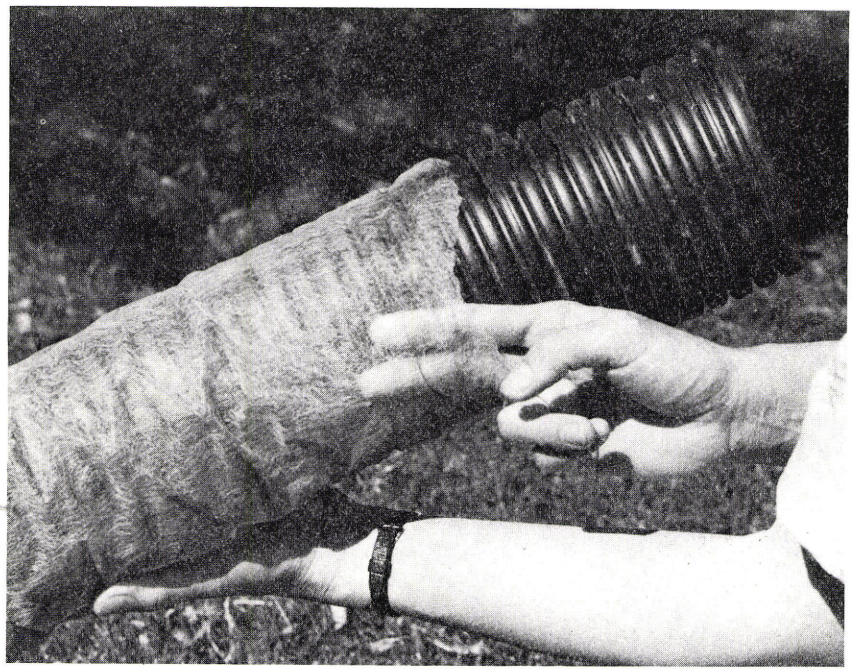
COOPERATIVE EXTENSION UNIVERSITY OF CALIFORNIA

SOIL and WATER

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SYNTHETIC DRAIN ENVELOPE. Can a synthetic sleeve replace the conventional envelope of gravel or sand? Story on page 1.

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TABLE OF CONTENTS

		Page
1.	Envelopes for Subsurface Drainage Systems	1
2.	Assessing Potentials for Agricultural Water Conservation	2
3.	Variation in Salt Concentrations in a Wheat Field ..	8
4.	"Up to Date on 208"	8
5.	Kearney Foundation Research Grants	10
6.	Guidelines for Water-Run Ammonia	11
7.	Drip Emitter Clogging Vs. Water Quality	11

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ENVELOPES FOR SUBSURFACE DRAINAGE SYSTEMS

Subsurface drainage systems are frequently installed with an envelope of gravel or sand placed around the drain tubing. This envelope has a two-fold purpose:

1. It acts as a filter and prevents fine soil particles from entering the tubing. This function of the envelope is particularly important in silty soils.

2. It promotes better flow conditions in the immediate vicinity of the tubing by increasing the effective diameter of the pipe. This is because the hydraulic conductivity of the envelope is much greater than that of the surrounding soil.

Pea gravel is the most common envelope material used in California. Because the hydraulic conductivity of the gravel is very high, this material improves flow condition around the drain tubing. However, pea gravel has a negligible effect in preventing particles from entering the drain tubing. Several cases have been reported where the backfill in the trench was washed into the drainage system. Pea gravel was used in these cases.

Because of the cost and inconvenience of gravel or sand envelopes, several manufacturers of tubing have developed synthetic envelopes. These envelopes consist of sleeves of synthetic materials fitted over the tubing. The materials used are nylon, polyester polypropylene or rayon.

One question concerning these materials is how do they affect the performance of the drainage system. A literature search on this subject indicates that synthetic envelopes perform satisfactorily in sandy soils. Table 1 contains data from a comparison of two drain laterals, one with a gravel envelope and the other with a synthetic material. The rate of decline of the water table was about the same for both laterals thus indicating that any envelope effects on flow into the drain are the same for both materials.

Unfortunately, little literature on the performance of synthetic materials in fine-textured soils is available. However, reports have been received where drainage systems initially installed with a synthetic envelope were reinstalled with gravel envelopes because the synthetic material appeared to plug.

