WEEKLY REPORTS

Following are USWCL "ARS Weekly Activity Report" submissions for 1999. Each research scientist submits a minimum of one report per year. These reports are consolidated at ARS Area level and submitted to ARS headquarters for the information of agency and departmental management.

Floyd J. Adamsen, Soil Scientist
ARS scientists at the U. S. Water Conservation Laboratory in Phoenix, Arizona, have begun evaluation of a new generation of probes that measure soil moisture. The new probes utilize time domain reflectance (TDR), which provides accurate measurement of soil moisture over a wide range of conditions. New prototypes from a commercial manufacturer are being evaluated under a range of soil moisture and soil salinity conditions to determine the limitations of the probes. These probes can be used with standard data loggers and the data collected used to control irrigation system. The new prototypes under evaluation are projected to cost less than $100. Older TDR systems cost from $800 to $8000. The cost of the new probes is low enough to make them practical at the farm level and from a research standpoint the new probes are inexpensive enough to allow detailed studies of soil water relations that can account for field variability. A CRADA may be initiated to support further development of this technology.

Edward M. Barnes, Agricultural Engineer
ARS scientists at the U. S. Water Conservation Laboratory in Phoenix, Arizona, are involved in a cooperative project with the University of Arizona, Texas A&M University, and the Idaho Environmental and Engineering Laboratory to determine new information sources for precision crop management systems. The project is focused on the integration of data collected by sensors which are mounted on farm equipment. These sensors are equipped with a computer simulation model that determines the water and nitrogen status of a crop. The sensors, measuring the amount of reflected light in the visible and near-infrared part of the spectrum, provide an inexpensive method to describe the within-field variation in crop development to the model. As the sensor data is collected at infrequent intervals, the model is used to provide predications of daily conditions when the sensors are not in use. The first year of the project is complete and initial results from data collected in cotton and barley experiments have demonstrated the sensor's ability to detect differences in water and nitrogen levels. A second cotton experiment is in progress to refine and validate the system. Ultimately this approach could provide agricultural producers with an inexpensive and convenient method to collect the data needed to practice site-specific crop management.

Eduardo Bautista, Agricultural Engineer
ARS scientists at the U.S. Water Conservation Laboratory in Phoenix are developing a computerized approach for scheduling the operation of irrigation water delivery systems for known or predicted water demands. Most scheduling approaches currently in use are empirical and rely on operator experience. With these traditional approaches, water control is not very precise and can result in significant variations in delivery flow rates to users and operational spills. Computerized scheduling approaches, which are based on an understanding of the canals hydraulic properties, can improve water control and thus improve the management of the resource at the canal level and ultimately at the farm level. Computerized canal scheduling has not been applied extensively in the past, partly because implementation of the schedule requires control hardware that is relatively expensive, and partly because of the complexity of the approaches. Because the cost of control hardware is

decreasing rapidly and labor costs for water delivery organizations are rising, significant adoption of computerized canal control technology is likely to occur in the near future, making these approaches more attractive. The proposed scheduling approach is computationally simple and intuitive to users and therefore appealing for practical applications.

Herman Bouwer, Research Hydraulic Engineer
Herman Bouwer, Research Hydraulic Engineer at the U. S. Water Conservation Laboratory in Phoenix is currently conducting research on how sewage irrigation affects underlying groundwater. Globally, increasing populations and finite water resources will lead to serious water shortages, more transfers of water from agricultural irrigation to municipal use, and more use of sewage effluent for urban and agricultural irrigation. The normal concern for such irrigation is that it will contaminate underlying groundwater with salts, nitrates, and pesticides to the point where this major water resource can no longer be used for drinking without further treatment. However, careful scrutiny of effluent quality parameters indicates that other contaminants such as disinfection byproducts (DBPs) and pharmaceutically active chemicals (PACHs) can also reach groundwater. In relatively dry climates, the concentrations of these chemicals in the drainage water can be a multiple of those in the effluent itself. Plant nutrients in effluent can enhance plant growth , leaving more plant residue in the field to decompose which increases the formation of humic and fulvic acids. DBPs include known and suspected carcinogens, PACHs comprise a multitude of drug residues and industrial chemicals, some of which can mimic estrogen. Long-term health effects and synergisms are of concern. Humic substances are DBP precursors, so that when contaminated groundwater is pumped up and chlorinated for drinking, a whole new suite of DBPs will be formed. More research on how sewage irrigation affects underlying groundwater is urgently needed. Various studies in cooperation with universities and health agencies are being planned. They range from sewage irrigated vegetated soil columns , where chemical inputs and outputs can be monitored, to analyzing groundwater below areas with a long history of sewage irrigation. Plans for international participation have been initiated through the World Federation of Scientists (WFS). A paper on these issues has been prepared and published, as well as a position paper on water for the 21st century and emerging issues for WFS.

