use of Bordeaux or copper sprays.

1. Zentmyer, G. A. 1953. Diseases of the avocado. 1953 Yearbook of Agriculture. U.S.G.P.O. Washington, D. C.

SALINITY MANAGEMENT RELATED ACTIVITIES AT

U. S. SALINITY LABORATORY

Jan van Schilfgaarde

The U.S. Salinity Laboratory of the U.S. Department of Agriculture is the only research unit in the USA solely dedicated to research on salinity as related to agriculture. This single-purpose mission, however, involves a multidisciplinary program ranging from biochemistry to engineering.

In philosophical terms, there are three approaches: One may work to select the plant best suited to the environment; the determination of typical salt tolerance values of various crop species leads in that direction. One may adapt the environment to the plant; leaching regimes and irrigation management practices are tools in that regard. Or one may match the plant to the environment; this calls for genetic manipulation based on biochemical understanding, or selection of tolerant varieties in a breeding program. All of these approaches, which of course overlap and integrate even if one describes them as separate pathways, require research to develop an understanding of what is happening, research to develop techniques of measurement and characterization, and packaging of the findings into management systems.

In this sense, the total program at USSL is management related. Today, however, I shall just describe three examples of rather applied research to illustrate the increasingly important interface between our research endeavors and the institutional and socio-economic environment in which irrigation agriculture operates. By this choice, I obviously must ignore a number of existing projects that may well be more important than the ones selected for discussion.

Near Lost Hills, in Kern County, we have completed the first season of an elaborate 4-year field experiment. The objective is to evaluate the potential of using drainage water of rather high salt content for irrigation of cotton. The experiment uses Aquaduct water, well water of 6000 mg/l and a 50-50 mix as the only source of water for irrigation. It includes three levels of water application (leaching fractions). The water is applied frequently into dead level furrows. The hypothesis under test is that, with 6000 mg/l water and careful management, it will be possible to obtain full cotton yields.

In the Sacramento Delta area near Stockton, a field study is just getting underway to determine the salt tolerance of maize. This study involves sprinkler irrigated plots with a range of salinities in the water, as well as subirrigated plots, all on organic soils. A complementary greenhouse study at Riverside concerns changes in salinity of the soil solution at specified phenological stages of growth.

Near Tacna, Arizona, in the Wellton-Mohawk Irrigation and Drainage District, a 5-year study is just now being terminated. It consisted of two parts. In the first, Valencia oranges were irrigated with Colorado River water with a trickle system at leaching fractions ranging from 5 to 20%. In the second, alfalfa was irrigated with a moving boom spray system at three leaching fractions. These studies were part of a broader program of research on field water management involving also the University of Arizona and U.S. Water Conservation Laboratory at Phoenix (cf. A. Dedrick, this program). All the data aren't yet in, but it

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appears there was no disbenefit in terms of citrus yields from irrigating with 1 to 1.5 m less water per year than is commercial practice; as to alfalfa, the crop management practices were incompatible with the irrigation regime used, so that no benefits could be assigned to the treatments imposed.

These brief descriptions serve to illustrate a common thread. Each project addresses an aspect of drain water disposal, investigating non-conventional management techniques to solve a pressing problem. Each project can be viewed as applied field research based on hypotheses and data derived from earlier research, and utilizing methodology and instrumentation developed in earlier work. In each case also, the problem addressed concerns with optimization of natural resource use in situations where institutional arrangements greatly complicate matters.

In Kern County, as in Fresno County and other parts of the San Joaquin Valley, suitable provision for disposal of agricultural drainage water is becoming ever more pressing. If the volume of drainage water can be reduced by productive use, the disposal problem is reduced in scope; to the extent the drainage water can be intercepted and reused for irrigation, a volume reduction by a factor of 4 can be achieved. On the other hand, such use creates first and second class irrigators: those with "good" water and those with "poor" water. Thus implementation of such a technically reasonable option must provide for acceptable institutional arrangements.

How much water from Northern California may be transferred south and how much needs to be released to maintain acceptable conditions in the Sacramento Delta is a political decision that should be based on a technically sound data base. Our work in the Delta is intended to help provide this data base.

To implement the 1973 agreement with Mexico relative to delivery of Colorado River water at Morales Dam just below Yuma, Arizona, provision must be made to prevent the drainage flow from the Wellton-Mohawk District from mixing with the irrigation water delivered, or to desalt it before mixing. Whereas desalting offers by far the simplest solution, it is expensive and consumes substantial electrical energy. Alternative solutions, including increased irrigation efficiency, are more cost effective and make better use of natural resources, but in general they conflict with one or more of many legal, political or institutional conventions. Again, our work is designed to provide a basis for technically sound alternatives, so that the essentially political decisions may be made from a factual base.

Selection and Breeding of Crops for Saline Soils and Waters

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Salinity has plagued mankind since the origin of irrigation agriculture. The problem arises from the gradual building up of dissolved minerals in the soil, carried there in the irrigation water and accumulated as water is removed by evapotranspiration. Continued salt accumulation inhibits plant growth. The rectifying measures taken in the past, and continuing today, have been largely restricted to physical management of the soil, mainly involving leaching of excess salts from the root zones. The standard practice then has been to alter the environment to fit the (salt sensitive) crop plant. An additional strategy is available, however: the genetic approach of altering the plant to fit the environment. Salinity being the problem, the need is to select and breed salt tolerant crops. This approach to the problem has been almost totally ignored until only very recently. Not a single crop species has been exhaustively screened for salt resistance. This has been the case despite mounting evidence of variability in response to salt stress within most crop species.

This laboratory undertook an intensive investigation into this research area after many years of preliminary study and experimentation. A composite cross of barley, derived from 6,200 entries, was screened for the ability to survive and set seed at a very high level of salinity. The survivors were salvaged and their progeny was field-tested on sandy dune soil near Bodega Bay, California, on the Pacific coast north of San Francisco. The selected lines were capable of producing grain of good quality even when irrigated with undiluted seawater. Attention is now being turned to screening the world collection of barley for salt resistance.

The project was soon extended to include wheat, because of the outstanding economic importance of this crop. Wheat is generally considered to be less tolerant of salinity than barley. From the world collection, over 5,000 entries of bread wheat were obtained and screened for salt resistance. Some 40 lines were isolated capable of germinating and surviving in 50% seawater, a level of salt stress lethal to commercial wheats. These lines are currently being tested in the Imperial Valley on a saline field site. Some of the lines are also being tested at the Bodega Bay experimental site, under irrigation with undiluted seawater. A few of the lines have been tested in the greenhouse against check varieties over a range of salinities, demonstrating their relative performances under salt stress.

The philosophy of selecting and breeding for salt tolerance also extends to crop species having narrow genetic bases or not possessing much variability with respect to this character. In such cases, it may be possible to introduce exotic germplasm from wild salt tolerant relatives of the crop. Such was the case with the tomato. A wild species of tomato, collected from one of the Galapagos Islands, was found to be both salt tolerant and fully interfertile with the commercial species. The two species were crossed, and selected F_2 progeny were backcrossed to the commercial variety. Subsequent testing of selected F_2's, F_3's, and backcrosses at the Bodega Bay field site showed that salt resistance had been transferred into a line of tomato producing good quality fruit, though of relatively small size (like cherry tomatoes).

These initial efforts into selecting and breeding for salt tolerant crops are encouraging and suggest that extensive investigations of these and other crops are in order.

The development of salt resistant crops should lead to increased production on salty inland soils, as well as on sandy coastal soils. In the latter case, it may even be possible to use the oceans as resources of both water and mineral nutrients. There should also be intensive study of the mechanisms of salt tolerance, to gain an understanding of what, physiologically, distinguishes salt sensitive and salt tolerant plants. Such an understanding in turn will reinforce the applied research-and-development discussed above.

USE OF SALINE WATER FOR IRRIGATION IN ISRAEL

Dr. I. Shainberg [1/]

A regosolic loess has been irrigated commercially with sodic water (EC, 4.6 mmho/cm^{-1}; SAR, 26.0; HCO_3, 9.6 meq/l) for 5 years. The exchangeable sodium percentage of the soils increases, and the physical properties of the soils deteriorate with use of this water for irrigation without special precaution. The high salt concentration of the brackish water suppresses the deleterious effect of adsorbed sodium during the irrigation season. Leaching of salt from the soil by rain, during the winter, makes the soil almost impermeable. Gypsum, $CaCl_2$, and $AlCl_3$ amendments were effective in preventing: a) the excessive accumulation of sodium, and b) the reduction in the infiltration rate of the soil. Gypsum was the most economical treatment and $AlCl_3$ was the most effective one.

When gypsum was applied, the cotton, sugar beet, and wheat yields in commercial fields irrigated with the brackish water were equal to those in fields irrigated with fresh water. Water management, with both types of waters, were the same during the irrigation season.

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USE OF DESALTING TECHNOLOGY IN MANAGING SALT IN THE ENVIRONMENT

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Control of salinity may be sought when salt buildup threatens an ongoing agricultural project, when irrigation is introduced to additional land, in reclamation of salt-damaged areas, and in making wastewater suitable for reuse.

