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Water Current

Deon Axthelm, Acting Director
Volume 12, Number 4

Karen E. Stork, Editor
July/August, 1980

NEW DIRECTOR FOR WATER CENTER . . .

Dr. Martin A. Massengale, Vice Chancellor for Agriculture and Natural Resources, has announced the appointment of Dr. William L. Powers as the new Director of the Nebraska Water Resources Center, effective September 1, 1980. Dr. Powers was also given the title of Professor of Agronomy, with tenure. Along with this new position, Dr. Powers was also appointed Acting Executive Secretary of the Universities Council on Water Resources, Inc. (UCOWR) by the UCOWR Board of Directors.

Dr. Powers was formerly director of the Water Resources Research Institute and the Evapotranspiration Laboratory at Kansas State University. He received his B.S. degree from Colorado State University in 1958, and his M.S. (1962) and Ph.D. (1966) degrees from Iowa State University in the field of soil physics.

The entire Water Center staff sincerely welcomes Dr. Powers. We all look forward to working with him in a renewed and accelerated effort to carry out the mission of the Water Center.

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ON THE HOMEFRONT

OWRT FIVE-YEAR RESEARCH PLANNING PROGRAM

P.L. 95-467 (Water Resources Development Act of 1978) mandates State Water Institutes to "cooperate. . . in the development of five-year water resources research and development goals and objectives." As reported in the March/April edition of WATER CURRENT, the Center has begun work on the development of Nebraska's portion of this report.

A graduate student has been hired to collect background information and data for the report. Dr. Paul Gessaman, Professor of Agricultural Economics, has agreed to assist us as project leader in this effort. A detailed outline of the Nebraska report has been drawn up, and work is proceeding to develop a five-year program of Nebraska's water problems and research needs.

Paul may be calling on some of you for information and assistance, and after the draft report is developed, it will be reviewed by the Water Center Executive and Advisory Committees. The final report is due by October 1, 1980.

DR. LEWIS RESIGNS

Dr. Gary Lewis has resigned his position as Assistant Director of the Nebraska Water Resources Center as of August 16, 1980. He will be taking a one-year leave of absence from his position as Associate Professor of Civil Engineering at the University of Nebraska-Lincoln.

The Water Center will certainly miss Gary's valuable experience and expertise. However, we wish him well in his new endeavors.

PUBLICATION AVAILABLE

The Fourth Edition of Publication No. 6, entitled "University of Nebraska Faculty with Competence in Water Resources," is now available through the Water Resources Center. This information was prepared in order to provide a basis for identifying individuals with special competence and expertise for research and/or teaching in the water resources field. It is hoped that this listing will be useful in the future development of both individual and interdisciplinary research project activities.

To obtain a copy of Publication No. 6, contact the Nebraska Water Resources Center, 310 Agricultural Hall, University of Nebraska, Lincoln, Nebraska 68583.

WATER CONSERVATION PRACTICES PRESERVE FINITE WATER SUPPLY

For centuries, water has been considered a free and unlimited resource available for all to use--wisely or indiscriminately. Today many are beginning to realize that water is a limited resource which is easily wasted, carelessly

polluted, and expensive to treat, transport, and store. Our supply of water is finite--we have no more today than we did in prehistoric times. About 3/4 of the world's surface is water--97 percent of that is saltwater and an additional two percent is frozen in glaciers and polar icecaps, leaving only a small percent for our use. These supplies are in great danger of being depleted and lost to man's use through irreversible contamination.

Despite the significant achievements this country has made in the last decade in preserving water and improving its quality, both the quality and quantity of the nation's water remain threatened as the demands of our highly technological society degrade the supply. Although water conservation programs and environmental protection efforts are expanding, the U.S. Water Resources Council reports that domestic and commercial sectors have untapped substantial opportunities for conservation that are needed to reduce demands.

The domestic use of water, which makes up only six percent of the total water withdrawals nationwide, requires the highest degree of treatment. The resulting sewage requires the most expensive treatment to make that water usable again as it costs twice as much to provide wastewater treatment as to provide potable water. The average household uses 87 gallons of water daily for each person--3/4 of that amount in the bathroom. Of all the drinking-quality water supplied to the home each day, only about four gallons are used for drinking and cooking.

