Wetting Front

Water Management Research Unit Newsletter

Vol. 4, No. 1 — USDA-ARS Conservation and Production Research Laboratory — February 2000

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PREDICTING CROP WATER USE–THE NEW FAO-56 METHODOLOGY . . .

by Judy Tolk

Crop evapotranspiration (ET_c) routinely has been estimated from reference evapotranspiration (ET_o) calculated by the Penman method, combined with crop coefficients (K_c). Calculation of ET_c by this method often used procedures outlined by Doorenbos and Pruitt (1977) in a publication commonly known as FAO-24 (United Nations Food and Agriculture Organization's Irrigation and Drainage Paper Number 24).

The crop coefficient is the ratio of ET_c to ET_o. It relates ET_o, which is based on ET of a reference crop, to ET_c by integrating the crop- and soil-specific characteristics that differ from those used for the reference crop, such as crop height (which affects crop aerodynamic resistance to heat and vapor transport), crop-soil resistance to water loss (affected by crop stomatal characteristics and soil texture), and soil albedo.

This methodology has been updated in FAO-56 (Allen et al., 1998), and now uses the Penman-Monteith combination reference ET_o method with grass as the reference crop. In addition to the methods for the single K_c approach which combines both crop and soil evaporation into one value, FAO-56 contains the procedures to calculate a dual K_c, which has separate coefficients for crop transpiration (K_{cb} or basal crop coefficient) and soil water evaporation (K_e).

The dual K_c methodology is recommended for daily calculation of ET_c which requires more accurate values of K_c. It calls for adjustments to K_c, as affected by daily climate as well as changes in soil water balance as determined by soil water holding characteristics and crop rooting depth. The soil water holding characteristics affect calculation of soil water evaporation as well as the water stress factor (K_s), which reduces ET as soil water content declines below the amount which initiates plant water stress.

METHODS

Our objective was to compare measured ET_c of grain sorghum grown in three soil types under full and limited irrigation with predicted ET_c using FAO-24 single crop coefficient and FAO-56 dual crop coefficient methodologies. Measured evapotranspiration (ET_c) of grain sorghum grown in lysimeters containing monolithic soil cores of either clay loam, silt loam, or sandy loam was compared to ET_c predicted using crop coefficients and reference evapotranspiration.

Dual Crop Coefficient

The dual K_c methodology requires some knowledge of the soil type in which the crop is being grown. FAO-56 provides general water holding characteristics based on soil type. As a test of the FAO-56 methodology, this study relied in large part on those recommendations (many of which were confirmed by our own data obtained in previous research). Soil characteristics needed in the calculations included permanent wilting point, field capacity, and first stage soil water evaporation. Also, rooting depth, depth of soil for first stage soil water evaporation, as well as fraction of water extracted before plant water stress begins (55% was used) are needed. Calculation of ET_o in general followed FAO-56 guidelines.

Adjustments were made to daily K_c to account for regional climatic differences from the standard subhumid conditions — minimum relative humidity > 45% and mean wind speeds < 2 m s^{-1} — as they affect K_{cb} and K_{cmax}. The K_{cmax} represents an upper limit of evaporation and transpiration from

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a cropped surface as determined by available energy. K_{cb} was based on four crop growth stages: initial, which runs from planting until approximately 10% ground cover; crop development, from 10% ground cover to effective full cover; mid-season stage, from effective full cover to start of maturity; and end-season stage, which runs from start of maturity to harvest or senescence.

Single crop coefficient

The single K_c approach was also used to predict ET_c. A locally derived coefficient was used for each of 14 crop development stages ranging from seeding through harvest. The stages were determined by the accumulation of heat units.

RESULTS

The differences between cumulative ET_c predicted by the dual K_c methodology and measured ET_c ranged from less than 1% for the limited irrigation treatment in the Ulysses soil in 1998 to 12% for the full irrigation treatment in the Amarillo soil in 1998. These differences represented 1 mm in the Ulysses soil and 74 mm in the Amarillo soil. However, cumulative ET_c predicted for the crop in the Ulysses soil was about 50 mm lower than measured ET_c until almost harvest when the cumulative values converged. For the crop in the Amarillo soil, the difference between measured and predicted cumulative ET_c began at the crop development phase and increased throughout the season.

In general, cumulative predicted ET_c was lower than measured ET_c. A general trend in both years and for all soils was for measured ET_c to be lower than predicted ET_c until mid season, when the trend reversed (Fig. 1). The ET_c of the limited irrigation treatments was adequately predicted in both years. In some cases, the reduction in ET_c predicted by the decline in soil water content below 55% of plant available water did not occur.

ET_c calculated by the single K_c methodology under estimated measured ET_c in every case. The error was as much as 170 mm, or about 25%, of a cumulative ET_c of about 660 mm.

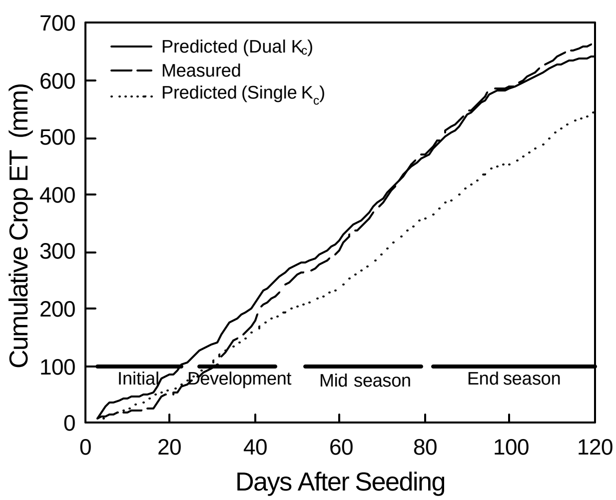

Figure 1. Predicted and measured cumulative water use were similar in most cases.

DISCUSSION

Figure 2 shows K_{cb}, K_c (dual), and K_c (single) for the

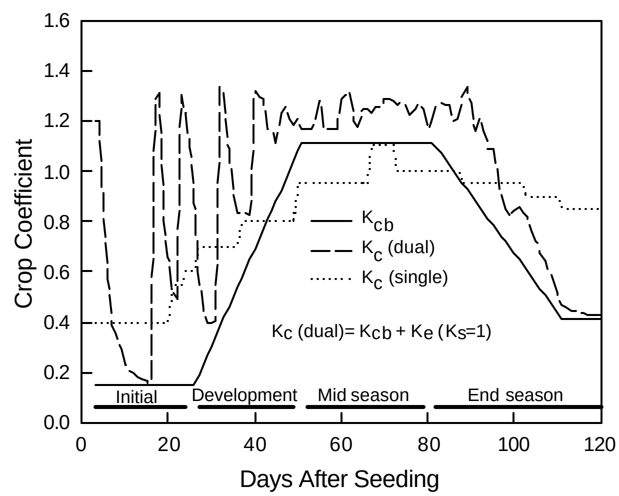

Figure 2. These crop coefficients (K_c) were used to predict the crop water use in Fig. 1. The single K_c was locally derived for short season grain sorghum. The dual K_c was the sum of the basal crop coefficient representing transpiration (K_{cb}) and the coefficient for soil water evaporation (K_e). No reduction in water use occurred due to water stress (K_s).