Agricultural problems associated with excess salts are often aggravated by departures from normal or desirable balances between chemical species present, and by deleterious interactions between substances in the water and the soil to which it is added. Amounts considered excessive vary from minute quantities of plant or animal poisons to significant fractions of the soil or other surface materials. Different remedial treatments are required depending on the severity and type of damage, such as poisoning, interference with germination, change of soil acidity, compaction of the soil, or reduction of soil permeability to water.

Effective long-term removal of salts to desired levels is possible and the means to do so are well known. A successful solution then reduces to choosing a means that is economically feasible and otherwise acceptable. One of the simplest ways of removing salt from soil is to flush it with irrigation water which may be allowed to percolate down into an empty stratum or one from which it may be pumped, or into drains underlying the root zone. The drainage water is then collected for disposal. This method of salt control is widely practiced and hence, except for final disposal of the wastewater, will not be considered further here.

The major methods for disposing of salt from the active environment are ponding, transporting to other areas including the ocean or salt marshes, injecting underground and exporting as salable materials. Waste agricultural drainage water and other wastewaters are sometimes disposed of as is. However, it is usual to consider evaporating off, or reclaiming some of the water for reuse, to reduce the quantity of saline water to be handled. The commercial methods of desalting or concentrating saline waters and reclaiming freshwater are distillation, electrodialysis, ion exchange, and reverse osmosis. Convenient summaries on the cost and status of desalination and bibliography are given in References 1 through 3. No one desalination method is universally best; the appropriate system depends on the particular situation.

Processes for separating a saline water into freshwater and a more concentrated brine include a water pretreatment step followed by the concentration or actual desalination step. To make it suitable for an intended use, water may be given a post-treatment step; the brine also may be treated.

Several studies have been made on ways to dispose of large amounts of agricultural drainage water. The most widely known concerned the upgrading of the Welton-Mohawk drainage canal water at the test facility near Yuma, Arizona. The principal pretreatment considered was the lime softening process, followed by filtration. The reverse osmosis and electrodialysis desalination processes were evaluated. It appears that desalination of this water will be carried out by the Federal Government using reverse osmosis units with a total capacity of approximately 100,000,000 gallons per day (120,000 acre-feet per year). Post-treatment of the water will include blending with canal water before discharging it into the Colorado River. The concentrate will be exported to a salt lagoon area by way of a canal. Sludge from the pretreatment will be buried or sold. Cost figures released by the Government (4) suggest that the investment would be in the neighborhood of $2 per daily gallon of capacity and the product water would cost approximately $0.80 per 1,000 gallons. Approximately 65,000 tons of salt will be removed from the area by the system each year.

In a cooperative study between the University of California and the California Department of Water Resources, it was shown (5) that agricultural drainage wastewater with a total dissolved solid content from 2,000 to 7,000 parts per million could be concentrated by reclaiming 90 percent of the water by means of University of California, Los Angeles, tubular reverse osmosis units with sponge ball cleaning. The key to the high recovery was the ion-exchange pretreatment system that removed calcium ions to prevent scaling. The use of chlorine to control bacterial attacks on the membranes was also important.

A module study undertaken by the California Department of Water Resources, utility companies, and the University of California, Sea Water Conversion Laboratory (6) showed that San Joaquin Valley agricultural wastewater which is nearly saturated with calcium sulfate could be concentrated in the cooling tower of a power plant by a factor of 12 to 20, further concentrated to a total dissolved solids content of 7 percent in a vertical tube distillation unit, and finally reduced to any desired degree of dryness in a crystallizer-evaporator. Tests showed that sodium sulphate could be produced as a saleable product. Again the key to successful operation was ion-exchange pretreatment to control calcium salt scaling problems. The effluent brine from the evaporator, being rich in sodium ions, was used to regenerate the ion exchange columns thus eliminating the need to import salt to the area as regenerant. The concentrated brine could be ponded in the vicinity or transported by canal or pipeline to the sea. If this system gains commercial acceptance, it will provide valuable cooling water for power plants and other processes as well as greatly reducing the bulk of saline water to be disposed of.

Several modifications of this system have been tested successfully at the pilot plant level. A major reduction in cost is to be expected from the use of high performance vertical-tube evaporators using foamy flow (VTFE) to increase heat transfer. A silica scale suppression method is also available. Heat to operate evaporators can be supplied from a variety of steam sources in a power plant by altering some of the auxiliary equipment.

Further operational information on the high-performance VTFE (Sephton process) distillation desalination evaporator/condenser is being provided by a 50,000 gallon per day single-effect module of a multieffect distiller in a test of this method to concentrate effluent brine from power plant cooling towers. An important feature of the system is the use of steam extracted from power turbines. The concentrated brine may then be disposed of in much smaller ponds or in other ways. The reclaimed water will effect further operational economies.

Several studies have been made on possible ways to control the elevation of the water surface and the increase of salinity of the Salton Sea in the Imperial Valley, Southern California. This sump for agricultural drainage wastewater with a surface area of about 360 square miles is used for recreation which is threatened by excessive salt. Real estate also is threatened by water level fluctuations. A study by the U. S. Department of the Interior and the Resources Agency of California (7) resulted in a proposal to evaporate the water at the rate of approximately 200,000 acre-feet per year by solar heat in a diked pond with an area of 50 square miles near the middle of that inland salt-water lake. The 5 to 6 million tons a year of salt removed could be contained in this concentration pond for a century. It was estimated that the salinity of the Sea could be reduced from 40,000 ppm to 34,000 ppm in 10 years, thus making the water suitable for bathing and fishing. The level of the Sea would be controlled also to preserve real estate values along the shore. Placing the solar evaporation pond within the area covered by the Salton Sea improved the practicability of this salt control method. That it required about 50 square miles shows that salt disposal by ponding can require the sacrifice of large land areas as well as incurring large construction costs.

An alternate scheme to control the salinity and the level of the Salton Sea was included in a study (8) of the use of geothermal energy available in the area. 125,000 acre-feet of water per year from the Salton Sea would be used as cooling water for a geothermal power and desalination plant and to replace the net loss of geothermal reservoir water caused by producing 100,000 acre-feet of irrigation water per year.

Desalination techniques can be used to adjust the salinity or balance of salts in irrigation or other waters. For example, germination or nurture of young salt sensitive plants in adverse salinity environments may be facilitated by application of purer water as needed. If storage could be provided, a desalting plant of small size might be run continuously to provide enough freshwater for the short periods it was needed by the plants. The rejected concentrate might be disposed of by adding it to much larger amounts of irrigation water when the salinity was less critical. A somewhat different strategy might be to provide water desalted just enough for more sensitive crops and dispose of the concentrated water from the desalter in the remaining irrigation water to be used on more salt resistant crops. Year-round operation would improve the benefit/cost ratio of this option.

Naturally, economic and environmental impact analyses would be necessary before any desalting scheme to help manage salinity could be recommended. Basic to the analysis would be the capital cost of candidate desalting processes, their operating cost and the amount of energy that would be consumed by their use. At present, desalination is too expensive and consumes too much energy to be used to provide irrigation water for any but the highest price crops. However, some salt control projects have been justified. Better technology has already been developed and may soon enter the marketplace. The resulting cost reductions can be expected to be from 30 to 40 percent over present practice. When future market volumes warrant mass production, costs of all commercial processes should be reduced as much again, making more salt management projects attractive.

References

1. R. E. Childers et al, "Manual of Procedures and Methods for Calculating Comparative Costs of Municipal Water Supply from Saline and Conventional Water Sources in Texas," U. S. Department of the Interior, Office of Saline Water Research and Development Report No. 257, November 1966.

2. H. M. Curran, D. Dykstra and D. Kenkeremath, "State-of-the-Art of Membrane and Ion Exchange Desalting Processes," Final Report, HIT-658, to U. S. Department of the Interior, Office of Water Research and Technology, November 1976.

3. B. M. Watson, "History, Status and Future of Distillation Processes," report to U. S. Department of the Interior, Office of Water Research and Technology, December 1976.

4. "Yuma Desalting Plant, Preliminary Engineering Analysis," Colorado River Basin Salinity Control Project by Burns and Roe, Inc., for the U. S. Department of the Interior, Office of Water Research and Technology and the Bureau of Reclamation, November 1974.

5. "Desalting in California," California Resources Agency, Department of Water Resources, Division of Planning, May 1976.

6. "Agricultural Waste Water for Power Plant Cooling, Development and Testing of Treatment Processes, Vol. 2, California Resources Agency, Department of Water Resources and the University of California Sea Water Conversion Laboratory, June 1978.

7. "Salton Sea Project, California," 1969 Federal-State Reconnaissance Report, U. S. Department of the Interior and the Resources Agency of California.

8. "Geothermal Resources Investigations, Imperial Valley, California, Developmental Concepts," U. S. Department of the Interior, Bureau of Reclamation and Office of Saline Water, January 1972.