Let's consider how these 87 gallons are used. The conventional flush toilet uses five to seven gallons of water a flush. About five gallons of water a minute flow through a faucet and between five and ten gallons a minute through a shower head. So allowing the water to run for just five minutes while shaving can use 25 gallons of water, while a 10-minute shower can send another 50 to 100 gallons down the drain. Even if the bathtub is filled only half full, a tub bath uses 25 gallons of water. It is easy to see that the 87 gallons of water are quickly used, and we have yet to consider the water used for laundry, gardens, car washing, cooking, and cleaning.

Although most people do not intentionally waste water, as much as 10 percent of the water coming into a home can be wasted because of carelessness or lack of awareness. A faucet dripping one drop a second can waste 2,000 gallons of water a year. A forgotten garden hose left running overnight can use more than the family's average monthly supply of water. High water pressure that forces water through the pipes at a rate faster than necessary can waste hundreds, or even thousands, of gallons of water a day.

If we change some of our water-wasting habits, we can save not only water, but also money and energy. In addition to extending present water supplies, water conservation measures can reduce wastewater treatment costs, postpone or eliminate expansion of municipal facilities and distribution systems, cut energy costs, and prevent water pollution. Water conservation does not require extensive renovation in homes or drastic changes in lifestyle. In fact, the most dramatic conservation of water in the home can be achieved with some simple water-saving devices, some maintenance, and a few changes in habits to make sure we use no more water than we need.

(WATER NEWS -- Virginia Water Resources Research Center)

WATER RESOURCES IN NEBRASKA

MRBC PREPARES DRAFT ENVIRONMENTAL IMPACT STATEMENT

A draft environmental impact statement encompassing over 500 projects and programs included in the Missouri River Basin Commission (MRBC) regional plan has been submitted to the Environmental Protection Agency and is now available for public review and comment.

The regional plan includes water projects and programs in 10 states. The approved plan elements are in various stages of consideration, authorization, appropriation, or construction. Although the regional plan has been published once previously, this is the first time an environmental impact statement has accompanied the plan.

"The environmental impact statement provides an overall perspective of how these projects and programs may affect or are affecting the environment throughout the region," MRBC Chairman Millard W. Hall said.

Copies of the statement are available from the Missouri River Basin Commission, 10050 Regency Circle, Suite 403, Omaha, Nebraska 68114. Written comments on the draft environmental impact statement will be accepted until August 20, 1980, with a final statement to be published shortly thereafter.

Comments should be addressed to MRBC Chairman Millard W. Hall. The comments will be reviewed and used in formulating the final environmental impact statement.

WATER AND POWER RESOURCES SERVICE

An appraisal study has been conducted by the Central Nebraska Projects Office of the Water and Power Resources Service in Grand Island, Nebraska, for the Crofton area. Six alternatives for irrigation in northeastern Knox County and in Cedar County in northeastern Nebraska were developed and analyzed in the appraisal report.

Copies of the Summary Sheets for the appraisal study of the Crofton Unit are available from the Water and Power Resources Service, P.O. Box 1607, Grand Island, Nebraska 68801.

FEDERAL HIGHLIGHTS

WATER POLICY IMPLEMENTATION REPORT

The Final Report on Phase I of Water Policy Implementation, a report submitted to the President by the Secretary of Interior, has just been issued. The report notes that "implementation of the water policy initiatives is occurring in two phases. The first phase consisted of interagency task forces

developing plans and specific implementation activities for all federal agencies. The task force work included consultation with states and considerable public participation. This phase also included the promulgation of certain regulations and the transmittal of legislation to Congress. This phase also included the promulgation of certain regulations and the transmittal of legislation to Congress. This phase is substantially complete, and is the primary focus of this report. The second phase will include continuing work on existing initiatives--joint state-federal financing of water development, the independent project review, a strengthened Water Resources Council and improved state-federal water planning. The federal agencies will be responsible for continuing work on such things as water conservation; completion of a unified structural and nonstructural approach to floodplain management; final implementation of the environmental quality (EQ) manual of procedures, changes in the principles and standards (P&S); and resolution of instream flow problems at existing federal water projects."

Copies of this report may be obtained from: U. S. Department of the Interior, Office of the Secretary, Washington, D. C. 20240.

CHANGES AT WRC

Interior Secretary Cecil D. Andrus, Chairman of the U. S. Water Resources Council (WRC), recently announced the resignation of Council Director Leo Eisel, effective August 8, 1980. Dr. Eisel, who has served in the position of Director since August 1977, cited personal and family reasons for his resignation.