Wetting Front is published semi-annually (January and July) and distributed by the USDA-ARS, Conservation and Production Research Laboratory, Water Management Research Unit, P.O. Drawer 10, Bushland, TX 79012-0010.

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fully irrigated crop grown in the Pullman soil in 1997. Soil water evaporation (K_e) is the difference between K_{cb} and K_c. This difference is greatest during the initial and development phases, when the soil surface is only minimally shaded. Soil water evaporation continued to be an important component of ET_c through the remainder of the season. K_c was adjusted for mean wind speeds other than 2 m s^{-1} and minimum relative humidity other than 45%. In the semi-arid climate of Bushland, TX, mean wind speed is near 4 m s^{-1} and minimum relative humidity often declines below 40%. This adjustment allowed K_c to be more finely tuned to the environment.

The impact of the adjustment of K_c for soil water evaporation and climatic factors can be seen in the comparison between K_c (single) and K_c(dual). Even though the single K_c values were locally derived, they did not adequately represent the relationship between ET_c and ET_o in this analysis.

At least part of the success of prediction of ET_c using the dual K_c methodology was due to the accurate knowledge of both soil water holding characteristics and especially initial soil water contents. Such accurate information may not be available for predicting ET_c at a non-research location, which would result in greater errors.

CONCLUSIONS

- The dual K_c methodology improved prediction of cumulative ET_c for irrigated grain sorghum crop compared with the single K_c methodology.
- Reduction in ET_c due to plant water stress was adequately predicted with a water stress factor based on soil water holding characteristics.

References

Allen, R.B., L.S. Pereira, D. Raes, and M. Smith. 1998. Crop evapotranspiration. Irrig. and Drain. Paper 56, Food and Agric. Organization of the United Nations, Rome, Italy. 300 pp.

Doorenbos, J., and W. O. Pruitt. 1977. Crop water requirements. Irrig. and Drain. Paper 24, Food and Agric. Organization of the United Nations, Rome, Italy. 144 pp.

EROSION OF WATER MANAGEMENT FUNDING . . .

by Terry Howell

Water Management funding from ARS has remained essentially constant at Bushland since 1979, when the last significant program funding enhancement occurred. WMRU did receive about $90,000 in ARS water quality funding in 1993 that is now part of the base permanent funds. Despite staff retirements and replacements with younger scientists and staff, salaries have increased with annual COLAs (cost of living adjustments), promotions, and performance awards for outstanding and superior performance, and have

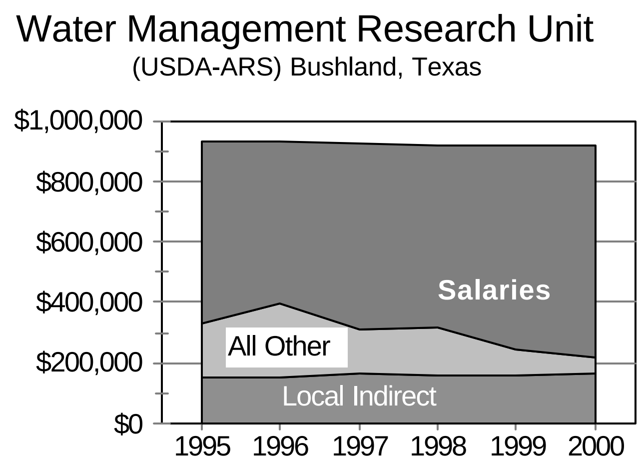


Figure 3. Water management funding (ARS) at Bushland, TX .

"squeezed" available "all other" funding for travel, experiment operational funds, and equipment to the point that only critical repairs and maintenance items can be funded (Fig. 3). The local indirect funds are the WMRU's share of the laboratory's operational costs for basic utilities, services, etc.

However, outside grants have provided the maintenance of new and some on-going projects. In the FY-2001, the executive branch budget for ARS (the president's budget) has a line item for Bushland included for $300,000 to develop irrigated farms in the High Plains to achieve water quality standards while maintaining economic viability. The new research would determine the potential of precision agriculture and supplemental irrigations to reduce nutrient and pesticide loadings to ground water. The funding is within the "Integrated Science for Ecological Changes" and the subheading "Prevent and Control Eutrophicaton, Harmful Algal Blooms, and Hypoxia." Any "new" funding *MUST* be embodied into either an appropriation bill from the U.S. House of Representatives or the U.S. Senate and likely a joint resolution committee and then signed by the President.

CALIBRATION OF NEUTRON PROBES AT UNCGRI, UZBEKISTAN . . .

by Steve Evett

From 24 July to 1 August 1999, I traveled to Uzbekistan at the invitation of the International Atomic Energy Agency (IAEA) to work with scientists of the Uzbekistan National Cotton Growing Research Institute (UNCGRI). I was met by Drs. Nazirbay Abragimov, Head of the Fertilizer Department, and Bakhtiyor Kamilov, Head of the Irrigation Department. The purpose of the trip was to train UNCGRI scientists in neutron probe calibration and radiation safety. Two neutron moisture meters (model 503DR, Campbell Pacific Nuclear International, Martinez, CA) were calibrated at the UNCGRI headquarters, Kibray District, Tashkent Province in a cotton field (Fig. 4). The field was furrow irrigated and had been in continuous cotton for many years. There was an area about 6-m square that had been protected somewhat from irrigation. Three dry-site access tubes were located there; and three tubes were located in the field

Figure 4. Field site for neutron probe calibration. The bare area in the foreground is the dry site. The persons in the background are standing near the wet site.

nearby in ridges of every other row for the wet site.

The best material available for access tubing was ungalvanized steel water pipe, 4.1-cm inside diameter, and 4.8-cm outside diameter. A length of this pipe was cut into six equal pieces of 1.92-m length. The available auger had a diameter slightly larger than the pipe's outside diameter. The tubes were a little loose in the holes but this was unavoidable because there was no other auger that was close to the right size and had a handle long enough to auger below the 1.5 m depth. Access tubes were installed to stand 15 cm above the soil surface. In the field, the ridges were flattened before augering and installing the access tubes. On 27 July, the wet site was bermed and irrigated until water was ponded. Ponding was continued through 28 July.