Estimating the Contribution of a Perched Water Table to the Seasonal Evapotranspiration of Cotton

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Several thousand acres in the San Joaquin Valley of California have a perched water table created by irrigation and a slowly permeable subsurface layer. The impact of the groundwater must be quantified to effectively maintain a favorable salt balance and minimize applied irrigation and drainage water and therefore drainage facilities. A short-term drought year strategy may utilize perched water of satisfactory quality as a resource in crop production.

Effective use of perched water as a resource depends on the upward movement of water from a water table in the presence of active roots. The rate and amount of water supplied from the water table depends on several factors including the water retaining and transmitting properties of the soil, evapotranspiration demand, and the distribution of the plant root system. Because the factors have not been quantified to a degree that provides a reliable predictive tool, field studies are required. This study was conducted to quantify the total amount of water supplied a growing cotton (Gossypium hirsutum L.) crop by the groundwater.

Two measurement techniques, a water budget method and a chloride tracer analysis, provided independent estimates of the water table contribution at one location (site 1) on a Panoche loam. A water budget method only was used at a second test site (site 2). The native chloride present in the groundwater and initial and final chloride levels in the soil profile provided the necessary information for estimates with the chloride tracer technique. Estimates of the groundwater contribution to seasonal evapotranspiration using the water budget method require measurements of initial and final soil stored water, the amount of irrigation water applied, and a previously established functional relationship between cotton yield and evapotranspiration, Y = f (ET). Water table depths were monitored in observation wells throughout the duration of the 1977 study and were observed to decline. Initial depths to the water table were 210 and 180 cm for sites 1 and 2, respectively.

Four irrigation treatments were established at site 1 by irrigating cotton 0 (W-1), 1 (W-2), 2 (W-3), and 3 (W-4) times during the growing season. Site 2 compared no irrigation after planting with a single irrigation applied in July.

Soil water content profiles, as a function of time and depth, showed soil water depletion, for the dry treatment of site 1, to greater depths with time in the upper 137 cm until 3 August. Little change was noted thereafter, indicating that the water demand was supplied primarily by the groundwater. The W-2 treatment, with one irrigation, showed a similar trend, but the W-3 and W-4 treatments did not stabilize in the upper 137 cm increment.

The water budget method estimated an average contribution to evapotranspiration of 36.2 cm with no difference observed for the various treatments. Since seasonal ET for the treatments was variable, the water table contribution (expressed as a percentage of seasonal ET) varied from 60 to 70 percent.

Chloride concentrations from 61 to 244 cm increased from the beginning to the end of the season. Little or no increase was observed above 61 cm. Calculations involving the change in chloride concentration in the soil profile between 5 July and 28 November and the average groundwater chloride concentration of 17.4 meq/l estimate the groundwater contribution to seasonal ET at 35 cm. While the average of observations (n = 64) is in close agreement with the water budget estimate, it should be noted that the standard deviation of the observations was 19.6 cm.

The water budget and chloride tracer methods of estimating groundwater contribution to seasonal ET for cotton mutually suggest a major part was supplied by perched water. However, the salt balance in the soil cannot be ignored in the process of optimizing profit on a yearly basis or developing a drought year strategy. Additional increments of water may be necessary to maintain an acceptable salt balance.

LEVEL-BASIN IRRIGATION FOR SALINITY CONTROL [1]

Allen R. Dedrick and Leonard J. Erie [2]

Level-basin irrigation involves applying water to a level ground area of any shape surrounded by a control barrier, such as a dike, bench, canal or road. Level basins differ from traditionally used sloping surface systems in that there is no slope in any direction. Water is applied to a level basin over a relatively short period of time and is confined within the basin until infiltrated into the soil. Level-basin irrigation can be adapted to all crops, soils, and to certain marginal-quality water not usable with other methods of irrigation. It is, however, best adapted to low or medium water-intake-rate soils.

Uniformity of application and resultant minimal water loss over the irrigated area are the major objectives of any irrigation system. These can be attained with level basins by balancing the basin size to the irrigation water supply (flow rate) and soil intake characteristics.

Primary advantages of level basins include uniformly distributed water and high application efficiency since runoff water is eliminated and deep percolation losses are controlled, soil leaching for salinity control, low labor requirements, minimal erosion from irrigation or rainfall since the soil surface is flat, and minimal drainage requirements. Main limitations are topography and topsoil availability, requirement for precisely leveled land, and problems associated with over irrigation or excessive natural rainfall.

A certain portion of water movement beyond the plant root zone need not be considered lost, but necessary to maintain a favorable salt balance. Leaching

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[1] Contribution from the Science and Education Administration, Agriculture Research, U. S. Department of Agriculture.

[2] Agricultural Engineers, U. S. Water Conservation Laboratory, Phoenix, Arizona 85040.

of salts is accomplished naturally with a properly designed level basin system, since water uniformly covers and remains static over the entire basin surface and has an opportunity to penetrate evenly. If properly designed, the quantity of deep percolation loss will be within a tolerable range. Since rainfall will not run off, it too, may be useful for leaching purposes.

Precision land leveling is a necessity for even water distribution, since most of the water infiltrated is ponded on the basin. If low and high areas exist within a basin, uneven water penetration will occur. Low areas mean overapplication and excessive inundation times and resultant crop damage. High areas will be under-application areas and may become salty, especially when an irrigator becomes too conservative with water. With the recent commercial availability of laser-controlled land leveling equipment, we find that maximum finished field elevation differences (range of high to low areas in fields up to 30 acres) are about one inch. These small elevation differences essentially eliminate the chance for insufficient leaching of certain portions of a basin but still allow sufficient irrigation water to be applied without excessive deep percolation losses.

HIGHER SALINITY IN THE COLORADO RIVER AND FUTURE IRRIGATION MANAGEMENT[1]

Frank E. Robinson[2]

Two separate but consecutive field experiments were conducted. The first consisted of applying Colorado River water artifically salinized to 1,350 mg/l TDS to several crops. Alfalfa was the only perennial that was present during the entire 32-month period.

The second experiment was conducted after the first and dealt with the leaching of salts which had accumulated in the soil profile during the first experiment. The area utilized for the experiments had an Imperial clay on the west side and a sandy clay loam on the east side. It was tiled at 180 cm and had a water table controlled by the tile.

Experiment 1

In this experiment five different quantities of 1,350 mg/l water were applied by sprinkler to alfalfa. The quantities were based upon percentage of ground cover and various fractions times the evaporation from a Class A USWB pan. Soil salinity increased in all treatments but was not associated with a decrease in yield during the first 16 harvests. During the last four cuttings a significant reduction in yield occurred in the three lowest application rates as compared to the highest. The alfalfa had been planted in October, 1973 and the yield reductions began to occur in January, 1976. This experiment terminated in May, 1976. A comparison of the quantity of water applied to the change that took place in the concentration of the cations in the profile at field capacity over the 32-month period can be expressed in equations 1 and 2 for clay and sandy clay loam, respectively:

$$(1)\ t = 2534 - 4.72\ q,\ r^2 = 85.0,\ F = 16.9$$
$$(2)\ t = 1511 - 1.60\ q,\ r^2 = 91.7,\ F = 22.0$$

t = meq/l change in total cations concentration in five liters of soil solution at field capacity over 32 months.

q = cm of water applied over 32 months.

Setting $t = 0$ indicates a q amount of water that would be needed to prevent an increase in soil salinity. This was 543 cm in the clay and 941 cm in the sandy clay loam. The higher requirement in the sandy clay loam was probably the additional needed to prevent upward movement from the ground water table.

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[1] Prepared for the California Chapter of the American Society of Agronomy, February, 1979, San Diego.

[2] Water Scientist, Department of Land, Air and Water Resources, University of California, Davis and El Centro.

Experiment 2

The second experiment was conducted after the first was concluded. Soil samples at 30 cm increments were taken to 150 cm depth and saturation extracts obtained before and after leaching the area with 41 cm of water. The entire surface had been chiseled to 56 cm prior to the sprinkler application. A compilation of all the treatments showed that after leaching the extracts in the clay were about 5 mmho/cm in the top 30 cm and increased about 0.6 mmho/cm for each 30 cm depth increment. The sandy clay loam treatments were about 2.0 mmho in the top 30 cm and increased approximately 1 mmho/cm with each 30 cm depth increment.

Table 1 presents a comparison of two irrigation management systems. The first corresponding to the driest treatment in Experiment 1, i.e., q = 358 cm in equations 1 and 2. This treatment utilized chiseling of the soil and intermittent leaching at 32-month intervals that removed the accumulated salts. The second system corresponding to t = 0 in equations 1 and 2 applied sufficient water to meet the needs of the crop plus enough additional to prevent accumulation of salt in the profile. In this treatment it was assumed that a 10% increase in yield would occur because of the lower salinity.

Table 1. Comparison of water management techniques on yield per cm of water applied.