A study of a drainage system with a synthetic envelope was conducted this past winter. The soil at this site was primarily clay with some silt. Piezometers were installed on top of the drain tubing to measure any water standing above the drain, thus possibly

TABLE 1. Rate of water table drop for an area drained with corrugated plastic tubing with gravel envelope and with synthetic envelope. (Hermsmeir, L.F. Economical Envelopes for Subsurface Drains, American Society of Agricultural Engineers. 1977).

Time After Irrigation (days)	Rate of Drop (cm/day) Gravel	Synthetic
1	14.8	10.5
2	9.7	11.0
3 - 6	5.6	5.2
6 - 9	3.4	3.6

indicating plugging.

The results showed that about three feet of water was standing directly above the drain tubing throughout the study. One lateral was uncovered downstream from the study area and the flow-rate from the tubing was measured. The discharge was about 0.5 gpm. The length of the lateral contributing to this flow was 1200 feet. A conclusion reached from this investigation was that the synthetic envelope was plugged.

Because of this study and other observations, it is suggested that caution be used in installing drain tubing with a synthetic envelope in fine-textured soils. Sandy soils appear to be relatively problem-free. More studies are in progress on these subjects. Results will be reported as they become available.

- Blaine Hanson

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ASSESSING POTENTIALS FOR AGRICULTURAL WATER CONSERVATION

In a revision of policy in 1975, the state Department of Water Resources (DWR) made water conservation a key element of California's water policy. In 1977 President Carter proposed a revised Federal Water Policy "with water conservation as its cornerstone," and in recent years the California legislature, water districts, various concerned groups, and the general public have placed major emphasis on water conservation.

Since agriculture uses 85% of California's applied water, the general public and many government officials understandably assume that more efficient use of water on farms would lead to a substantial net saving of water-which could then be available to others who need it. However, large usage of water does not necessarily lead to excessive waste. An important point, often not well understood, is the sequential use of water that takes place in most agricultural areas. Water that runs off

irrigated farmland or percolates below the plant roots usually is not wasted from the viewpoint of the total resource since it returns to surface or groundwater supplies. That water is not actually lost unless it evaporates to the air or flows to some sink, such as the ocean, from which it cannot be feasibly recovered.

This article provides a conceptual framework to clarify what happens to agricultural water and where true water losses occur. Only then can we realistically assess the potentials for agricultural water conservation and the accompanying trade-offs.

Water that remains on or below the land surface, e.g., seepage (S), leakage (L), operational spills (SP), surface runoff (RO), and deep percolation below the root zone (DP), is recoverable for reuse. Water lost to the air by evaporation or transpiration or to highly saline bodies such as the Pacific Ocean or Salton Sea is not feasibly recoverable. Since waters leaving a farm, irrigation district, or hydrologic basin as S, L, SP, RO, or DP are still part of the area's water supply, they are not *true* losses, and are therefore referred to as *recoverable* "losses". In contrast, 1) flows to saline sinks or to soil and rock formations from which extraction is difficult, and 2) evaporation from open water (EW) or from soil (ES) and transpiration (T) are termed *irrecoverable* losses since they cannot be recovered, except through the lengthy hydrologic cycle.

Conservation means different things to different people. Webster defines it: "to keep from being damaged, lost, or wasted; to save; also, planned management of a natural resource to prevent exploitation, destruction or neglect". Controversies arise not so much over the idea of water conservation itself but over the side effects of conservation measures and who benefits or is adversely affected. The following are a few examples of water-conservation measures:

1) Storing water in reservoirs behind dams allows timely release, but may have some adverse environmental effects.

2) Storing water underground, where it is not subject to evaporation or to outflow to the ocean, makes it available when needed, e.g., in conjunction with surface water when the latter is in short supply. Pumping groundwater, however, is energy-consuming, and over reliance on it could cause overdrafts, seawater intrusion in coastal areas, and land subsidence with an associated reduction in groundwater storage capacity.

3) Lining canals and farm ditches reduces S losses but could eliminate useful contributions to groundwater recharge and wildlife habitats.