Thirty-five aluminum soil cans were available, as well as several types of soil sampling tubes and rings. The best available soil samplers were 4.7 cm long and 5.1-cm inside diameter at the cutting edge. The cutting edge had a slightly smaller inside diameter than the rest of the sampler. This was a fairly good design that allowed most samples to be obtained without compressing the soil. To avoid compressing the soil at the top of a sampling cylinder, an aluminum ring was placed above the cylinder while driving the cylinder into the soil. Sample cylinder volume was 96.0 cm^3 and fit into the available sample cans. There was no PVC tape with which to seal the cans, so an umbrella was used to protect the cans from heating in the sun; and they were weighed as soon as possible to avoid loss of water after sampling.

The name of the soil is Typical Gray Soil. It is a deep, uniform soil with no obvious argillic horizon and some $CaCO_3$ nodules beginning at about 50 cm depth. The soil appeared to be an old loess modified such that it is more clayey. Data from an UNCGRI report indicated that it would be considered a silt loam in all horizons in the USDA system. The soil is hard when dry. Although cracks appear in the furrows after irrigation, these are superficial and the dry soil is not cracked deeply.

Neutron probe readings and soil sampling of the dry site began on 28 July. A tube was set in a shallow hole so that standard counts could be taken with the gauges at least 1 m above the ground. At least three standard counts were taken with each gauge. Then, 60 s readings were taken in tubes no. 2 and 3 at depths of 10, 30, 50, 70, 90, 110, 130, and 150 cm with both gauges. With 15 cm of the tubes above the soil surface, there was only 177 cm of tube below ground. That was not enough room to allow a reading at 170 cm. The bottom of the probe was at least 15 cm above the bottom of the hole so that soil in the bottom of the hole did not influence the neutron counts at the 150 cm depth. After the readings were finished, four volumetric samples were taken at each depth around tubes no. 2 (only three at the 10 cm depth) on 28 July and around tube no. 3 on 29 July. It took about four hours to obtain 31 samples with hand digging. There was little or no sample shattering and no discernible compaction.

Samples were weighed to 0.1 g and dried in an oven at 105EC. Because we did not have enough cans, we removed the tube-2 samples from the oven after just 12 h of drying time, so the cans could be used in the field the next day. Twelve hours was considered long enough because the samples were fairly dry when taken. Samples taken from the wet site were dried for 24 h.

Sampling of tube no. 4 at the wet site occurred on 31 July. As soon as sampling started, it became evident that the soil was not as wet as expected. Although the neutron counts indicated that the soil was much wetter than at the dry site, the soil had internally drained much beyond expectations. Close inspection of the undisturbed soil revealed a fine, but visible, porosity throughout the profile that would allow fairly rapid drainage. After sampling at tube no. 4, the soil was re-wet and samples taken at tube no. 5 on 3 Aug.

Data from two dry-site access tubes and one wet-site access tube were used to develop the calibration equations presented in Table 1. Calibrations were good, though not as good as desired. The range of water contents obtained was much less than required for a really useful calibration (Fig. 5). This occurred because the dry-site was not really dry, having been chosen as simply the best site available at the time. A better dry-site might well be obtained directly after winter wheat harvest when the profile had been depleted by the wheat. Such a site could be made even drier by withholding water from a portion of a field after the wheat was well established. The r^2 values were slightly lower than desired, probably due to the inadequate range of water contents. The number of samples for the 10 cm depth is too low for confidence, even though the r^2 values were quite high. It was desired to sample six access tubes, but a lack of time and equipment limited sampling to three tubes.

TABLE 1. Calibration equations for two Campbell Pacific Nuclear International model 503DR neutron moisture meters, obtained at UNCGRI, Tashkent. The r^2 values are adjusted. (CR is count ratio, è is water content in m^3 m^{-3}, RMSE is root mean square error in m^3 m^{-3}, and N is number of samples.)

Serial Number	Equation	r^2	RMSE	N
	10 cm depth			
4791	è = 0.017 + 0.2428(CR)	0.99	0.002	3
4792	è = 0.029 + 0.2268(CR)	0.99	0.003	3
	30 through 150 cm depth range			
4791	è = -0.056 + 0.2685(CR)	0.92	0.008	21
4792	è = -0.029 + 0.2404(CR)	0.92	0.008	21

Data from the second wet-site access tube (tube no. 5) were not used in the calibration because they plotted below the other data (Fig. 6). There are two possible causes of this. First, it is possible that the soil cans lost water between the time that the samples were placed in the cans and the time the cans were weighed. Second, it is possible that the soil samples were taken too long after the neutron probe readings were taken, and soil water drainage in the interim caused the soil to be drier when sampled. It is probable that internal drainage in this soil is rapid at water contents above 0.3 m^3 m^{-3}, making it difficult to sample quickly enough to obtain good data when the soil is very wet. Tube no. 1 in the dry site was not sampled due to lack of time.

The fact that there were four samples for each depth at each of three access tubes allowed the comparison of bulk density and water content values between samples at each depth. Ten samples were omitted from the regression analysis because they had bulk density values much lower or higher than others collected at that depth. Omitting such samples improved the calibration results a good deal. Low bulk densities were associated with water contents that were lower than those of other samples at that depth. The low bulk densities and water contents occurred because of samples that shattered as the sampling ring was driven into the soil. Bulk densities that were higher than normal were due to compression of samples as the rings were driven in. Better sampling equipment, such as the Madera probe, would reduce compression and shattering. Ninety-five samples were taken at the three access tubes. Bulk densities were higher at 10 and 30 cm depths, probably indicating soil compaction due to tillage (Fig. 7).

Slopes and intercepts were as expected for this model of neutron probe and the respective depth ranges. Intercepts are normally positive for the 10 cm depth and negative for depths of 30 cm and below. Slopes for the 10-cm depth calibrations were lower than those for the same probe for the 30 to 150-cm depth range, again as expected. Also as expected, the slopes and intercepts were different for the two probes, illustrating once again that these neutron moisture meters are not interchangeable. Given the narrow range of water contents and the fact that the access tubes were loose in the augered holes, these calibrations should would not be used for soil water measurements. A more thorough field calibration will be conducted when a really dry site has been found or prepared by using a crop to dry out the site by root water extraction.