Irrigation management		Soil texture	
		Clay	Sandy clay loam
Adequate for crop needs	Water cm	399	399
Soil salinity increases	Yield T/ha	57.7	66.7
Leach 2-3 years	T/ha/cm	0.145	0.167
Adequate for crop needs	Water cm	543	941
Adequate to prevent	Yield T/ha	63.5	73.4
Salt buildup	T/ha/cm	0.117	0.078

The two management systems may be referred to as the periodic leaching and continuous leaching systems. The periodic leaching at 32-month intervals had a higher water use efficiency over the first 32 months. The continuous leaching system would have higher efficiency of labor and energy used for stand establishment. For instance, if the continuous system extended the crop life to 44 months, the cost of stand establishment would be 32 months ÷ 44 months, or 73% of that at 32-month intervals. If it could extend the crop life to 56 months, the cost of stand establishment would be 57% of that at 32-month intervals. This trade-off will have to be assessed continually as the salinity increases.

When the Colorado River reaches 1,350 mg/l TDS, the extremes in water management systems discussed here will be available together with the wide range of choice between them that weigh water, energy, and labor efficiencies.

INTRODUCTION TO THE CALIFORNIA ORNAMENTALS INDUSTRY

Raymond Hasek
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In the year 1977 the combined wholesale value of all types of ornamentals produced in the state of California was in excess of one-half billion dollars (Table 1). California far outproduces all other states in the field because of the availability of a multitude of climatic conditions and diversity of crops grown. No less than thirteen counties reported wholesale dollar values of more than $10 million for ornamentals production within their boundaries. Relative importance of these counties can be seen in Table 2. It is interesting to note that 80% of the total dollar volume is generated by income from the categories of Deciduous and Evergreen Trees, Shrubs and Vines, Cut Flowers and Cultivated Greens plus Potted Plants both Flowering and Foliage. The dollar value for the ornamentals industry has tripled in the ten years between 1967 and 1977. Little of the increase is due to higher income per unit since cut flower or container-grown plant prices have remained relatively constant in the face of inflated production costs. Only through improved production techniques and efficiency in scheduling has the industry been able to advance and grow.

CALIFORNIA ORNAMENTAL PRODUCTION 1977

CATEGORY	FARM GATE WHOLESALE VALUE
Deciduous & Evergreen Trees, Shrubs and Vines	$162,721,362
Cut Flowers & Cultivated Greens	139,353,605
Potted Plants Flowering & Foliage	126,456,459
Bedding Plants	27,211,600
Turf Seed & Sod	20,262,997
Rose Plants	17,012,403
Propagative Materials	13,441,900
Flower Seed Production	8,597,678
Christmas Trees	8,474,930
Bulbs, Corms Etc.	5,875,239
Herbaceous Plants	3,060,168
Total	$532,468,341

Compiled by: H.G. Schierenberg, Nursery and Seed Service, Sacramento, CA. and R.F. Hasek, U.C. Cooperative Extension, U.C. Davis

Table 2

CALIFORNIA COUNTIES REPORTING $10 MILLION OR MORE FARM GATE VALUE OF ORNAMENTAL PRODUCTION IN 1977

		DOLLAR VALUE	
RANK	COUNTY	Ornamentals	Nursery Other Than Ornamentals
1	Los Angeles	84,829,000	1,940,000
2	Orange	72,639,600	46,000
3	San Diego	67,772,604	4,246,000
4	San Mateo	48,812,700	-0-
5	Monterey	33,336,000	1,506,000
6	Santa Clara	31,795,700	-0-
7	Santa Barbara	27,044,717	943,192
8	Ventura	24,293,900	1,791,000
9	Alameda	23,834,500	265,000
10	Santa Cruz	19,809,238	320,262
11	Kern	18,353,200	1,769,000
12	Contra Costa	11,869,700	303,000
13	San Joaquin	10,995,000	1,160,000

Table 3

LEADING COUNTIES FOR PRODUCTION OF VARIOUS ORNAMENTAL CROPS

1977

CATEGORY	% OF TOTAL DOLLAR VALUE	LEADING COUNTIES
Deciduous & Evergreen Trees, Shrubs & Vines	30.6	Los Angeles, Orange, San Diego, San Bernardino, Santa Cruz, San Mateo & Sacramento
Cut Flowers & Cultivated Greens	26.2	San Diego, Santa Clara, Monterey, San Mateo, Santa Cruz, Alameda & Santa Barbara
Potted Plants Flowering & Foliage	23.7	San Mateo, San Diego, Los Angeles, Orange & San Joaquin
Bedding Plants	5.1	Los Angeles, San Diego, Contra Costa, Alameda & Riverside
Turf Seed & Sod	3.8	Ventura, Orange, Kern & Riverside
Rose Plants	3.2	Kern, Glenn & San Bernardino
Propagative Materials	2.5	Monterey, Alameda & Los Angeles
Flower Seeds	1.6	Santa Barbara, Ventura & Santa Clara
Christmas Trees	1.6	Shasta, Los Angeles, San Mateo, Orange & Plumas
Bulbs	1.1	Del Norte, San Diego, Los Angeles & Riverside
Herbaceous Plants	.6	Santa Clara, Contra Costa, San Mateo & Riverside.
TOTAL	100.0	

POTTING MIX STUDY

by

John M. Rible

At the last U.C. Soil Fertility Conference (Davis, March 30 - 31) a report was given on the results of a study of commercial potting mixes conducted at the request of the State Department of Food and Agriculture. The mixes were evaluated by chemical analyses and greenhouse tests. As so often happens, there were some unexpected results that should be of interest to those of you working with soil mixes:

1. The drop in pH after three months of plant growth was positively correlated with the concentration of NH_4-N in the saturation extract of the initial mix. All mixes were liquid fed with 200 ppm each of N and K from ammonium nitrate and potassium nitrate (see Table).
2. There was a strong suggestion that 30 ppm $NaHCO_3$ soluble phosphorus in the initial mix is a critical level above which the probability of a response to added P fertilizer is very low (see Fig. 1).
3. After three months' growth, the plants were rated for market quality on a 1 to 5 scale. Ratings of 4 and 5 were considered indicative of marketable quality. Nitrogen analyses of the leaf blades revealed that no samples with less than 3 per cent nitrogen were in the 4 to 5 category (see Fig.2).

Such findings emphasize the usefulness of laboratory analyses for programming production with soil mixes.