4) Improving irrigation efficiency, by reducing RO and DP (both recoverable "losses") through improved water application systems and timing of irrigation, based on crop needs, would reduce irrigation delivery requirements, sometimes energy, and possibly other production inputs *for individual farmers*. However, it also would result in reduced leaching of salts and lower return flows for other users. Reducing RO and DP will generally not conserve water *for the state* except in situations where RO and DP are subsequently lost to E, T, or to a sink from which recovery is not feasible. Some people suggest that improved irrigation efficiency could, in some situations, actually increase water losses

from the state where the reductions in farm water demands would leave more water in rivers for outflow to the ocean.

5) Reusing water by utilizing farm return flow systems conserves water on-farm and thus reduces farm water diversions. Reusing water several times within a basin can result in high basin efficiencies in spite of low on-farm irrigation efficiencies. Such reuse, although achieving higher water use efficiency, may have some energy-and water-quality-related disadvantages.

6) Reducing irrecoverable flow to saline bodies (mainly the ocean) by diverting or intercepting them before they are lost would benefit users of diverted water and would result in less outflow of usable water from the state.

Reducing irrecoverable ET losses to the air by modifying water surfaces, watershed and riparian vegetation, by selecting crops, and by more carefully managing irrigation, would clearly reduce the most important losses of pure water from the state. Since total ET losses (including losses from watershed vegetation) amount to 150 of the 206 million acre-feet (MAF) of California's annual water inflow, it can be said that a large potential for conservation exists. However, the practicality of reducing ET from all vegetated land, and especially from irrigated crops, needs investigation. Reducing ET could provide benefits both *on-farm* (reduced demands and associated energy costs) and *for the state* as a whole (i.e., increased water available for other uses).

In addition to the cost of the conservation measures listed above, adverse effects could include loss of crop yield, possible microclimate changes, reduced wildlife habitat, and need for additional water storage and conveyance facilities. Thus, it should be recognized that water conservation can encompass an array of actions, many of which are endorsed by both those who believe that water conservation will largely balance California's future water supply and demand and by those who acknowledge the desirability of conservation but believe that California's needs will require additional water development.

On-farm water conservation measures include improvements in water distribution and application systems. Possible water conservation measures on irrigated fields and their effects on-farm, off-farm, and for the state are summarized in Table 1 (see page 5).

In California, transpiration from plants-which necessarily accompanies plant growth-is usually the largest component (70-95%) of total ET losses during a growing season. ET, however, helps to moderate the climate. The magnitude of crop ET varies with time of year, location, crop spacing, and length of crop growing season. Some examples for typical irrigated crops in the San Joaquin Valley, California, in inches ET per growing season, are: beans, 17; corn, 25; grapes, 28; sugar beets, 35; clean-cultivated orchards, 38; alfalfa, 44; and orchards with a cover crop, 51. An estimated 25 MAF of water are annually lost by ET from California's irrigated agriculture. Accordingly, even a small percentage reduction in ET would provide a substantial decrease in consumptive use, thus lowering demand on presently developed water supplies or permitting new uses.

How might ET losses be reduced significantly? It is necessary to look at three dimensions of the process: 1) the surface area, 2) the rate, and 3) the time duration of evaporation or

Table 1. Effects of water conservation measures applied on-farm to irrigated fields.

Loss	Aim	How	Water Conservation Effect: On-Farm	Off-Farm (other users)	State
Recoverable Losses					
Runoff	Reduce it	Improve application efficiency by land leveling, determining root zone water deficit, measuring water & changing irrig. system	Reduced delivery reqt. & thus reduced $ paid for water and/or pumping energy	More water left in source for others to use	Does not conserve water unless there is loss to saline sinks or loss of ponded water to ET
	Reuse it	Tailwater system	Reduced delivery reqt. & thus reduced $ paid for water and/or pumping energy, but may need energy for tailwater pumpback	Less tailwater for other users and for in-stream flow maintenance	Does not conserve water unless there is loss to saline sinks or loss of ponded water to ET
Deep Percolation	Reduce it	Improve application efficiency by land leveling, determining root zone water deficit, measuring water & changing irrig. system	Reduced delivery reqt. & thus reduced $ paid for water and/or pumping energy	Could reduce groundwater recharge and result in greater pumping costs	Does not conserve water unless there is loss to saline sinks or non-recoverable formations
	Reuse it	Collect in drains, or by wells, & pump as needed to place of reuse	Reduced delivery reqt. & thus reduced $ paid for water and/or pumping energy, but requires pumping energy to recover it	If intercepted by tile drains, could reduce groundwater recharge	Does not conserve water unless there is loss to saline sinks or non-recoverable formations
Irrecoverable Losses					
Evaporation (from soil)	Reduce it	Less surface wetting by drip irrig. or reduced irrig. frequency. Mulches, etc.	Will save some water (& thus reduce delivery reqt. somewhat), usually without depressing crop yield. Reduces irrecoverable loss to atmosphere but not as much as T reduction	Little, if any, effect	Reduces irrecoverable loss to atmosphere, but savings small relative to transpiration
Transpiration (from crops & weeds)	Reduce it	Reducing area, rate, & time duration of transpiring surfaces, e.g., by crop selection & mgmt., deficit irrig., antitranspirants, and weed control	Has potential for substantial water saving (& thus reduce water demands & $ paid for water and/or pumping energy), but generally reduces crop yield proportionately	More water left in source for others to use	Potential for large reduction of water that is irrecoverably lost from the state to the atmosphere, but will likely reduce crop production