Thomas R. Clarke, Physical Scientist
A remote sensing experiment run during the 1999 cotton growing season is showing promising results in the development of a suite of sensors for detecting the crop's fertilizer and water needs. A very rugged multi-spectral radiometer built at the U.S. Water Conservation Laboratory in Phoenix measured surface temperature and reflected light from the crop three to five times a week throughout the season. Scientists at the laboratory believe these combined sensors will enable growers to manage water and fertilizer applications more precisely. The experiment was conducted in cooperation with The University of Arizona Department of Agricultural and Bio-Engineering

Albert J. Clemmens, Laboratory Director
ARS scientists and Bureau of Reclamation engineers collaborate on the release of software for flow measurement structures--an important contribution to water management and conservation. Over the last three decades, ARS scientists at the U.S. Water Conservation Laboratory in Phoenix, Arizona, have developed technology for measuring the flow rate of irrigation water in open channel canals, particularly using long-throated flumes, which have become standard devices worldwide because of their low cost, simplicity, and high accuracy. ARS previously developed software for design and calibration of these structures and recently worked with U.S. Bureau of Reclamation

engineers who converted the software to a more user-friendly windows environment. This software is now available on the Bureau's web site and has been distributed widely.

Terry A. Coffelt, Research Geneticist

ARS scientists at the U. S. Water Conservation Laboratory in Phoenix, Arizona, and Western Regional Research Center in Albany, California, in cooperation with scientists at the University of Arizona, Texas A&M University, University of California, New Mexico State University, and University of Akron have been awarded a two-year grant from the Fund for Rural America to help solve problems in the commercialization of guayule for the U.S. Guayule is a source of hypoallergenic natural rubber latex suitable for making medical products. Latex allergies are becoming a serious health problem with over 40 % of U.S. medical workers and 60% of multiple surgery cases now allergic to Hevea latex products. Specific goals of this project are: 1) to identify weed control strategies necessary for successful production; 2) to determine optimum seed harvest times for maximum seed production and seed quality; and 3) to determine methods for optimizing the yield and quality of guayule latex as they relate to harvest methods and harvest time as well as storage conditions prior to latex extraction. Knowledge obtained from this cooperative project will facilitate the commercialization of guayule.

David A. Dierig, Research Geneticist

Scientists at the U. S. Water Conservation Laboratory in Phoenix have developed a new line of *Lesquerella fendleri*, a potential new industrial oilseed crop, that will significantly advance its commercialization. The improved line overcomes an important obstacle to the plant's commercialization. Many applications of this hydroxy seed-oil require special processing, thereby increasing costs, to remove pigmentation from the oil. Plants were selected for a mutant seed coat color, which is associated with the seed-oil pigment. The oil from this new germplasm line has less pigmentation and provides germplasm with high genetic diversity for future improvements by public and private researchers. Development of lesquerella into a viable commercial crop will provide an alternative crop for U.S. farmers and an alternative domestic source of hydroxy fatty acids, presently filled by imported castor.

Sherwood B. Idso, Research Physicist

Scientists at the U.S. Water Conservation Laboratory at Phoenix, Arizona, and Arizona State University's Cancer Research Institute, have recently completed a study of the effects of atmospheric CO_2 enrichment on the growth of a tropical spider lily plant that produces a number of substances that possess strong anti-viral and anti-tumor activity. The findings have positive implications for the production of a number of important new medicines, as well as the long-term health effects of natural products obtained from plants growing in earth's increasingly-CO_2-enriched atmosphere. In two 2-year field studies, they found that a 75% increase in the air's carbon dioxide concentration increased the production of spider lily bulbs (where the medicinal substances are found) by an average of 56%. In addition, they found that the average concentration of the therapeutic substances in the plant bulbs was increased by 18%.

Bruce A. Kimball, Supervisory Soil Scientist

Future water requirements for wheat production in the future may be reduced somewhat by the increasing atmospheric carbon dioxide (CO_2) concentration according to recent measurements by personnel at the U.S. Water Conservation Laboratory, USDA-ARS, in Phoenix, Arizona. Previous studies, mostly using chambers, have found evidence that the increasing atmospheric CO_2 concentration may change the amount of water used by plants. Such a change in plant water use could impact regional water supplies and require farm managers to modify their management practices. To determine the magnitude of such changes under field conditions, plots of wheat were exposed to elevated CO_2 concentrations using free-air CO_2 enrichment (FACE) apparatus. Devoid of walls, the FACE approach is the most natural technique available to conduct such research. Data were collected for four growing seasons at ample water and fertilizer and for two seasons when soil nitrogen was limited The FACE treatment increased daytime foliage temperatures about 0.6 and 1.1°C (1.1 and 2.0°F) at high and low nitrogen, respectively, which suggests optimal regions for wheat production could shift in the future because of the elevated CO_2 alone, regardless of any climate change. Daily water evaporated from the soil and transpired by the plants was consistently lower in the FACE plots, by about 6.7 and 19.5% for high and low nitrogen, respectively. These results suggest that future water use requirements will decrease slightly, provided that changes in climate are not adverse.