Secretary Andrus announced that Deputy Director Gerald Seinwill will assume the role of Acting Director immediately upon Dr. Eisel's departure. Seinwill has served as Deputy since February 1978.

It was also recently announced that Dr. Frank H. Thomas has assumed the position of Assistant Director Policy in the U.S. Water Resources Council, replacing Lewis D. Walker who left the WRC staff in April. The Council's Office of Policy is responsible for the revisions to the Council's Principles and Standards for Planning Water and Related Land Resources. The Office is also responsible for developing the procedures for use by federal agencies in implementing the Principles and Standards.

Thomas, a native of Illinois, was Chairman of the Department of Geography at Georgia State University before joining the Council in 1975 as a specialist in floodplain management. In early 1979, Thomas became Director of the Policy Analysis Division. He received his B.A. degree in geography from the University of Illinois and his M.S. and Ph.D. in geography from Northwestern University.

CONFERENCES

SECOND NATIONAL IRRIGATION SYMPOSIUM

The American Society of Agricultural Engineers (ASAE) is sponsoring the Second National Irrigation Symposium to be held October 20-23, 1980, at the

Nebraska Center for Continuing Education at the University of Nebraska-Lincoln. The objectives of the symposium are to present a summary of current irrigation practices, to review irrigation development during the 70's, to describe significant current research, and to predict future developments in irrigation equipment and practices.

Conference topics include: (1) Challenges to Irrigation in the 80's; (2) Irrigation Development in Nebraska and the Great Plains; (3) Current Status of Irrigation in the U.S.; (4) Discussion of Key Issues--economic return to irrigation, public image of irrigation, benefits of irrigation to the consumer, and environmental concerns of irrigation; (5) Irrigation System Design and Selection; (6) Operation and Management of Irrigation Systems; and (7) Advances in Irrigation Science and Technology. The registration fee, though not yet finalized, is expected to be \$65-75.

For additional information on the program contact: Mr. Dale Heermann, Program Chairman, USDA-SEA-AR, Box E, Fort Collins, Colorado 80522. Telephone (303) 221-0577. Specific details on registration and housing may be obtained from: Mr. Mark Purschwitz, ASAE Headquarters, Box 410, St. Joseph, Michigan 49085. Telephone (616) 429-0300.

MEETING ANNOUNCEMENT

A national conference on "Utilization of Municipal Wastewater and Sludge for Land Reclamation and Biomass Production" will be held September 16-18, 1980, at the Pittsburgh Hilton, University Park, Pennsylvania. The purpose of the conference is to review and discuss current knowledge related to the use of municipal wastewater and sludge for the revegetation of all types of disturbed land. Special attention will be focused on lands disturbed by coal mining activities. The conference will include a field trip to view several strip-mined areas reclaimed with sludge.

For additional information, contact Dr. William E. Sopper, Institute for Research on Land and Water Resources, The Pennsylvania State University, University Park, Pennsylvania 16802. Telephone (814) 863-0291.

INLAND WATERS AND LAKE RESTORATION SYMPOSIUM

An International Symposium for Inland Waters and Lake Restoration will be held September 8-12, 1980, at the Holiday Inn (Downtown) in Portland, Maine. The symposium will provide international exchange of scientific information on the most current lake water quality problems and worldwide investigative efforts. Presentations will be made by recognized world experts in a variety of water pollution control fields. Sessions will also foster discussions among water quality experts, planning personnel, those charged with regulatory responsibilities, lake restoration consulting engineers and the general citizenry for whom the benefits are designed.

The symposium is sponsored by the U.S. Environmental Protection Agency, the Organization for Economic Cooperation and Development and the Maine Department of Environmental Protection. There is no registration fee.

For additional information or to obtain a copy of the program, contact:
Dr. Ann M. Clarke, Project Manager, AWARE, Inc., P.O. Box 40284, Nashville,
Tennessee 37204.

CONFERENCE ON PUBLIC INVOLVEMENT AND SOCIAL IMPACT ASSESSMENT

The Water Resources Center and the College of Business and Public Administration at the University of Arizona, along with the U.S. Army Engineers, is sponsoring a conference on "Public Involvement and Social Impact Assessment" in Tucson, Arizona. Tentative dates for the conference are October 24-25, 1980.

The conference sponsors are looking for presentations on the results of actual evaluations and/or other empirical findings on the progress of public involvement, as well as individuals with insights to provide regarding useful techniques and strategies for involvement and social impact assessment.