transpiration. Reducing any of these would curtail ET. In some parts of the system, little if any water savings appear feasible, e.g., we can't reduce the surface area of existing reservoirs, but EW rate may be curtailed by hexadecanol on the surface of reservoirs that are not subject to frequent wind and wave action. Reducing the area of soil wetted by using drip irrigation or by reducing the time available for soil evaporation by irrigating less frequently could curtail ES, but the magnitude of ES savings is usually considerably smaller than that of transpiration losses.

The possibility of reducing transpiration deserves special attention because it involves the largest potential for water savings as well as for resultant costs. For example, reducing the area of land cropped would reduce ET but obviously would also diminish production proportionately. Some groups strongly recommend a reduction in the acreage of crops grown for livestock feed in California. They argue that while such crops consume nearly half of the state's irrigation water, they are valued at less than one-third of California's total annual agricultural production of $10 billion and do not contribute to California's export revenue. However, they do reduce imports and have other benefits. While reducing the acreage of forage crops would indeed curtail demand, the consequences of such action would have to be considered in terms of: 1) the water demand and value of the replacement crop or municipal and industrial uses; 2) the impacts on industries and consumers allied to forage production, i.e., meat, dairy and poultry; and 3) increased imports of these products. Thus, the idea of changing cropping patterns to reduce water demands is complex, and the effects must be considered at all levels throughout the food supply and economic systems.

An increasingly suggested option, probably close to the idea of "having your cake and eating it too," is the theory that acceptable crop yields can be achieved under deficit irrigation which reduces transpiration by stressing the plant, hopefully during growth stages when water stress affects yield only minimally. However, since the relationship between crop ET and yield (the water production function) is often essentially linear, few crops will produce near-maximum yields if stressed. Nevertheless, for those crops with flatter production functions, the relatively small yield reduction per unit ET curtailment may be acceptable where crops are relatively low in value but water is costly. Reducing ET by selecting and breeding varieties with shorter growing seasons may also lower yields to a greater or lesser degree depending on the crop and the situation. Curtailing ET could result in fewer irrigations per season and in reduced inputs of labor, water, energy, and fertilizer. Gain or loss in net dollar returns per acre will depend on the relative values of these inputs.

Various estimates by DWR of possible annual agricultural water conservation have ranged from 0.2-1.2 MAF (up to 3.8% of water applied to agriculture). Some environmental groups believe it is closer to 2 MAF (6.3%). What is the *potential* for agricultural water conservation? *All* the water now delivered for irrigation could be "saved" by returning to dryland agriculture, where some production would be possible, and by abandoning production in low rainfall areas. But such moves would be absurd!

The pertinent question, therefore is: What is the realistic potential for agricultural water conservation? The short answer is-we really don't know because:

1) The potentials for water savings depend upon many things including the practicality and economic feasibility of changing cropping patterns;

2) the acceptability of risks inherent in practicing deficit irrigation or of closely matching ET losses to available water in order to maximize water use efficiency;

3) the desirability of reducing RO and DP in terms of impacts on other uses and users; and

4) the capability of feasible changes in water distribution and irrigation systems to actually reduce significantly on-farm and basin-wide water use.