Aside from the field calibration, training in radiation safety and interesting discussions on alternative crops and limited tillage systems were conducted. Since Independence in 1991, Uzbekistan has converted some 700,000 ha of irrigated cotton land to winter wheat production. At the same time,

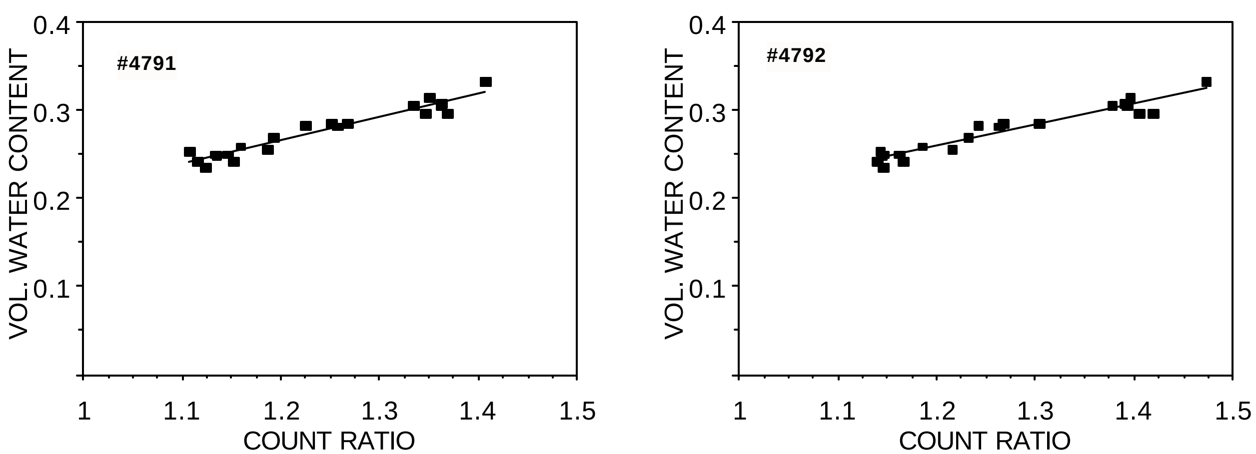


Figure 5. Data and regression lines for calibration of the two neutron probes for the 30 to 150-cm depth range.

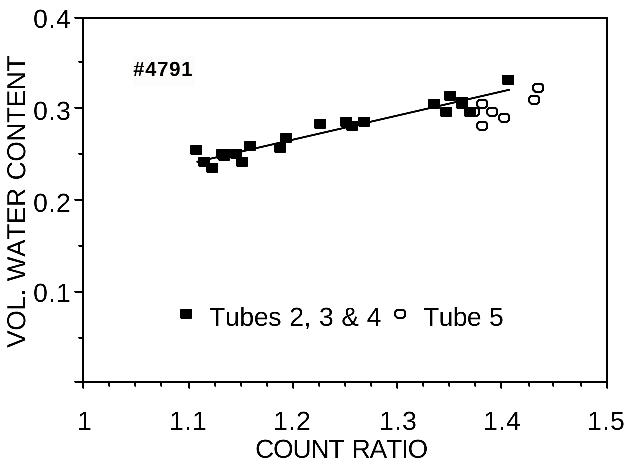


Figure 6. Regression line through data for tubes 2, 3, and 4 showing that data from tube 5 plot below the other data and the line.

dryland wheat production has grown by 200,000 ha. Sugar beet production is also rapidly expanding. The heavy residues left from irrigated wheat production are causing new tillage systems to be examined. Also, lack of scientific irrigation scheduling methods and inefficient irrigation systems have contributed to salinization of most of the irrigated soils of Khorezem and

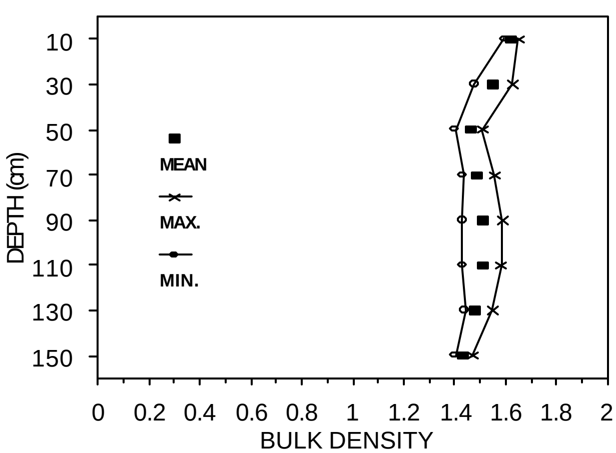


Figure 7. Bulk densities measured during neutron probe calibration.

Kashkadarya Provinces. It is thus quite appropriate that the UNCGRI and IAEA have envisioned a program to measure crop water use with the neutron probe. This is the first step to a rational irrigation scheduling program for Uzbekistan.

I want to thank my collegues in Uzbekistan including Nazirbay Abragimov, Bakhtiyor Kamilov and Shermat Nurmatov, Director of the UNCGRI, for their kind guidance, willing participation, and unfailing hospitality during his visit.

CONTROL OF SPRINKLER RUNOFF IS CRITICAL . . .

by Arland Schneider

Two field studies, recently completed at the Bushland laboratory, illustrate the critical relationship between sprinkler runoff and crop yields and water use efficiency. With modern LEPA and spray sprinkler methods, spray pattern diameters have been drastically reduced to reduce or eliminate drift and droplet evaporation and crop canopy evaporation. As spray patterns have become smaller, instantaneous application rates have increased to the extent that they can greatly exceed the infiltration rate of the soil. As a result, runoff now has the potential to reduce sprinkler efficiency and uniformity more than evaporation losses do. In the two Bushland studies, spray irrigation was used for corn, and both spray and LEPA irrigation were used for grain sorghum.

In the corn study, three tillage treatments — diked furrows, undiked furrows, and flat tillage — were spray irrigated for full or limited soil water replenishment. Full soil water replenishment was achieved through managing the applications of the at 1-inch irrigations to maintain the soil water level (verified with neutron soil water measurements) at a non-yield limiting level. Limited soil water replenishment was 50% of the full irrigation amounts on the same date. Spray heads on a lateral move irrigation system were spaced on 5-ft centers and about 5 ft above the ground surface. Cultural practices were similar to those used for high-yield on-farm corn production in the Southern Plains. Three year average corn yields with full soil water replenishment were 223, 184 and 194 bu/ac with diked furrows, undiked furrows and flat tillage, respectively. Corresponding yields with limited soil water replenishment were 113, 95 and 98 bu/ac. The 1998 yields with limited irrigation were dramatically reduced by smut in addition to the reduction due to limited irrigation in a drought year.

Furrow diking had greater value under full irrigation with grain yields being 21% larger than for undiked furrows and 15% larger than for flat tillage. Furrow diking was also important for limited irrigation with grain yields being 19% larger than for clean furrows and 15% larger than for flat tillage.

In the grain sorghum study, surface runoff and its effect on grain yields were measured for LEPA and spray irrigation with diked and undiked furrows. Full irrigation was 100% of soil water replenishment for maximum grain yields similar to the corn study. Limited irrigation amounts were 0, 40, 60 and 80% of the full irrigation amount on the same date. LEPA double ended socks and spray heads, about 5 ft above the ground, were positioned in or above alternate 30-inch furrows. The 5 gal/min/nozzle flow rate, used uniformly along the lateral move irrigation system, was similar to that at the end of a quarter mile center pivot with a system flow rate of 750 gal/min. Pioneer variety 8212Y variety grain sorghum was planted in mid-May, and fertility and cultural practices were similar to those used by growers for high-yield grain sorghum production. Surface runoff from 66-ft long plots was pumped into steel tanks and measured volumetrically.