Those chosen to participate in this conference will be provided travel expenses and a modest honorarium, as well as an opportunity to interact with other scholars and practitioners in an attempt to improve the state-of-the-art.

Interested participants should submit a brief, yet detailed, proposal and/or review of findings to: Gregory A. Daneke, Associate Professor of Public Policy and Planning, College of Business and Public Administration, University of Arizona, Tucson, Arizona 85721. Telephone (602) 626-5024.

ROCKY MOUNTAIN GROUND WATER CONFERENCE

The Tenth Annual Rocky Mountain Ground Water Conference will be held at the University of Wyoming in Laramie on April 30-May 2, 1981. Planned sessions include: (1) Madison Aquifer Studies--emphasis on USGS Madison Aquifer program; (2) Recharge of Ground Water in Arid and Semi-Arid Lands; and (3) General Session--all types of ground water papers.

Those interested in submitting a paper or desiring additional information should contact the following session chairmen:

Madison Aquifer Studies

Academic and Industry Papers:
Mr. Carle Fricke
Woodward-Clyde Consultants
3 Embarcadero Center, Suite 700
San Francisco, California 94111

General Sessions

Dr. Peter Huntoon
Department of Geology
University of Wyoming
P.O. Box 3006
Laramie, Wyoming 82071

USGS Papers

Mr. Lee Dutcher
USGS - Water Resources Division
Box 25046, Stop 418
Denver Federal Center
Denver, Colorado 80225

Recharge in Arid and Semi-Arid Lands

Ms. Susan Keith
Water Resources Research Center
Douglas Building #28
University of Arizona
Tucson, Arizona 85721

All special inquiries should be directed to Dr. Peter Huntoon.

WATER REUSE SYMPOSIUM II

The American Water Works Association Research Foundation is organizing Water Reuse Symposium II under the sponsorship of the Office of Water Research and Technology, Department of Defense, National Science Foundation, U.S. Environmental Protection Agency and Water Pollution Control Federation. This second week-long series of meetings devoted entirely to renovation and reuse of wastewaters from municipal, industrial and agricultural sources will be held in Washington, D. C., August 23-28, 1981.

Under the theme "Water Reuse in the Future" subjects to be covered include recent case histories, new water recycling research and practical applications. In the selection of papers special consideration will be given to innovative approaches; new, updated or unreported system design and performance data; and practical applications of water reuse as a method of satisfying pollution discharge requirements, as a conservation technique or as an economical and energy efficient water supply alternative. Special emphasis will also be given to the recycling of water by industry, municipalities and agriculture.

Interested parties should submit 10 copies of an abstract no more than two pages long by December 15, 1980 to, along with an Abstract Information Sheet obtainable from: Richard D. Heaton, Water Reuse Symposium II, AWWA Research Foundation, 6666 West Quincy Avenue, Denver, Colorado 80235, USA. Phone (303) 794-7711.

POSITIONS AVAILABLE

PROFESSOR OF HYDROLOGY

A tenure track position in quantitative surface water hydrology is available in the Department of Hydrology and Water Resources at the University of Arizona. Starting date is negotiable but could be as soon as August 1980. First priority will be given to candidates qualified for full professorship who are also qualified and willing to serve as department head, but other candidates will be considered. Academic or professional credentials at the Ph.D. level are required.

Interested applicants should write for further information to Professor Stanley N. David, Chairman, Search Committee, Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona 85721.

The University of Arizona is an Equal Opportunity/Affirmative Action Employer.

GRADUATE RESEARCH ASSISTANTSHIPS IN WATER RESOURCES ENGINEERING

Four doctoral positions are available immediately in the areas of deterministic and stochastic modeling and systems analysis of surface and groundwater systems at the University of Kansas.

Interested students should send a resume to Professor A. K. Tyagi, Department of Civil Engineering, University of Kansas, Lawrence, Kansas 66045. Telephone (913) 864-3807.

WATER RESOURCES/ENVIRONMENTAL ENGINEERING

Case Western Reserve University is seeking applicants with a strong combined background in water resources and wastewater treatment to work jointly with the Chemical Engineering and System Engineering Departments on water-related problems.

Desired qualifications include a Ph.D. and some teaching or industrial experience. Duties include teaching graduate and undergraduate courses, initiating and conducting research, and generally contributing to the continued development of the Department.