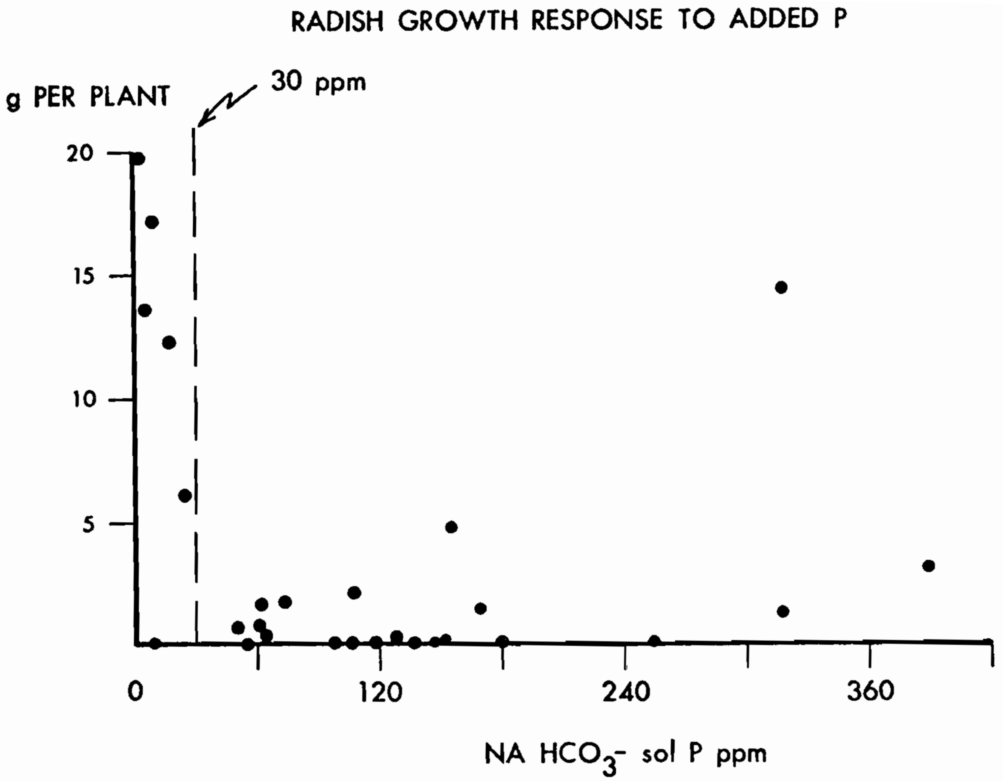

Figure 1

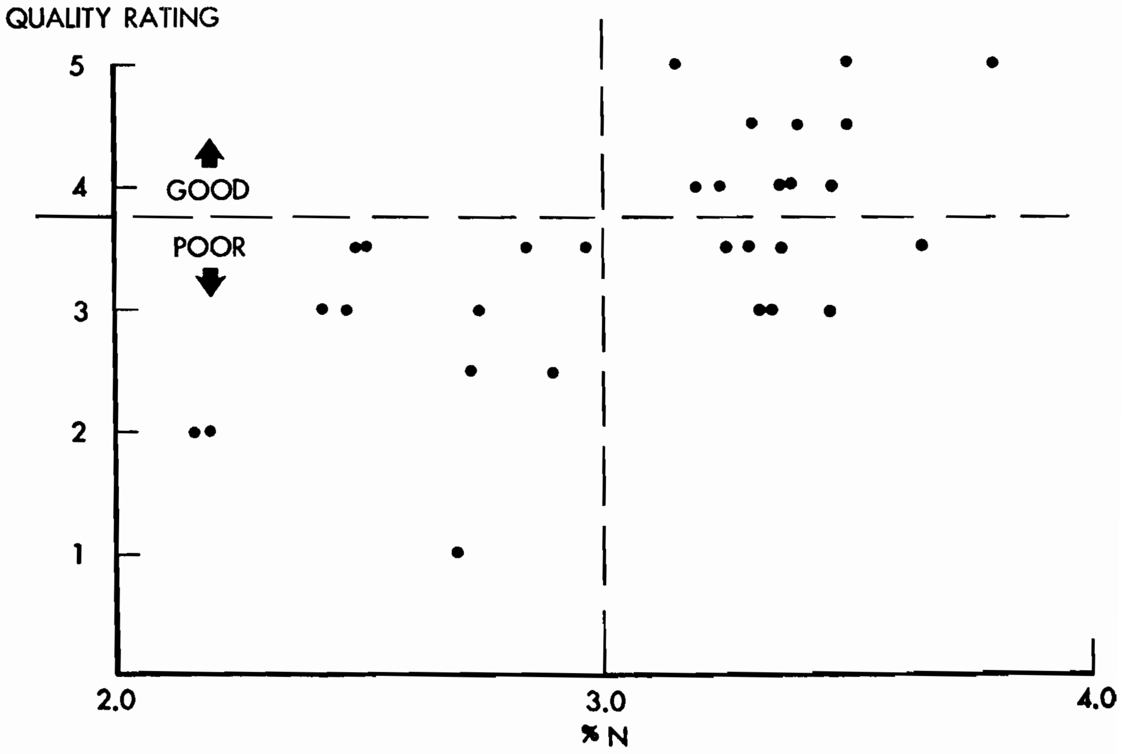

Figure 2

TABLE

pH		pH Difference	
Initial	Final	(Initial-Final)	NH_4-N in sat'n ext. meq/l
7.1	5.9	1.2	1.0
4.1	4.3	-.2	1.1
4.6	4.4	.2	1.2
6.6	6.2	.4	1.6
6.6	6.5	.1	3.3
6.1	5.9	.2	4.1
6.6	4.7	1.9	5.8
5.0	4.3	.7	6.9
4.3	3.8	.5	9.3
5.7	4.7	1.0	10.2
5.3	4.3	1.0	11.9
5.8	3.8	2.0	14.3
6.6	3.7	2.9	16.4

STRATEGIES FOR MAKING SLOW RELEASE FERTILIZERS MEET PLANT DEMAND

O.R. LUNT

There have been five techniques used for regulating the availability of minerals from fertilizer sources. Perhaps other techniques will be devised or new combinations of the techniques used to achieve the desired objective.

1. Reliance on microbial transformation to convert insoluble nutrients to soluble forms. Urea-formaldehyde and soil humus are examples of source materials which are made available by this technique. A variation on this technique is the use of nitrifying retardent to delay conversion of NH_4^+ to NO_3^- which is much more leachable than is the NH_4^+.

2. Controlled diffusion by membrane encapsulation. Sulphur coated urea and "Osmocote" materials are examples of materials acting on this principle. The rate of diffusion of dissolved minerals through the membrane can be controlled in the manufacturing process.

3. Limited solubility is in theory an ideal means of sustaining a given level of nutrient. The metal ammonium phosphates operate on this principle as does gypsum.

4. The utilization of exchange resins for absorbing cations or anions. The nutrient ions are released to be absorbed by plants in exchange for cations and anions produced by plant roots, i.e. H^+ and HCO_3^-.

5. Physically restricted solution or diffusion of nutrients. Perhaps this should be viewed as a variation of technique 2. Nutrients may be admixed with a slightly soluble mineral such as gypsum then physically pelletized by pressure. The gradual dissolution of the gypsum retards the dissolution of the fertilizer materials imbedded in the gypsum.

All techniques can be made to be effective in a given management program. Cost has been an obstacle in wider application. The increased use of liquid fertilization which continually supplies nutrients has met the need for continuous nutrient supply at low cost. However, pollution concerns directed at liquid fertilization will require modification of procedures in many situations. Thus, slow release materials are gradually finding management nitches where they are advantageous. They often prove to be advantageous in the establishment stage of a crop and may be effectively combined with a liquid fertilization program.

A variation of the fifth technique listed merits consideration. Pumice is a mineral found in large quantities in California. Materials often exhibit porosities of 70%. The precipitation of soluble fertilizers in the pumice and its incorporation as a coarse ingredient in potting mixes would be expected to supply minerals for an extended period. Water would move around the pumice particles rather than through them, thus leaching losses of nutrients would be slow. The fertilizer materials would dissolve slowly due to only temporary filling of the pores with water when the soil mix is near water saturation. Diffusion into the soil medium proper would be fairly slow. These conclusions are based on the observed difficulty in leaching soluble salts from salinized soil mixes containing a significant fraction of pumice.

RECENT DEVELOPMENTS IN SLOW RELEASE FERTILIZERS

by

Wesley M. Jarrell
University of California, Riverside

The last few years have seen considerable development in slow release fertilizer materials. The types of materials now manufactured for sale or experimentation vary greatly in their characteristics, but roughly fall into about four groups: coated materials, low-solubility materials, materials which require the activity of microorganisms for release of their nutrients, and finally materials which reduce the rate of oxidation of ammonium ion to nitrate. Nearly all of the slow release materials now produced are primarily designed to supply N to the plant; however, some contain other nutrients as well as N and a few contain no N. Non-nitrogen slow release fertilizers generally contain potassium.

Coated fertilizers have increased in importance over the last few years, and a great deal of work has been done with one product in particular, sulfur-coated urea (SCU). The scale of SCU production by the Tennessee Valley Authority (TVA) has advanced from the bench-top level to a small pilot plant (1-2 T/hr) to a production plant (10 T/hr). Quality control has improved so that each lot is more uniform and the coating characteristics are more predictable. In the past few years, several commercial companies, including Imperial Chemical Industries in England and AIM in Alabama, have begun producing, experimenting with, and in some cases marketing various forms of SCU. Projections for the future suggest that further developments in the product will make it even more attractive to users, with one recent quotation as low as $215/ton for 32-0-0. SCU is currently being applied on an experimental basis in California to celery, strawberries, tomato, trees, irrigated pasture, and ornamentals.

Potassium substrates can also be coated with sulfur, but no S-coated K materials are currently manufactured.

Osmocote fertilizer, manufactured by Sierra Chemicals, is a complete fertilizer coated with resin. In a recent advance Sierra has developed the technology to coat potassium sulfate and urea, allowing the user more flexibility in providing N and K to the crop.

Among the low-solubility materials, IBDU (Swift Chemicals) has gained wide acceptance, especially for fertilization of turf grasses. Mag AMP (magnesium ammonium phosphate) is being marketed extensively on the East Coast where waters are generally acidic, but is little used in areas of the West where waters are often alkaline and response to Mag AMP is variable.

Ureaformaldehyde fertilizers are marketed for use on turf grass and on container-grown ornamentals, as well as in the landscape. Ureaformaldehyde-

Chemicals such as nitrapyrin (N - serve) which inhibit nitrification (oxidation of ammonium to nitrate in soil) are becoming more widely used, although results can be quite erratic. Because the plant still has access to the N in the ammonium form, fertilizers applied with nitrapyrin do not truly behave as "slow release fertilizers" but act more as extenders, keeping N in a non-leachable form in the soil for a longer period of time.

Future objectives in slow release fertilizer development will probably aim at reducing production costs and making the release rate more predictable.

REVEGETATION OF EXTENSIVE LANDSCAPE AREAS

F.J. CHAN

What is a realistic approach to revegetation?

The answer to this basic question can best be made if one has an understanding of a number of related questions in regards to design, horticultural possibilities, and costs.

Some questions that are applicable include:

Is it realistic to "restore" the site to its original state?

Is it realistic for the designer to go to the site and not understand the site conditions in relation to species adaptation and to determine what minimal establishment results are needed to assure the desired landscape effect? How soon can a landscape effect be expected?

Is it realistic to plan for a one-year budget for landscape installation? What kind of follow-up is realistic?

Is it realistic for nurseries to grow native plants without a commitment? How could they determine production?

Is it realistic for contractors not to train their men to be knowledgeable about plant establishment and plant growth requirements?

What is a realistic cost for revegetation?

All these questions are related and the answers need to be worked out before a comprehensive revegetation program can be developed.

Revegetation Programs

A revegetation program can be considered in four phases. Timing is always essential in all phases. The most essential timing is to be in a position to plant at the optimal time to maximize results.