Full assessment of on- and off-farm benefits and costs of specific conservation measures will necessarily require extensive basic data and numerous site-specific studies, including effects on groundwater supply, water quality, and energy use. Approximate information could, however, be developed soon to 1) clarify the extent to which the agricultural water conservation can reduce water demand, and 2) provide a sound basis for selecting and implementing water conservation programs where potentials of realistic water savings have been shown to exist. Different levels of water conservation stringency may be appropriate concurrently in different parts of the state.

Because so many considerations are involved, some justification can be found for widely divergent estimates of potentials for water savings in California's irrigated agriculture. However, it is important to be realistic and to specify the changes which would be needed to accomplish the water savings which are projected.

Nearly two years ago, the University of California proposed that an Interagency Task Force (involving state and federal agencies and the University) conduct an objective re-evaluation of water conservation potentials in California's irrigated agriculture. They consulted with a Study Committee representing other concerned agencies, interest groups, and viewpoints to achieve maximum objectivity. This re-evaluation study will hopefully be undertaken soon and lead to a preliminary report at an early date.

University studies now include water production functions for principal crops (begun more than 10 years ago); relative water application efficiencies of different kinds of irrigation systems; E losses from surface vs. drip systems; usefulness of irrigation management services and improving irrigation programming information for farmers; feasibility of using brackish water and treated wastewater for crop irrigation; relation of irrigation management to groundwater recharge and groundwater quality; possible benefits of agricultural water conservation; and also a number of economic, social, and institutional aspects such as water pricing and management alternatives. The University expects to intensify these studies in cooperation with agencies, water district, farmers and others.

Summary

It is important that recoverable water *be* recovered and re-used as efficiently as possible. However, it should not be permitted to accumulate under conditions where it is subject to evaporation or to transpiration losses by non-productive vegetation. Furthermore, if seepage, surface runoff, and deep percolation make contributions to soil moisture available to crops, to groundwater, or to wildlife habitat and re-

creation, that water cannot be regarded as lost. High priority should be given to preventing water flow to saline sinks and also to assessing the feasibility of reducing evaporation and transpiration because such losses are irrecoverable. Conservation decisions must take into account the appropriate balance of potential water savings against net farm income, possible reductions in food and fiber production, infrastructural viability, and the ability of California farmers to retain flexibility in their operations and remain competitive in the market.

- David Davenport, Assoc. Res. Scientist, and Robert Hagan, Land, Air and Water Resources, UCD.

(This article is reprinted from Western Water, Nov./Dec. 1979 issue).

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VARIATION IN SALT CONCENTRATIONS IN A WHEAT FIELD

As part of a larger study into the breeding potential of wheat and barley for salt-affected crop land, we have also examined the variability in salt concentrations in the root zones of a wheat field. Results reported here were obtained from an irrigated wheat crop near Stratford in Kings County.

To survey the basic variation in salt concentrations in the top 60 cm of soil, samples at soil depths 0-30 cm and 30-60 cm were taken every 15 meters in a square grid pattern in November. The variability encountered is shown in Fig. 1

To monitor salt concentrations in different parts of the root zone throughout the growing season, salinity probes were placed at five points along a 15 m transect. The flux in salt concentrations was monitored at different depths at each point. Salt concentrations at each point and each depth remained similar over the growing season. Mean electrical conductivities averaged over the grain filling period are given for each point in Table 1. Similar variation to that shown in Table 1 has also been observed in much smaller transects one metre in length.

Editorial Note: For comparison, Bernstein reports that wheat yields are reduced 10% when EC_e is about 7 mmhos cm^{-1} and 50% when EC_e is about 14 mmhos cm^{-1} (Salt Tolerance of Plants. USDA Agr. Info. Bull. 283, 1964).

- Richard A. Richards and Charles Dennett, Dept. of Land, Air and Water Resources and Dept. of Agronomy and Range Science, UCD.

(Figure 1 and Table 1 are on following page)

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"UP TO DATE ON 208"

The State Water Resources Control Board on April 17, 1980, accepted a grant of $2.1 million from EPA to assist the state with eight projects to improve water quality conditions. Work plans for these projects have been developed under Section 208 of the Federal Clean Water Act which sets forth appropriate procedures to be used to solve non-point source water quality problems.