Interested candidates should send resumes to: Professor Adel S. Saada, Chairman, Department of Civil Engineering, Case Institute of Technology, Case Western Reserve University, Cleveland, Ohio 44106.

Case Western Reserve is an Equal Opportunity/Affirmative Action Employer.

HYDRAULIC DESIGN/GROUNDWATER FACULTY POSITION

The Department of Civil Engineering, University of Houston invites applications for a tenure track faculty position for a versatile, research oriented person with a Ph.D. degree. The position will involve teaching graduate and undergraduate courses in several of the following areas: Hydraulics, Design of Water and Sewer Systems; Groundwater Hydrology, Open Channel Hydraulics; and Hydrodynamics, Cardiovascular Flows, Hydraulic Structures.

Interested applicants should send a typed resume to: Chairman, Civil Engineering, University of Houston, Houston, Texas 77004.

Telephone inquiries may be placed with Dr. Ned Hwang (713) 749-4489 or Dr. Jerry Rogers (713) 749-4476.

The University of Houston is an Equal Opportunity/Affirmative Action Employer.

EXTENSION WATER RESOURCE MANAGEMENT SPECIALIST

New Mexico State University announces an opening for an Extension Water Resource Management Specialist. Responsibilities will include the development and implementation of an educational program in water management for horticultural crops; development and implementation of an educational program to solve water management problems; training and assisting county extension personnel in water resource management pertaining to horticulture crops, live stock production and water in the home environment; and working cooperatively with advisory committees, teaching and research faculty, county and state extension faculty, Water Resource Institute personnel and producers in the identification and solution of water resource problems of horticultural producers, the ranching community and the home environment.

Qualifications include a Master's degree in agricultural engineering (Ph.D. preferred); knowledge of water resource management; ability to communicate orally and in writing and to teach effectively with farm and ranch clientele; and satisfactory experience in extension or related area demonstrating ability to work with youth and/or adults. Salary and rank will be commensurate with training and experience.

Inquiries and applications should be sent to: John J. Durkin, Acting Assistant Director/Ag and Resource Development, Box 3AE, New Mexico State University, Las Cruces, New Mexico 88003. Telephone (505) 646-1541. Deadline for applications, transcripts and references in August 22, 1980.

New Mexico State University is an Equal Opportunity Employer, and applications will be accepted without regard to race, color, religion, sex, age, handicap or national origin.

QUESTIONS & INQUIRIES

NEWSLETTER ITEMS SOLICITED

The WATER CURRENT Newsletter will publish, without charge, announcements, programs for upcoming conferences, employment opportunities or other newsworthy items on hydrology, water resources or related topics.

QUESTIONS AND INQUIRIES

Newsletter items and inquiries should be sent to: Editor, Nebraska Water Resources Center, 310 Ag. Hall - East Campus, University of Nebraska, Lincoln, Nebraska 68583; or phone (402) 472-3305.

RESEARCH REVIEW

PROJECT TITLE: Management of Irrigated Agriculture With a Limited Water and Energy Supply

PRINCIPAL INVESTIGATORS: Darrell G. Watts, Associate Professor
James R. Gilley, Associate Professor
Department of Agricultural Engineering
Charles Y. Sullivan, Professor
Department of Agronomy
University of Nebraska-Lincoln

The objectives of this project were to: (1) develop management guidelines for producers who are directly faced with limited irrigation water supplies; and (2) develop data of the quality and detail required both for economic analyses of various management plans and for studies of regional impacts of water shortage.

The field research consisted of experiments to increase understanding of corn and sorghum response to water shortage (moisture stress). The experiments were designed to impose stress in a wide range (from none to severe); to impose it for different lengths of time (from as little as a few days up to most of the growing season); and to confine the stress to either one, two or all three of the major growth stage periods (vegetative, flowering and grain-filling). Intensive measurements were made to evaluate the physiological response of the crops to these stresses. The understanding gained from these intensive measurements made possible the improvement and calibration of computer models of plant growth, which were used to evaluate probable impacts of different irrigation management plans for soil and climatic conditions different from those at the experimental site. The emphasis in the modeling study was on corn because of its relative importance and because of the capability to simulate corn growth and yield at this time.