A. Planning - develop a practical design concept, provide the technical resources for developing specifications and drawings, allow enough time for circulation and review, and for bidding and review.

B. Acquisition of materials and labor - avoid disappointment, know availability of all materials, reserve or have contract grown stock available when needed. Plan for contingencies - substitute species or substitute seeds for plants.

C. Implementation - know capability of contractor or crews - set deadlines, anticipate weather and field problems, keep planting material in good condition until planted, plan for accessibility and mobility in remote area.

D. After care or follow-up work - monitor for early detection of problems, replant in same season if feasible - if not, replant the second season, time maintenance practices for maximum effectiveness, i.e., weed control and plant protection.

Common problems

In seeking answers on how to revegetate, it is helpful to be aware of common problems that often occur. These problems must be overcome and often they influence the species selection and techniques for revegetation:

A. Difficult soils - poor texture, poor depth, lack nutrients, compaction, excessive chemicals

B. Weed competition - herbaceous vs. woody plants

C. Animal and insect depredation - rodents, deer, cattle, grasshoppers

D. Drought and other environmental extremes

E. Erosion - mechanical means sometimes needed before planting is feasible.

Each site is unique; therefore it is important to carefully analyze sites and identify problems. Because individual solutions need to be worked out, governing agencies concerned must be flexible in their treatment. Generally, revegetation can be considered in two phases: A. Erosion control and B. Landscaping or woody plant establishment. Sometimes the two phases are not mutually exclusive of each other depending on the potential for erosion.

Erosion control is the first and most critical responsibility in revegetation. A common practice today is hydroseeding using seeds of herbaceous spp including grasses, forbs, legumes and wildflowers. Other techniques include stabilizing the soil surface with straw, liquid mulches, jute and other mattings in conjunction with seeding. Once erosion is under control, establishing woody plants can proceed.

Woody Plants establishment

Often it is characteristic to deal with the "numbers game" in establishing woody plants. One has to have an idea of the chances of establishing a plant to determine the planting rate in order to achieve a desired number or density. In addition, one should understand the role of "finesse" to assure a higher percent of establishment and increased vigor in plant growth. The "numbers game" could best be achieved utilizing techniques such as hydroseeding, top soiling, brush chipping, seed spotting, direct rooting and planting where a relatively large number of planting materials are used. These seedings or plantings would have minimal or no maintenance. They are highly dependent on timing and species adaptation to existing site conditions. Finesse can be exemplified by providing extra care to seeds or plants to assure establishment. Generally the extra care amounts to timely applications of fertilizer, weed control and plant protection to encourage germination and growth to the stage where the plant can grow and survive on its own. When economically feasible, supplemental irrigation just to assure establishment can be considered.

Key Words:

Techniques:

A. Pre-planting - top soiling, brush deposition, mechanized seed acquisition, slope preparation-serrated slope, pocket planting, scarified slope.

B. Seeding - broadcast seeding, seed spotting, seeding blocks, collar seeding.

C. Planting - liners, large container, cuttings, bare root.

Adapted species - a plant that is capable of completing its life cycle under existing environmental conditions. This includes seed germination, competition, maturation, flowering, seed production.

TREATMENT OF FIELD SOILS ACCIDENTLY CONTAMINATED WITH HERBICIDES

MIKE MELLANO

Portions of a 35 acre field of Shasta daisies was accidently contaminated with an unknown toxic chemical during an aerial pesticide application. Indicator plants were used to show that: (1) the chemical was concentrated in the upper 1" of soil; (2) the chemical was still toxic to plant growth six months after application; and (3) the chemical could be inactivated by preplant soil treatment with activated charcoal. The affected areas were treated with activated charcoal (400 lbs/acre) nine months after the accident occurred and the field replanted. Plant growth was normal and the field was returned to normal production.

LAND AND LIFE

CALIFORNIA PLANT AND SOIL CONFERENCE
February 8, 1979
San Diego, California

Since the beginning of civilization man has been concerned with the land that supports him. At times the land seems bountiful and kindly, and again harsh and unyielding, but it is always a challenge to man's strength and ingenuity and he has learned to adapt his ways accordingly.

Needs of man extend far beyond what nature unassisted can furnish him. He must plow and sow, he must work with nature and conduct her producing forces through carefully organized channels. From the accumulation of experience and knowledge, man gradually learns to bend natural forces to his advantage, and thus reduces the hazards of life and lessens his direct dependence on natural environment. Thus it is through the use of techniques that civilized man produces his particular necessities.

Yet no matter how complicated become these techniques, social or individual, the fundamental fact of the technique we call agriculture continues to involve the relationship between man and the plant and soil in which it grows. The

VERY RESPONSIVENESS OF SOIL TO TECHNIQUES IS ONE OF ITS UNIQUE CHARACTERISTICS, INDIVIDUAL AND FINITE. UNCONSCIOUSLY MAN ADJUSTS HIMSELF TO THESE PHYSICAL REQUIREMENTS, INDIVIDUALLY AND COLLECTIVELY. HIS DAILY LIFE, HIS WORK AND HIS PLAY, FROM THE SIMPLE ACTS OF LIFE TO THE MORE COMPLICATED ECONOMICS MECHANISMS HE CREATES, ARE CONDITIONED BY THE NECESSITIES OF HIS LANDSCAPE. THE AGRICULTURAL TECHNIQUES THAT MAN EMPLOYS ARE BASICALLY DESIGNED TO PRODUCE A RELATIONSHIP OF SOIL TO PLANT SUITABLE TO THE AIMS OF MAN. MEN AND SOCIETIES ARE THUS PRODUCTS OF THE LANDSCAPE.

TO THE PEOPLES OF ANTIQUITY, THE UNITY OF MAN AND THE SOIL WAS THE GREAT PRIMARY FACT OF EXISTENCE. "AND THE LORD GOD FORMED MAN OF THE DUST OF THE GROUND," IT IS WRITTEN IN THE BIBILICAL STORY OF CREATION. THIS THOUGHT RUNS LIKE A REFRAIN THROUGH THE OLD TESTAMENT.

THROUGHOUT THE ANCIENT WORLD THIS FEELING OF KINSHIP TO THE SOIL WAS EXPRESSED IN THE VARIOUS BREAD-AND-CORN RELIGIONS. THE EGYPTIANS CALLED THEMSELVES "SONS OF THE BLACK EARTH." FOR MANY YEARS THE MOST POPULAR RELIGIOUS CULT OF ANCIENT GREECE WAS THE WORSHIP OF DEMETER, GODDESS OF THE EARTH, WHO NOT ONLY DETERMINED THE RESURRECTION OR DESTRUCTION OF THE SOUL, BUT WAS REVERED ALSO AS THE FOUNDER OF LAW, THE FAMILY, AND THE STATE. PLOWING WAS VAGUELY REGARDED AS AN ACT BORDERING UPON IMPIETY, TO BE EXPIATED BY RELIGIOUS OBSERVANCES AND THE OFFERING OF SACRIFICES TO THE DIVINITIES OF THE EARTH.

SUCH RELIGIOUS OBSERVANCES CONTAINED A DEEPER PHILOSOPHY OF THE RELATIONSHIP OF MAN TO THE SOIL. INTUITIVELY, THEY ANTICIPATED SOME OF THE SCIENTIFIC KNOWLEDGE OF THE MODERN ERA; THEY RECOGNIZED THE SOIL AS A LIVING THING, DERIVING ITS ENERGY FROM THE SUN; THEY RECOGNIZED THE PRINCIPLE OF MALE AND FEMALE IN THE GROWTH OF VEGETATION; THEY HELD THE LIFE AND FERTILITY OF SOIL, PLANT, ANIMALS, AND MEN TO BE ONE AND INDIVISIBLE. CRUDE THOUGH THESE BELIEFS WERE, THEY NEVERTHELESS PENETRATED CLOSER TO THE TRUTH THAN THE PSEUDO-SOPHISTICATION THAT HAS ALL TOO LARGELY DETERMINED THE MODERN ATTITUDE TOWARD THE LAND.

THE PROGRESSIVE INDUSTRIALIZATION AND URBANIZATION OF LIFE HAS LIMITED THE ECONOMIC PERCEPTIONS OF AN INCREASING NUMBER OF PEOPLE TO THE ENVIRONMENT CHARACTERIZED BY SUBURBAN RESIDENTIAL DEVELOPMENTS AND CITY SLUMS, GIANT SKYSCRAPERS AND VAST INDUSTRIAL PLANTS. THEY HAVE TENDED MORE AND MORE TO CONCEIVE OF THE PRODUCTION OF WEALTH IN TERMS OF MEN AND MACHINES ALONE, FORGETTING THE LAND.