M. Susan Moran, Physical Scientist
Information on regional soil moisture conditions is important for mapping rainfall events, monitoring different drying patterns, and assessing water availability for plant growth. Though the demand for such information is high, the means for mapping soil moisture are few. Scientists at the U.S. Water Conservation Laboratory have demonstrated that information from orbiting satellite-based sensors could provide a regional assessment of surface soil moisture content. These sensors detect the return signal from a radar beam directed at the earth's surface, and this signal is related, in part, to variations in soil moisture. The approach developed at USWCL minimizes the effects of varying topography and vegetation on the radar signal, and thus, enhances the link between the radar backscatter and surface soil moisture. With this technique, it may be possible to use the orbiting radar sensor to map soil moisture over large areas with reasonable accuracy. This will lead to a better understanding of weather conditions and improvements in management of scarce resources.

Francis S. Nakayama, Research Chemist
The fabrication of hypo-allergenic medical products from latex extracted from the guayule plant (*Parthenium argentatum*) is coming close to realization. The latex present in the harvested plant can deteriorate rapidly with more than 80% lost after only a few days of field storage. ARS scientists at the U.S. Water Conservation Lab, Phoenix, Arizona, found that the latex content could be maintained by keeping the harvested shrub moist by simply misting the plant. With this treatment, the latex level remains constant for at least a 16-day period, allowing greater flexibility in the processing of the shrub. Improved methods for optimizing latex extraction are being developed that will accelerate commercialization of guayule and its products.

John A. Replogle, Research Hydraulic Engineer
Engineers at the USDA-ARS U.S. Water Conservation Laboratory, Phoenix, Arizona, are addressing a persistent problem of flow fluctuations in farm canals caused by variations in flow conditions in the source canal. Typically, the flow to the farm ditch is through large pipes under the canal road, which are controlled by a gate on that pipe. If the main canal flow deepens in an effort to deliver more water flow further downstream, each of these side deliveries will need adjusting to prevent excess flow from diverting through them, thereby robbing the intended delivery. Because electric power is not available at many remote canal headings, this favors the use of non-electric means to control the flows. We previously built such a non-electric system that worked well enough, but required

expensive constructions at each site. This current effort is to design and evaluate a conceptual system that is expected to be in a "kit" format that will require minimal site modification and significantly reduce installation costs. The system includes newly designed, inexpensive float valves for low pressure applications. These valves will resist plugging by the trash-laden waters. If flow depth in the source canal changes slightly, the float valves will either feed or leak water from an obstructing bladder placed in the pipe to bring the water level in the farm ditch back to the desired depth.

Theodor S. Strelkoff, Research Hydraulic Engineer
The U.S. Water Conservation Laboratory's suite of software for the simulation, management and design of surface-irrigation systems was extended this summer to include a first-draft furrow-erosion component. The principle aim of the user-friendly, menu-driven software is to provide quick responses to a variety of what-if scenarios considered by field advisors, consultants, extension personnel, etc., in developing their recommendations for furrow design and operation. The simulations would show the trade-offs between irrigation uniformity and efficiency on the one hand and top-soil movement downfield or off-field on the other. With irrigation-induced furrow erosion a significant problem in the Pacific Northwest, western Nebraska, and some areas of California, for example, its control can mitigate the loss of soil fertility in the upper parts of fields -- even when the eroded soil is deposited further downfield -- and the pollution of receiving surface waters with sediment when it is not. This software suite, including earlier releases of basin and border-strip design-aid programs, is now available for downloading from the "Software..." link on the Laboratory's web-site home page: <www.uswcl.ars.ag.gov>

Preliminary comparisons between the simulations performed with Idaho soils show good agreement with some measured data on erosion, deposition, and off-field transport but an overly sensitive response to selection of a representative soil particle size. The model is slated for enhancement by inclusion of measured distributions of particle sizes in the soil mix present in the furrow beds.

Brian T. Wahlin, Civil Engineer)
The Imperial Irrigation District (IID) in Southern California has been under political pressure to reduce the amount of its diversions from the Colorado River through improved irrigation practices. Engineers at the USDA-ARS U.S. Water Conservation Laboratory in Phoenix, Arizona, have assisted IID in improving their irrigation practices by estimating the accuracy of the flow measurements into and out of the irrigation district. In this study, errors for individual flow measurements at five key sites in IID were determined and used to validate the estimates of the uncertainty of the annual volume that passes through these sites. This information can then be used to identify opportunities for improving water management practices within the district.

Gerard W. Wall, Plant Physiologist
Researchers at the U.S. Water Conservation Laboratory in Phoenix, Arizona, have shown that elevated carbon dioxide (CO_2), such as is expected in the 21st century, is advantageous for the root system of a wheat crop and consequently, for grain production. Because the atmospheric CO_2 is expected to rise throughout the next century, this work addresses the need to determine if this change in global climate would impact wheat production, the world's foremost grain supply. Scientists investigated the relationship between atmospheric CO_2 and net production by exposing a wheat crop in an open field to about double the amount of CO_2 presently in the earth's atmosphere. The root system of the crop showed an increase in branching, surface area, and thickness for all growth phases,

and the effect was more pronounced under water stress compared with a well-watered crop. This CO_2-induced enhancement in root growth was accompanied by a 10 percent increase in yield under well-watered conditions and a 20 percent increase under water-stressed conditions.