Large differences in surface runoff and grain yields occurred between the two sprinkler methods and smaller differences occurred due to the furrow diking. For full LEPA irrigation, the 2-year average irrigation runoff with diked and undiked furrows was 22 and 52% of the seasonally applied water. Grain yields for the diked and undiked LEPA were 5800 and 5340 lb/ac. For full spray irrigation, 2-year average irrigation runoff with diked and undiked furrows was reduced to 0 and 12 % of the seasonally applied water. Grain yields for the diked and undiked spray increased to 7660 and 7350 lb/ac. Percent runoff decreased with irrigation amount until it was essentially zero for all 40% deficit irrigation. As a result, grain yield differences due to sprinkler method and furrow diking also decreased to insignificant amounts when 40% irrigation was applied. All grain yields were reduced by the drought year of 1998 when the maximum grain sorghum yield of any treatment was only 6690 lb/ac.

Sprinkler runoff can be decreased by reducing irrigation depth and increasing crop residues, but basin tillage to increase surface water storage is generally the most effective method. With that tillage method, dikes are placed in furrows to create basins provide the needed surface water storage capacity. For 30-inch spaced rows, the storage capacity is about 2 inches of sprinkler irrigation or rainfall (over whole area) or 1 inch of water applied by LEPA to alternate furrows. Water storage capacity with basin tillage increases slightly with wider furrow spacing and the resulting larger bed heights.

Reference

Schneider, A. D. and T. A. Howell. 1999. Surface runoff from LEPA and spray irrigation of a slowly-permeable soil. ASAE Paper No. 99-2054, St. Joseph, MI. 49085, 16 p.

IA & ASCE TEAM UP ON UNIFYING ET EQUATIONS . . .

by Terry Howell

The Irrigation Association's (IA) *Water Management Committee* asked the American Society of Civil Engineers' (ASCE) *Evapotranspiration in Irrigation and Hydrology* of the EWRI (Environmental and Water Resource Institute) of the Irrigation and Drainage Council to develop a benchmark reference evapotranspiration (ET) equation for the purpose of bringing commonality to the various reference ET equations and crop coefficients now in use. The ASCE committee met with the IA committee representatives in Denver, CO, in May 1999 to present and develop concepts for this project. At the ASCE's committee meeting in August 1999 in Seattle, WA, a special ASCE TASK Committee was formed to complete this assignment that is chaired by Ivan Walter of W.W. Wheeler and Associates in Denver, CO. The Task Committee met again in November 1999 in Phoenix, AZ, to compare calculated daily and hourly ET rates for several ET equation versions.

Both committees have developed products that will have wide utility. The IA Water management Committee has a list of ET resources on a state by state basis on the IA web page at http://www.irrigation.org/ called "The ET Connection" that leads to the committee's page at http://www.irrigation.org/ia/about/wtrmgmt.html that has links to a paper about the ET Connection, a hyper linked version of the ET Connection table, and an Adobe "pdf" version of the table. Several papers are being prepared for the 4th Decennial National Irrigation Symposium in Phoenix on November 14-18, 2000, to present the results.

Newsletter . . .

The *Wetting Front* newsletter is designed to foster technology transfer from our research to industry and to agricultural producers in the Southern High Plains and to improve communications with our stakeholders and partners. For actions or corrections to our mailing list, contact Mrs. Carole Perryman by fax [(806) 356-5750], e-mail (cperryma@ag.gov), phone [(806) 356-5749], or mail [USDA-ARS, P.O. Drawer 10, Bushland, TX 79012]. The *Wetting Front* can also be found on the WWW at http://www.cprl.ars.usda.gov/wmru/wfront.htm. Any suggestions or comments are welcome.

The *Wetting Front* is changing publication dates to permit development at times that don't correspond to heavy meeting, field work, or ARS reporting deadline periods. The former issue months of May and November are being moved to January and July (although) this issue was published at the end of February. Volume 3, therefore, will have only *ONE* issue.

Awards and Recognitions . . .

The **NP-PET Network Team** received an award for Federal Energy Management and Water Conservation from the U.S. Department of Energy on behalf of USDA-ARS on October 28, 1999, in Washington, D.C. The **team** received the Texas A&M University Vice Chancellor's Award for Excellence in Research on January 9, 2000, from the Agricultural Program at the annul staff conference in College Station, TX. The **team** received a Superior Award from USDA-ARS for Technology Transfer on February 9, 2000, in ceremonies at Beltsville, MD.

Karen Copeland received a "superior" annual performance rating and award for service to the Research Unit. **Keith Brock** received an "outstanding" annual performance rating and award.

Jim Cresap received a Spot Award for "superior" performance for 1998-99 research projects and another Spot

Award for operating, recording, and maintaining the laboratory weather station following Ron Davis' retirement and the hiring of Byron Neal in the Wind, Soil and Animal Waste Resources Research Unit.

Brice Ruthardt received a Spot Award for "superior" annual performance in 1998-99.

Carole Perryman received a Spot Award for "superior" performance in 1998-99 and another Spot Award for her outstanding performance filling in for Rayma Cox who was on a temporary duty assignment in Fayetteville, AK.

Terry Howell was elected to *Fellow* by the American Society of Agronomy, and the award was presented at the 1999 annual meeting in October in Salt Lake City, UT.

Steve Evett received an "outstanding" annual performance rating and a *Quality Step Increase* based on 1998-99 performance. **Terry Howell** received an "outstanding" rating and performance award. **Arland Schneider** and **Judy Tolk** received "superior" annual performance ratings and awards.

Grant News . . .

A grant proposal titled "Improving Water Use Efficiency/Reducing Salinization in Irrigated Wheat and Sugar Beet Production" was made by **Steve Evett** to the Civilian Research and Development Foundation for the amount of $79,882.00. Steve is the U.S. co-investigator and Nazirbay Abragimov, Head of the Fertilizer Department, Uzbekistan National Cotton Growing Research Institute is the co-investigator in Uzbekistan. Other investigators are Bakhtiyor Kamilov, Head of the Irrigation Department, UNCGRI, and Maksudkhon Sarimsakov, also of the UNCGRI.