NEVERTHELESS, THE BASE OF THE SOCIAL PYRAMID RESTS TODAY WHERE IT HAS ALWAYS RESTED--UPON THE LAND. UPON THE LAND MAN MAKES HIS FIRST APPLICATION OF PRODUCTIVE EFFORT-TO EXTRACT FROM IT FOOD TO SUSTAIN HIS LIFE AND GIVE HIM ENERGY, FIBER FOR CLOTHES TO PROTECT HIS BODY AND CONSERVE ITS VITAL WARMTH, WOOD TO BUILD SHELTER AGAINST THE ELEMENTS, AND ORE FROM WHICH TO FASHION HIS TOOLS.

The work of fashioning the natural materials into forms serving human wants, of exchanging them and transporting them, must follow on the work of extracting them from the earth. As the arts of production advance, the division of labor multiplies, and the whole industrial process increases in complexity and size. But no matter how big and complex it becomes, every human engaged in productive effort, no matter how far removed from the actual tilling of the soil, is working, in the last analysis, on the land. Nevertheless, many people seem to think that, because the apex of the pyramid has grown higher, the base has been lifted from the land.

The facts that proportionately fewer people are engaged in the primary extractive processes as the arts of production advance, that primitive barter is replaced by a vast and intricate system of exchange based on monies and credit, and that we talk in terms of billions of dollars rather than in hundreds--these facts do not, and cannot alter the basic relationship of mankind to the soil. Like the dust that forms our bodies, everything we work on or with, everything we buy or sell, everything we use in any way comes originally from the earth and goes ultimately back to the earth. That is nature's cycle, and man's puny devices cannot alter it. Man can create nothing and destroy nothing. He cannot add so much as a grain of sand to the universe or subtract one

FROM IT. ALL HE CAN DO IS CHANGE THE FORM AND THE LOCATION OF NATURAL MATERIALS TO HIS ADVANTAGE OR DISADVANTAGE.

THE BASIC CHARACTER OF CIVILIZATION HAS BEEN DETERMINED LARGELY AT THE AGRICULTURAL FRONTIER. THE HARSH REALITIES OF THE FRONTIER SIFT AND WINNOW OLD VALUES, ATTITUDES, AND INSTITUTIONS, KEEP THOSE WHICH ARE RELEVANT UNDER NEW CIRCUMSTANCES, AND REPLACE THOSE WHICH ARE NOT, BY NEW SETS OF VALUES, NEW CONCEPTS OF LIFE, NEW INSTITUTIONS FOR ORGANIZING HUMAN EFFORT. AT THE FRONTIER THE VALUES OF INDIVIDUAL INDEPENDENCE AND OF PERFORMANCE AS THE MEASURE OF WORTH ARE BUILT INTO A STRUCTURE OF INSTITUTIONS WHICH ORGANIZE INDIVIDUAL EFFORT INTO GROUP ACTION, WHICH CHANNEL PRIVATE INCENTIVE INTO PUBLIC PURPOSES, WHICH EXPAND HUMAN CAPABILITIES BY PROVIDING INDIVIDUALS WITH MEANINGFUL MECHANISMS THROUGH WHICH THEY CAN IN SOME MEASURE CONTROL THEIR OWN DESTINIES. AS THESE VALUES AND INSTITUTIONS ARE TRANSFERRED INTO THE CITIES BY THE CITY-WARD MIGRATION OF RURAL PEOPLE, THEY ARE ADAPTED AND MODIFIED TO MEET THE NEEDS OF THEIR NEW ENVIRONMENT AND SOLIDIFIED TO FORM TOGETHER WITH THEIR PARENT RURAL INSTITUTIONS THE HARD SKELETON OF MODERN URBAN LIFE.

AS PRESENTLY UNDERDEVELOPED COUNTRIES ENTER INTO ACCELERATED PROGRAMS OF ECONOMIC DEVELOPMENT THEY WILL PERFORCE ENTER ALSO INTO A PERIOD OF SOCIAL AND INSTITUTIONAL CHANGES--CHANGES AS DEMANDING AND PROFOUND AS THOSE WHICH LAY AHEAD

OF THE FOREFATHERS OF THE DEVELOPED NATIONS OF THE WORLD. AS IN THE EARLY YEARS OF THOSE NATIONS, THE BASIC SOCIAL AND POLITICAL CHARACTER OF EMERGING NATIONS IS NOW BEING FORGED AT THEIR AGRICULTURAL FRONTIERS. AGRICULTURAL DEVELOPMENT OF THESE COUNTRIES INVOLVES DIFFERENT TYPES OF FRONTIERS TO BE SURE, A PUSHING BACK OF PRESENT SCIENTIFIC AND TECHNOLOGICAL RATHER THAN GEOGRAPHIC FRONTIERS. BUT MASSIVE ADJUSTMENTS OF OLD INSTITUTIONS AND CREATION OF NEW VALUES WILL JUST AS INEVITABLY RESULT FROM BRIDGING THE TIME GAP OF CENTURIES OF TECHNOLOGICAL PROGRESS AS THEY DID FROM CROSSING A CONTINENT AND SUBDUING THE FOREST, PRAIRIES, AND DESERTS.

THE TECHNOLOGY AND IMPROVED EFFICIENCY OF MODERN AGRICULTURE ARE AS FABULOUS AS THE CONQUEST OF OUTER SPACE, AND THEY ARE FAR MORE SIGNIFICANT FOR THE WELFARE OF MANKIND. YET, AS WE MARVEL AT WHAT MAN HAS WROUGHT FROM THE LAND IN THE APPLICATION OF SCIENCE AND TECHNOLOGY, WE ARE AWARE THAT SERIOUS ECONOMIC AND SOCIAL PROBLEMS HAVE BEEN GENERATED BY THESE ACHIEVEMENTS.

UNDER THE TWIN SPURS OF ADVANCING TECHNOLOGY AND ECONOMIES OF SCALE, THOUSANDS OF PEOPLE LEAVE THE LAND FOR THE CITY. IN THE UNITED STATES, THE NET MIGRATION FROM FARM TO CITY WAS HEAVIEST DURING THE 1950'S, WHEN IT AVERAGED 800,000 PERSONS A YEAR, AND THE TREK TO THE CITIES PERSISTS AT A RATE OF WELL OVER 100,000 ANNUALLY.

TO A VERY SUBSTANTIAL DEGREE, THE PROBLEMS OF OUR CITIES ARE CREATED BY THE MIGRATION OF PEOPLE WHO, ONCE THEY DECIDE TO LEAVE THE LAND, DO NOT AUTOMATICALLY TURN INTO SKILLED, OR EVEN SEMI-SKILLED FACTORY EMPLOYEES. THE CHALLENGE TO GOVERNMENT, TO BUSINESS, TO EDUCATION TO HELP THESE URBAN NEWCOMERS GET AN EDUCATION, JOBS, AND A DECENT PLACE TO LIVE IS OBVIOUS.

GOVERNMENTS, NATIONAL AND LOCAL ALIKE, HAVE ONE HOPEFUL ANSWER--INDUSTRY. HERE AND THERE INDUSTRY HEEDS THE CALL. NEW PLANTS ARE BEING LOCATED IN RURAL AREAS; INCOME OR SALES TAXES ARE ELIMINATED. TAX-FREE BONDS WHICH USE LOCAL CREDIT TO ATTRACT INDUSTRY TO AREAS OF LABOR SURPLUS HAVE BEEN OFFERED.

IN THE LONG RUN DIRECT GOVERNMENTAL HELP TO AGRICULTURE'S CASTOFFS AS THEY STREAM FROM COUNTRY TO CITY MAY BE REQUIRED. THIS HELP MIGHT TAKE THE FORM OF RETRAINING FOR NEW JOBS, INCLUDING INCOME OR SUPPORT PAYMENTS DURING THE RETRAINING PERIOD. IT MIGHT TAKE THE FORM OF COUNSELING SERVICES BEFORE, DURING, AND AFTER MOVES. IT MIGHT INCLUDE SOME FINANCIAL HELP FOR THE DIRECT MOVING COSTS. AND LASTLY, IT MIGHT INCLUDE SOME MODEST SUPPLEMENTARY INCOME PAYMENTS FOR A LIMITED TERM IN THE NEW LOCATION TO FACILITATE THE PAINS AND PRESSURES OF CHANGE.

GOVERNMENTS MIGHT ALSO CONSIDER SHIFTING FINANCIAL AID PROGRAMS FROM COMMODITY PRICE SUPPORTS TO FARM INCOME, AND THE TYING OF THIS SUPPORT TO PEOPLE RATHER THAN TO LAND; FUNDS FOR EARLY RETIREMENT PROGRAMS FOR PRESENTLY ACTIVE BUT OLDER FARMERS, AID TO RESIDENTS OF SMALL RURAL TOWNS WHICH ARE DEPENDENT PRIMARILY UPON AGRICULTURAL SUPPLY BUSINESSES FOR THEIR EXISTENCE, COOPERATIVE PROGRAMS FOR RESTRICTING RURAL LAND SETTLEMENT PATTERNS AND RURAL SOCIAL SERVICES, AND A DIRECT ATTACK ON RISING LAND PRICES.