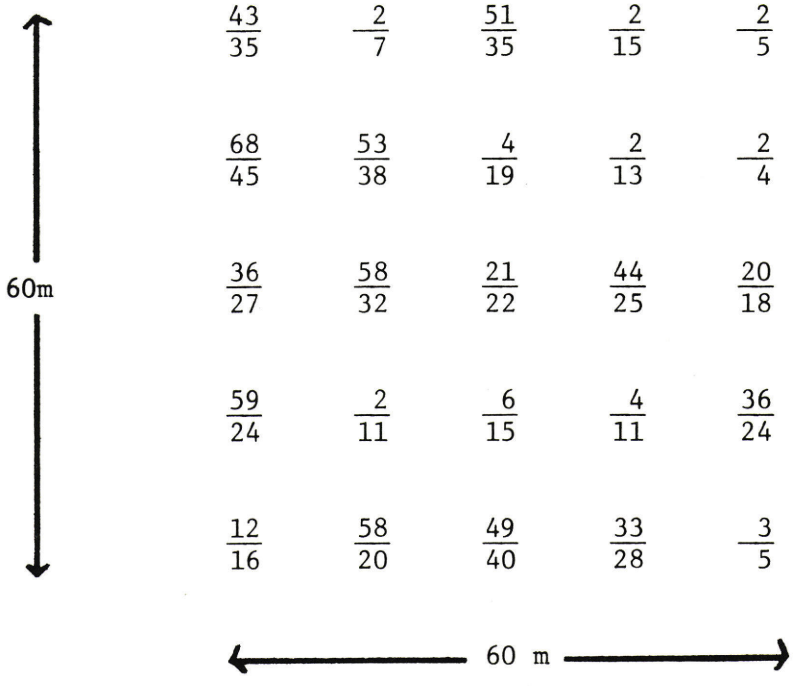
The projects are located throughout the state, from the north (North Coast Watershed Evaluation) to the south (upper Newport Bay Sediment project). Of particular interest are two projects in which Cooperative Extension will probably provide considerable leader-

From article on page 8.

TABLE 1. Variation in salt concentrations (EC_e in mmhos cm^{-1}) at 15 m transect at different soil depths.

Depth (cm)	Transect Point A	B	C	D	E
5	2	2	8	45	10
15	7	22	30	42	45
30	18	33	23	34	18
45	14	28	33	-	-

Figure 1. Variation in salt concentration in part of experimental site. Upper figures: EC_e at 0-30 cm; lower figure: EC_e at 30-60 cm. EC_e values in mmhos cm^{-1}.



ship.

The first project is the Pajaro Groundwater Study in which the Association of Monterey Bay Area Governments proposes to alleviate overdrafting and seawater intrusion of the Valley basin by implementing an irrigation scheduling service. The second is the San Joaquin River Study which will identify and control nonpoint sources of pollutants which reach the San Joaquin River and adjacent area groundwater basins. It is anticipated that Best Management Practices (BMP's) that could help to control existing problems caused by agricultural return flows will be developed. County Extension offices will be kept informed of the progress of the project and where appropriate contacted for their advice. It is most encouraging that state agencies concerned with water pollution control problems are beginning to use the resources available through the University and Cooperative Extension.

The problems of urban runoff have led to the establishment of a Nationwide Urban Runoff Program (NWRP) to collect and study data on urban nonpoint sources of water pollution. In California, there is a great need for a better understanding of the causes and results of erosion in urbanizing areas together with the cost effectiveness of control measures. To allow discussion of these concerns in greater detail, an Urban Erosion and Sediment Control Seminar is being planned for California this next September. It will be held once in Southern California and once in the north.

The California Association of Resource Conservation Districts is the lead agency in the planning effort, but other agencies and organizations will act as co-sponsors. Cooperative Extension is participating in the Steering Committee. As soon as program details are finalized, we will inform our Extension staffs of this effort to provide information on the effects of urban runoff on water quality.

- Stephen P. Carlson
and Jack M. Rible

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KEARNEY FOUNDATION RESEARCH GRANTS

The 1980-85 mission of the Kearney Foundation of Soil Science is "Soil and Crop Response to Water and Fertilization Under High Salinity and Limited Water Supply". Twelve research projects are to receive funding during the 1980-81 period. The titles and principle investigators are listed here:

1) Response of Plants to Dissolved and Adsorbed Boron. F.T. Bingham, UCR, and J.D. Rhoades, USDA Salinity Lab.