A total of $11,000.00 was contributed by three Texas Panhandle groundwater conservation districts, High Plains, Panhandle, and North Plains, for the purchase of profiling soil water content measuring equipment to be used in a comparative study of such devices in three major soils of the Southern High Plains. The funds will be combined with funds from a grant proposal made to the International Atomic Energy Agency for $20,000.00. Title of the proposal is "Accuracy and Precision of Neutron Scattering, TDR and Capacitance Methods of Soil Water Measurement." Co-investigators are **Steve Evett**, **Judy Tolk**, **Terry Howell**, and **Arland Schneider**. *High Plains Underground Water Conservation District #1*, Lubbock, TX, provided $5,000.00; *North Plains Groundwater Conservation District #2*, Dumas, TX, $4,000.00; and *Panhandle Ground Water Conservation District #3*, White Deer, TX, $2,000.00

Terry Howell received $20,500 from the Texas Agricultural Experiment Station for the state fiscal years 2000 and 2001 for the PROFIT (Productive Rotations on Farms in Texas) for proposal #12-9901 "High Plains Cropping Systems" for cooperative research with Drs. Brent Bean and Steve Winter.

Upcoming Events, Meetings, and Presentations . . .

EVENT:

April 18, 2000 – Dedication of the Grahm-Hoeme chisel Plow as an ASAE Historical Landmark at the USDA-ARS Conservation & Production Research Laboratory, Bushland, TX. **Contact:** Dr. Nolan Clark, (806) 356-5734 or rnclark@ag.gov.

FIELD DAYS:

May 25, 2000 – Wheat Field Day at Bushland. **Contact:** Dr. Mark Lazar (806) 359-5401 or m-lazar@tamu.edu.

September 2000 – North Plains Field Day at Etter. **Contact:** Thomas Marek (806) 359-5401 or t-marek@tamu.edu.

UPCOMING MEETINGS:

March 6-10, 2000 — "Automated Weather Stations for Applications in Agriculture and Water Resources Management: Current Use and Future Perspectives" at the University of Nebraska at Lincoln. **Contact:** Ken Hubbard, (402) 472-8294, (402) 472-6614 (fax), or khubbard1@uln.edu.

March 22, 2000 — USDA-NRCS "Irrigation Water Management Conference" at Boise City, OK. **Contact:** Cleon Namken, (806) 785-5644x142 or Cleon.Namken@tx.usda.gov.

June 20-23, 2000 — Texas Council of Chapters, Soil and Water Conservation Society (TC-SWCS) Meeting "Nutrient/Animal Waste Management" at Tyler, TX. **Contact:** Texas Council SWCS, Dr. Steve Evett, President-Elect (Program Chair), P.O. Drawer 10, Bushland, TX 79012-0010, (806) 356-5775 or srevett@ag.gov.

June 20-24, 2000 — USCID International Conference on "The Challenges Facing Irrigation and Drainage in the New Millennium" to be held on the Colorado State University campus in Fort Collins, CO. **Contact:** Larry Stephens, U.S. Comm. ICID, 1616 Seventeenth St., #483, Denver, CO 80202, (303) 628-5430, (303) 628-5431 (fax), stephens@uscid.org, http://www.uscid.org/~uscid.

July 2-7, 2000 — ISTRO – 2000 (International Soil Tillage Research Organization) at Fort worth, TX, "Tillage at the Threshold of the 21st Century: Looking Ahead."

July 9-12, 2000 — ASAE Annual International Meeting, Milwaukee, WI.

Nov. 14-16, 2000 — "4th Decennial National Irrigation Symposium," ASAE & IA, Phoenix, AZ. **Contact:** Dr. Derrel Martin, Univ. of Nebraska, Biol. Systems Engr. Dept., L.W. Chase Hall, Lincoln, NE 68583-0726, (402) 472-1586, (402) 472-6338 (fax), dmartin@unlinfo.unl.edu.

UPCOMING PRESENTATIONS:

USDA-NRCS Irrigation Water Management Conference, Boise City, OK.

Terry Howell, "Irrigating Corn Using the NP-PET Information" (talk)

ISTRO – 2000 (International Soil Tillage Research Organization), Fort Worth, TX.

Terry A. Howell, A.D. Schneider, and D.A. Dusek, "Effects of Furrow Diking on Maize Response to Limited and Full Sprinkler Irrigation Regimes" (poster & proceedings paper)

ASAE Annual International Meeting, Milwaukee, WI.

Terry A. Howell, A.D. Schneider, and D.A. Dusek "Effects of Furrow Diking on Maize Response to Limited and Full Sprinkler Irrigation Regimes" (oral & paper)

Technology Transfer News . . .

CUSTOMER/CLIENTELE NEEDS:

Steve Evett planned the "Training of Trainers" for Neutron Moisture/Density Gauge Radiation Safety with the USDA Radiation Safety Staff. The training meeting was held May 5, 1999, in College Station, TX. At the meeting, he presented a paper titled, "Achieving ALARA Through Scientific Efficiency in Neutron Probe Use." He wrote training modules on Nuclear Gauge Design, Theory and Operation, and on Routine Cleaning, Lubrication, and Pre-Use Inspection for the course, which was be offered beginning in December 1999. He attended another training session on March 1-2, 2000, to video tape the training materials.

Steve Evett undertook a mission on behalf of the International Atomic Energy Agency to Tashkent, Uzbekistan. Steve worked with Dr. N. Ibramigov of the Uzbek National Cotton Growing Research Institute to evaluate water management practices and fertilizer use under the wheat-cotton rotation and impacts on soil water balance and irrigation water use efficiency. He also assisted in planning and installing a network of soil water content measurement sites using the neutron probe and provided training in probe use and calibration.

Steve Evett attended the regional W-188 committee meeting "Characterization of Flow and Transport Processes in Soils at Different Scales" in Las Vegas, NV, 4-6 January 2000.

MEDIA CONTACTS:

Judy Tolk was interviewed by Bedford Forest of KZRK radio about area agriculture and her research on Sept. 29, 1999.

Steve Evett was interviewed by Bob Givens of KGNC radio on June 30, 1999, about water use and ET estimation for alfalfa and his work with Egypt for the CREET BEAT news item for that week.

Steve Evett was interviewed by Bruce Gaarder with Agrinet Radio from Oklahoma City, OK about crop water use and estimation. He also discussed the NP-PET network and the ATUT project with Egypt.

Arland Schneider was interviewed by Bruce Gaarder with Agrinet Radio from Oklahoma City, OK about cotton irrigation on July 9, 1999.

Terry Howell was interviewed on Dec. 1, 1999, by Bob Givens of KGNC radio about irrigation in the world, U.S., and the Texas High Plains and its importance for the CREET BEAT news item for that week.

VISITORS:

On May 4, 1999, a video crew from Austin, TX tapped interviews with **Terry Howell** and others on the NP-PET team along with **Karl Johnson**, a farmer at Morse, TX, for the TNRCC award presentation.

Dr. James Coppedge, Assoc. Area Dir. Southern Plains Area, visited the laboratory on May 5, 1999.

Tom McDonald, Continental Grain Co., and **Hobert Shaffer** and **Lee Gates** with Premium Standard Farms visited the irrigation research facilities and toured the laboratory on June 3, 1999.