THE FOREGOING SUGGESTIONS ON HOW GOVERNMENT MAY AID MAN IN DEALING WITH THE PROBLEMS OF OBTAINING HIS LIVELIHOOD FROM THE LAND COME FROM AGRICULTURAL RESEARCHERS AND PLANNERS IN UNIVERSITIES. NO AGENCY OF SOCIETY HAS CONTRIBUTED MORE TO MAN'S UNDERSTANDING OF THE SOIL AND HOW HE MAY MANAGE IT BEST FOR HIS SURVIVAL THAN THESE INSTITUTIONS. IT IS ABOUT THEIR ROLE THAT I SHALL DIRECT MY CONCLUDING REMARKS ABOUT LAND AND LIFE.

FOR MORE THAN A DECADE I HAVE BEEN CHALLENGING OUR INSTITUTIONS TO BROADEN THEIR CONCEPT OF AGRICULTURE. NO LONGER SHOULD THEY DEFINE AGRICULTURE SOLELY IN TERMS OF THE FIELDS WHICH GROW OUR CROPS AND THE PASTURES AND RANGES WHICH PRODUCE OUR LIVESTOCK. THEY MUST CHANGE THEIR DEFINITION TO INCLUDE ALL LAND--CULTIVATED LAND, GRAZING LAND, FOREST AND WILD LAND,

THE DESERT AND THE OPEN LAND ADJACENT TO CITIES. IT MUST ALSO INCLUDE THE WATERS IN LAKES AND STREAMS.

I HAVE ALSO SUGGESTED THAT AGRICULTURAL SCIENTISTS AND PLANNERS BROADEN THEIR CONCEPTS. IN THE PAST THEY HAVE GENERALLY CONCENTRATED ATTENTION ON THE ALLOCATING OF RESOURCES AS THESE AFFECT AGRICULTURAL PRODUCTION AND THE MARKETING OF FOOD AND FIBER. THEY MUST NOW EXTEND THEIR THINKING BEYOND THESE OBJECTIVES AND CONSIDER HOW FARMERS AND URBAN PEOPLE CAN LIVE AND WORK TOGETHER, EACH OBTAINING FULL USE OF NATURAL RESOURCES AND EACH PAYING HIS FAIR SHARE.

WHEN WE LOOK AT PROJECTIONS MADE BY LEADING AGRICULTURAL RESEARCHERS ON THE LAND THAT WILL BE REQUIRED TO PRODUCE THE FOOD FOR THE WORLD'S RAPIDLY EXPANDING POPULATION, WE ARE CONFRONTED WITH A MYRIAD OF COMPLEX, CONFLICTING QUESTIONS ON LAND USE. AMONG THEM ARE:

HOW CAN WE ADJUST AGRICULTURAL RESOURCES TO PROVIDE MAXIMUM BENEFIT FOR SOCIETY AS A WHOLE, BUT WITH MINIMUM HARDSHIP FOR A FEW?

SINCE LANDS CURRENTLY NOT IN PRODUCTION, BUT WELL SUITED FOR PRODUCTION, SHOULD BE AVAILABLE FOR USE BY FUTURE GENERATIONS, WHAT TYPE OF COST SHARING WILL BE EQUITABLE AND FEASIBLE?

WHAT ARE THE BEST USES OF THIS LAND THAT ONE DAY WILL GO INTO PRODUCTION? DO WE NEED NEW TYPES OF PROPERTY ARRANGEMENTS TO SHIFT LANDS TO BEST USES FOR AN INTERMEDIATE PERIOD?

IT HAS BEEN ESTIMATED THAT IN THE UNITED STATES ALONE EXPANDING POPULATION WILL CONTINUE TO SUBTRACT APPROXIMATELY ONE MILLION ACRES OF AGRICULTURAL LAND ANNUALLY FOR URBAN DEVELOPMENT. ANY EXPANSION OF THIS MAGNITUDE CREATES INEQUITIES, PARTICULARLY IN THE RURAL-URBAN FRINGE. WHAT METHOD OF TAXATION IS EQUITABLE IN A MIXED RESIDENTIAL-AGRICULTURAL AREA? HOW CAN THE AESTHETIC VALUE OF OPEN SPACE BE PRESERVED?

AGAIN, ESTIMATES HAVE BEEN MADE THAT THE DEMAND FOR OPEN SPACE FOR RECREATION ALONE WILL INCREASE TEN-FOLD IN ANOTHER FIVE YEARS. THE POTENTIAL MARKET FOR RECREATIONAL USE OF AGRICULTURAL LAND IS ALMOST UNTAPPED. RESEARCH IS NEEDED TO ANSWER SUCH QUESTIONS AS:

WHAT ARE THE DEMANDS? WHAT ARE THE DIMENSIONS OF BOTH DEMAND AND SUPPLY?

HOW CAN FARMERS SELL RECREATIONAL PRIVILEGES TO AN URBAN SOCIETY WHICH LOOKS UPON THESE AS AN INHERITED RIGHT?

IF RECREATIONAL PRIVILEGES ARE TO BE KEPT FREE, HOW CAN FARMERS BE REIMBURSED FOR THE USE OF THEIR LAND AND ITS WILDLIFE?

DO WE HAVE A TRESPASS PROBLEM? WHAT IS IT? HOW DO WE SOLVE IT?

THESE AND MANY OTHER QUESTIONS MUST BE ANSWERED SATISFACTORILY IF AGRICULTURE IS TO DEVELOP ITS FULL RECREATIONAL POTENTIAL. THE AREAS OF INQUIRY ARE ALMOST LIMITLESS. HOW WILL AUTOMATION AFFECT LIVING AND RECREATIONAL HABITS OF OUR CITIZENS RELEASED FROM MANY TYPES OF WORK?

AND IN AN ENTIRELY DIFFERENT FIELD-WHAT ARE THE SOCIAL SCIENCES DISCOVERING ABOUT MAN'S NEED TO BE PHYSICALLY LINKED WITH NATURE?

AGRICULTURAL SCIENCE AS A WHOLE HAS DEVELOPED REMARKABLY IN SEVERAL PARTS OF THE WORLD, BUT IN A PIECEMEAL FASHION. ESPECIALLY THERE HAS BEEN ONLY A BEGINNING IN THE APPLICATION OF THE SOCIAL SCIENCES TO PROBLEMS OF AGRICULTURE AND THE PEOPLE ON THE LAND, AND ALREADY THERE IS A DANGER OF APPLICATION ATTEMPTING TO GO BEYOND THE BASIS OF FACT THAT MUST SUPPORT IT.

WORLD AGRICULTURE CONSISTS OF MANY AGRICULTURES. PROBLEMS RELATED TO THE WHOLE CAN BE STATED ONLY IN THE MOST GENERAL TERMS. REFERENCE TO PARTICULAR REGIONS, AND ABOVE ALL TO INDIVIDUAL FARMS, MUST BE BASED ON SPECIFIC KNOWLEDGE. WHAT IS LEARNED IN ONE REGION MAY HAVE LITTLE APPLICATION IN ANOTHER.

TOO MANY OF THE IDEAS WE HAVE NOW ARE GENERALIZED FROM TOO FEW PARTICULARS, AND ARE INSPIRED MORE BY BOOKS THAN BY LAND; AND TOO MANY OF OUR BOOKS ARE WRITTEN SIMPLY FROM OTHER BOOKS, NOT FROM STUDIES OF ACTUAL LANDS AND THE PROBLEMS OF PEOPLE WHO LIVE ON THEM.

MAN LIVES AND MUST WORK TO SUPPLY HIS NEEDS IN AN ENVIRONMENT THAT IS BOTH SOCIAL AND PHYSICAL. ALL OF THE LAND IN THE COUNTRY COULD BE MADE TO PRODUCE CROPS, AND THERE IS NONE THAT WILL PRODUCE WITHOUT LABOR. WHAT LAND WILL BE USED AT ANY MOMENT, WITH WHAT TECHNIQUES, AND WITH WHAT SUCCESS, DEPENDS UPON THE SOCIAL AND ECONOMIC FRAME OF REFERENCE WITHIN WHICH PEOPLE WORK, AS WELL AS UPON THE PHYSICAL ENVIRONMENT. EVERY TIME THE ECONOMIC AND SOCIAL CONDITIONS CHANGE, A NEW PHYSICAL PROBLEM IS CREATED, AND EACH TIME A NEW TECHNIQUE IS DEVELOPED, A NEW ECONOMIC QUESTION APPEARS. NEW PROBLEMS FOR BOTH THE PHYSICAL AND SOCIAL SCIENTIST WILL ARISE AS LONG AS SOCIETY CHANGES. AND WHEN SOCIETY CEASES TO CHANGE, THE END WILL HAVE COME. STUDENTS OF AGRICULTURE ARE COMING TO THIS REALIZATION. LAND STUDIES IN AN ECONOMIC VACUUM AND ECONOMIC STUDIES IN A PHYSICAL VACUUM COMPETE FOR USELESSNESS AS CONTRIBUTIONS TO A SOLUTION OF OUR LAND PROBLEMS.

THERE IS MORE SERIOUS THINKING TODAY ABOUT MAN AND THE WAY HE OCCUPIES THE LANDSCAPE THAN EVER BEFORE, AND A NEW SCIENCE