One of the important experiments in the field work included a search for evidence of stress conditioning. This is defined as the conditioning of the plants by imposing stress during non-critical growth stages so that during critical periods the plants would be better able to withstand continued stress. If a "conditioning" effect existed, the end result would be a higher level of yield for a given (but restricted) amount of crop water use (ET), as compared to "non-conditioned" plants. Researchers in California have previously described a strong conditioning effect in corn but did not find this effect in sorghum for their growing conditions. The importance of stress conditioning would be that it could provide a means of reducing yield loss when water was insufficient to supply the water required for full yield without producing stress. It was felt essential that this possibility be explored as one tool for improved management when water is limited.

Following is a summary of some of the observations and conclusions from this project:

Corn

- (1) In 1978, the driest year, withholding of early irrigation causes an evapotranspiration (ET) reduction of 23% during the vegetative stage (prior to tasseling); has no negative effect on final grain yield; and saved 12 cm of irrigation application. The saving was not just because of reduced early-season evaporation from the soil surface, since vegetative growth was also reduced, indicating a transpiration reduction. It is not known how much more water use could be reduced in the vegetative period before there would be an impact on grain yield.
- (2) There was no indication of stress conditioning in the corn genotype that was used most extensively. Early stressing of the crop did not make it more efficient in water use when stress was imposed later in the growing season. For the general conditions under which the work was conducted, stress conditioning of corn does not seem to be a major possibility for a water management tool with limited irrigation.
- (3) The general findings of other workers were confirmed that yield reduction and ET reduction are linearly related. There are some exceptions, however: (a) early-season ET reduction was obtained without yield reduction; and (b) an ET reduction during the tasseling period greater than 40% of that of fully irrigated corn resulted in reduced ear number/plant and caused yield points to be below the linear yield-ET relationship.
- (4) When tasseling period ET reductions were less than 40%, a unit reduction of ET during tasseling caused no greater yield reduction than a unit ET reduction during grain-fill. One period was no more sensitive than another.
- (5) Crop water use efficiency (yield per unit of ET) increased with increasing ET up to maximum yield. Irrigation water use efficiency (yield per unit of irrigation water) decreased with increasing irrigation on all treatments.
- (6) It is important to note that the relationship of yield and applied irrigation is more complex than that of yield and ET. The former is strongly affected by management. When water is limited, increased application during the tasseling and early grain-fill appears to be the more efficient use of the irrigation water. This also serves to reduce stored soil water during later grain-fill near the end of the growing season and allows for the greater retention of snowmelt and spring precipitation in the soil in the following year.

Sorghum

- (1) Maximum grain yields tended to occur when only 80% of the sorghum crop's ET losses were replaced each week. Irrigating at greater than 80% did not improve yield and may, in fact, have decreased it. This effect was most dramatic with the highest yielding hybrids.

- (2) Irrigation cutbacks during the vegetative growth period had significant effects on grain yield, even when the reductions were small. It was expected that some restriction in irrigation application would have no effect on yield, but any amount of irrigation reduction in this period produced some increment of yield reduction.
- (3) Stress conditioning was important in grain sorghum. Grain sorghum adapted physiologically to drought stress during initial exposure periods so that it was better able to withstand subsequent stress exposures with less loss in productivity than when not pre-exposed to stress. A buildup of stresses beginning early in the growing season lowered the relative yield reduction per cm of ET deficit far below that observed when initial stress was imposed during the early grain-filling period. In contrast, for stresses developing only in mid to late grain filling, the conditioning response was slight.
- (4) Data support a general conclusion that the optimal strategy for allocating water in the limited irrigation situation would be to attempt to allow moisture stress to gradually and steadily intensity throughout the growing season. This can be done under sprinkler irrigation by applying each week a constant fraction of the crop's estimated potential water use. The fraction chosen would depend on the degree to which the irrigator needs or desires to cut back on water application. Yield reductions will occur, but these will tend to be lower per unit of irrigation water saved than under any alternative limited irrigation strategy. All irrigation strategies in which ET deficits were confined to one growth stage tended to be less efficient than those where the same total deficit was distributed over the growing season.
- (5) Much greater genotypic differences in relative response to stress were brought out by treatments in which ET replacement was restricted to a particular growth period or periods, than when the restriction was applied throughout the growing season.
- (6) Both grain yield and total above-ground dry matter showed a strongly linear relationship with ET. The slope of this relationship varied, however, depending on the variety and the growth period treatment to which the crop was subjected.
- (7) The water use efficiency tended to decline under any conditions in which moisture stress was experienced by the crop. The decline was least severe when moisture stress was allowed to build up steadily over the growing season.

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