Arland Schneider hosted **Daryl McDonald**, a farmer from Australia, visiting about SDI (subsurface drip irrigation) on July 8, 1999.

Terry Howell and **Rick Todd** explained irrigation and ET research to AISD students on July 16, 1999.

Dr. Howard Graves, Chancellor of the Texas A&M University System, visited and toured the facilities on July 26, 1999.

Arland Schneider and **Terry Howell** met with Amin Iqbal from the Univ. of Stuttgart in Germany, and Arland toured and discussed the SDI (subsurface drip irrigation) research at Bushland with him on Aug. 19, 1999.

On Sept. 7, 1999, the **Texas Agricultural Experiment Station Council of Directors** toured the laboratory.

Dale E. Henry with Resource Exchange International, Inc. of Colorado Springs, CO, along with **Ken Thompson**, a farmer from Brownwood, TX, brought six irrigation scientists and engineers from Uzbekistan on their OASIS 99 tour through Bushland, TX, on Sept. 15-16, 1999.

On Sept. 16, 1999, the **Panhandle Water Planning Committee** toured the research facilities.

On Oct. 9, 1999, a tour was given to two scientists from NASA by TAES and **Terry Howell** discussed the NP-PET and ET research.

Michael Dawes with the Tobacco Research Board, Kutsaga Researcg Station, Harare, Zimbabwe visited on Jan. 17-18, 2000, and toured local farms with drip and center pivot installations. He presented a seminar on "Centre-Pivot Irrigation Research on Tobacco at Zimbabwe."

Jerry Funck and **James Phene** with Netafim visited on Jan. 21, 2000, and discussed drip irrigation research with **Terry Howell**.

SEMINARS/PRODUCER/CLIENTELE MEETINGS/ PRESENTATIONS:

1999 ASAE Meeting:
"Surface runoff from LEPA and spray irrigation of a slowly-permeable soil"
A.D. Schneider and **T.A. Howell**.

1999 ASCE WRE Meeting:
"Efficiency of LEPA and spray irrigation. Proc. Water Resources into the New Millennium: Past Accomplishments, New Challenges"
A.D. Schneider

Don McRoberts attended the Randall Co. Cotton Demonstration at the **Randy Darnell** farm near Bushland in August 1999.

Terry Howell met with the TAES water planning group on PET at Lubbock, TX, on Sept. 28, 1999.

1999 ASA/CSSA/SSA Meeting:
"Corn canopy temperature under feedback irrigation control"
S.R. Evett, T.A. Howell, and **A.D. Schneider**
"Enhancing WUE in irrigated agriculture"
T.A. Howell
"Surface runoff from LEPA and spray irrigation of a slowly-permeable soil"
A.D. Schneider and T.A. Howell
"Field estimation of hydraulic properties using a tension infiltrometer"
R.C. Schwartz and **S.R. Evett**
"Stomatal response of alfalfa to increasing water deficit"
R.W. Todd, J.A. Tolk, T.A., Howell, and **S.R. Evett**
"Daily evapotranspiration of irrigated grain sorghum grown in three high plains soils"
J.A. Tolk and **T.A. Howell**

1999 IA Meeting:
"The ET connection"
B.Q. Mecham, T.L. Spofford, R.G. Allen, and **T.A. Howell**

Terry Howell met with TAES leaders on Dec. 3, 1999, to discuss weather station network needs in Texas at Beaumont on Dec. 3, 1999.

Brice Ruthardt, Jim Cresap, Keith Brock, and **Don McRoberts** attended the Cotton Production Meeting at Memphis, TX,on Jan. 13, 2000.

Terry Howell attended the Pioneer Hybrid Corn Producers Meeting in Panhandle, TX, on Jan. 14, 2000.

Jim Cresap attended the Southwest Crop Production Conference in Lubbock, TX, on Feb. 23, 2000.

POPULAR MAGAZINE ARTICLES: Howell, T.A., Marek, T.H, and New, L.L. 1999. Weather station networks: Data helps improve irrigated agriculture. Resource Magazine 6(10): 7-8.

Howell, T.A. 2000. Drops of life in the history of irrigation. Irrig. J. 50(1):8-10, 13-15.

CRADA/INTER-AGENCY COLLABORATION:

A CRADA is still being finalized with a large swine producer in the Texas High Plains on "Sustainable Irrigation for Swine Production in the Southern High Plains" to identify water efficient cropping systems to utilize swine waste effluent in a semi-arid environment adapted for center pivot sprinkler irrigation to avoid impacting surface and ground water quality.

OTHER TECHNOLOGY TRANSFER ACTIVITIES:

The TACQ program for soil water content measurement by time domain reflectometry was updated on the Unit's WWW site as was the documentation.

Recent Publications (since May 1999) . . .

Evett, S.R. 1999. Energy and Water Balances at Soil-Plant-Atmosphere Interfaces, Chapter 5 in M.E. Summer (ed.) A-129-A-184, CRC *Handbook of Soil Science*. CRC Press.

Evett, S.R., F.H. Peters, O.R. Jones, and P.W. Unger. 1999. Soil hydraulic conductivity and retention curves from tension infiltrometer and laboratory data. *In* pp. 541-551, *Proc. of the International Workshop on the Characterization and Measurement of the Hydraulic Properties of Unsaturated Porous Media*, Oct. 22-24, 1997, Riverside, CA.

Evett, S.R., T.A. Howell, and A.D. Schneider. 1999. Corn canopy temperature under feedback irrigation control. Agron. Abstr. p. 17. (Abstract)

Howell, T.A 1999. Enhancing WUE in irrigated agriculture. Agron. Abstr. p. 18. (Abstract)

Mecham, B.Q., T.L. Spofford, R.G. Allen, and T.A. Howell. 1999. The ET connection. In 1999 Irrig. Assoc. Technical Conference Proc., Fairfax, VA. pp. 185-192.

Schneider, A.D. 1999. Efficiency of LEPA and spray irrigation. Proc. Water Resources into the New Millennium: Past Accomplishments, New Challenges. ASCE, Seattle, WA. p. 151. (Abstract)

Schneider, A.D., and T.A. Howell. 1999. Surface runoff from LEPA and spray irrigation of a slowly-permeable soil. ASAE Paper No. 99-2054. 16 p. (Technical Paper)

Schneider, A.D., and T.A. Howell. 1999. LEPA and spray irrigation for grain crops. J. Irrig. Drain. Engr. (ASCE) 125(4):167-172.

Schwartz, R.C., and S.R. Evett. 1999. Field estimation of hydraulic properties using a tension infiltrometer. Agron. Abstr. p. 185. (Abstract)

Todd, R.W., J.A. Tolk, T.A. Howell, and S.R. Evett. 1999. Stomatal response of alfalfa to increasing water deficit. Agron. Abstr. p. 90. (Abstract)

Tolk, J.A., and T.A. Howell. 1999. Daily evapotranspiration of irrigated grain sorghum grown in three high plains soils. Agron. Abstr. p. 14. (Abstract)

Unger, P.W., and T.A. Howell. 1999. Agricultural water conservation – a global perspective. J. of Crop Production [special issue on "*Water Use in Crop Production*," M.B. Kirkham (ed.)] 2(2#4):1-36.