2) Genetic Engineering of Osmoregulation (Osm) Genes: 1) Response of Rhizobium/Host Plant Symbiosis to Specific Salts in Saline Soils; 2) Survey of Osm Genes and Selections for Salt Tolerant Mutants. D. Munns, UCD, R.C. Valentine, UCD, L. Csonka, UCD.

3) Boron Interactions in Saline Soils as Affected by Sodium Calcium and Magnesium. S.V. Mattigod and A.L. Page, UCR.

4) Nitrogen Use Efficiency as Influenced by Sulfur Assimilation in Wheat Exposed to Salinity. R.C. Huffaker, D.W. Rains, C.O. Qualset, UCD.

5) Responses of Crops to Fluctuating Salinity. A. Lauchli, and E.

Epstein, UCD.

6) Competitive Exchange and Adsorption of Ionic Solutes in Low Quality Waters During Transport Through Soil. G. Sposito, S.Y. Chu, A.L. Page, K.M. Holtzclaw, T.J. Ganje, UCR.

7) Ultrastructural Studies on the Effects of Salinity on Seed Germination. W.W. Thomson, UCR.

8) Estimate of the Mean Value and Variance of Solute Concentrations, Soil Water and Solute Fluxes From Discrete Measurements and Computer Modeling for a Field Experiment Using Saline Water for Crop Irrigation. W.A. Jury and L.H. Stolzy, UCR.

9) Plant Physiological Response to Interactions Between Salt and Water Stress and N Utilization. V.V. Rendig, and F.E. Broadbent, UCD.

10) Salinity Responses of Crop Plants at Different Levels of Mineral Nutrient Supply. N. Terry, and L.J. Waldron, UCB.

11) Carbonate and Sulfate Chemistry and Mineralogy in Salt-Affected Soils. K.K. Tanji, and L.D. Whittig, UCD; R. Levy, Israel.

12) Crop Response to Temporal and Spatially-variable Soil Salinity Profiles. D.E. Rolston, J.W. Biggar, R.J. Miller, D.R. Nielsen, F.E. Broadbent, UCD.

- Stuart Pettygrove

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GUIDELINES FOR WATER-RUN AMMONIA

For water-run nitrogen, UAN 32 and urea-water solutions will result in lower volatilization losses than aqua or anhydrous ammonia. Even so, many growers have used, and will continue to use, ammonia for water run applications of nitrogen. Guidelines for use of NH_3 appear in Agricultural Anhydrous Ammonia (M.H. McVickar, et al., ed., American Society of Agronomy, 1966). The following paragraph is from a chapter written by R.E. Warnock: "Many furrow-irrigated row crops have been found to respond favorably to ammonia in the irrigation water. It is generally accepted that up to about 100 ppm N as ammonia (22 lb N/acre-inch) may be applied in surface irrigation before losses become serious. At this concentration a 4.5-inch irrigation might apply as much as 100 lbs of N per acre. However, in practice, rates of application are usually less than 50 lbs N/acre at each irrigation. At higher rates of application some risk of toxicity from volatile ammonia exists, but experience has shown little or no problem at 15 to 30 ppm N in the irrigation water".

- Stuart Pettygrove

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DRIP EMITTER CLOGGING VS. WATER QUALITY

A recent publication by U.S.D.A. water scientists will be of interest to those who are plagued by clogging problems in drip irrigation systems. The article is a summary of work done at the U.S. Water Conservation Laboratory in Phoenix by Dale Bucks, Francis Nakayama and R. Gene Gilbert. Entitled "Trickle Irrigation Water Quality and Preventive Maintenance", it is available from USDA, SEA-Agricultural Research, U.S. Water Conservation Laboratory, 4331 E. Broadway, Phoenix, Arizona, 95040.

The authors introduce a system for classifying irrigation waters to estimate potential clogging problems. They do state that it is not yet a foolproof system but it has worked out fairly well in their work. If you're interested, either write for the publication or let me know and I'll send you a summary.

- Jack Rible

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Stuart Pettygrove

Stuart Pettygrove
Editor

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