Yazar, A., T.A. Howell, D.A. Dusek, and K.S. Copeland. 1999. Evaluation of crop water stress index for LEPA irrigated corn. Irrig. Sci. 18:171-180.

Personnel News . . .

Steve Evett was elected president-elect of the Texas Council of Chapters of the Soil & Water Conservation Society and is program chair for the 2000 meeting at Tyler, TX.

Judy Tolk was elected as president-elect of the Golden Spread Chapter of the Soil & Water Conservation Society.

Terry Howell was appointed to the Texas A&M University System Agriculture Program Water Leadership Team to develop a final report and a Water Research and Education Plan of Action.

Don McRoberts was hired as a full-time Biological Technician working mainly with Dr. Arland Schneider on his projects. Don lives in Canyon, TX, and is graduate of West Texas A&M University. Don has been an irrigation farmer and brought those experiences and his past extension demonstration experiences in applied research to this position.

Terry Howell was elected as vice-chair of P-511 the ASAE Referred Publications Committee.

Rick Todd accepted a permanent position as soil scientist in the Wind, Soil and Animal Waste Resources Research Unit at Bushland.

Terry Howell is chair of the American Society of Agronomy Division A-3, Agroclimatology & Agronomic Modeling for 1998-99 and will be A-3 Program Chair for the 2000 meeting in Minneapolis, MN.

Keith Brock traveled to Baton Rouge, LA, on Dec. 3, 1999, to tour the ARS water quality research facilities and to be trained in water sampling techniques and instrumentation.

Carole Perryman is serving as the 2000 CFC Amarillo Coordinating Committee representative for the laboratory.

Judy Tolk was appointed to the Southern Plains Area DEAR (Diversity Enhancement in Agricultural Research) Committee which met on Jan. 14, 2000, in Dallas, TX.

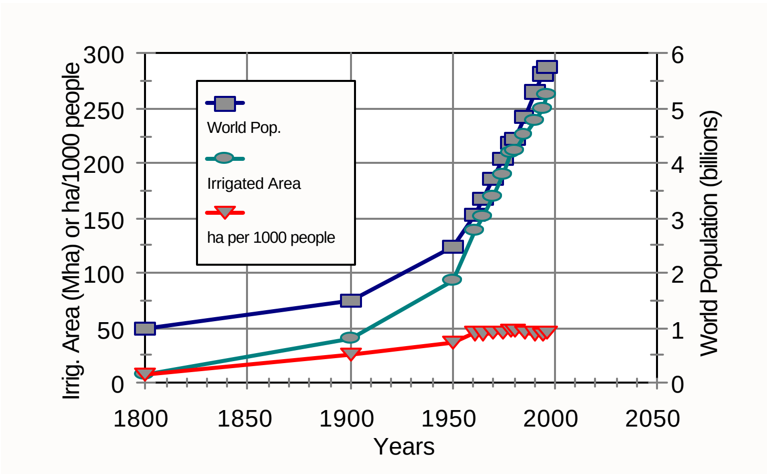
Terry Howell participated in the Ph.D. Final Examination of Qingwu Xue at the University of Nebraska on January 24, 2000.

Terry Howell was appointed as a Research Leader representative member of the USDA-ARS Management Information Systems Redesign (RMIS) team and attended a meeting in Beltsville, MD, that was canceled by the *Northeaster Blizzard of 2000* on Jan. 25-26.

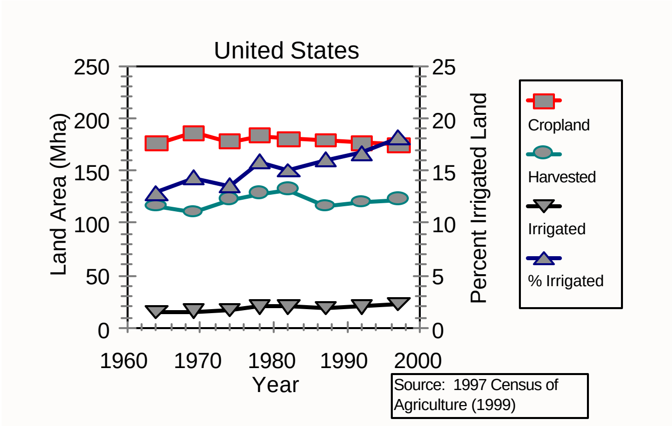
Brice Ruthardt and wife, Jeannie, are the proud parents of Nathan Brice Ruthardt born on Feb. 11, 2000.

Jack Musick continues to battle cancer and related health problems. His address is 5502 Floyd in Amarillo, TX 79106 [home phone is (806) 352-7549].

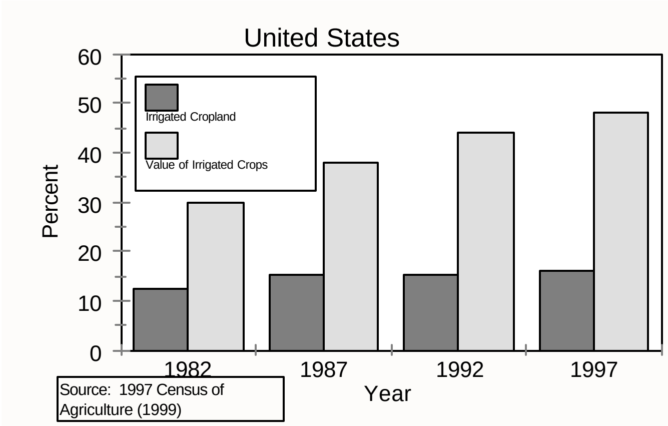
Don Dusek has announced his intention to retire from ARS effective on April 8, 2000, (April 7th is last work day) after 37 years of service to ARS. Don was hired by Jack Musick after completing his B.S. degree from Texas Tech University. Don has plans to remain with ARS in a collaborator status to complete some on-going research papers. He will likely accept a part-time position with the Texas Agricultural Experiment Station to continue his work with the NP-PET. Don was the Support Scientist of the Year in 1999 for the Southern Plains



CAN WE FEED THE WORLD WITHOUT IRRIGATION?



U.S. PERCENTAGE OF IRRIGATED CROPPING INCREASES!



VALUE OF IRRIGATED CROPPING GROWS!

Area and a key member of the NP-PET team that has received many state and federal awards recently.

Brice Ruthardt passed his written examination and will received his M.S. degree in Biology specializing in Wildlife Management from West Texas A&M University at Canyon in May 2000.

Arland Schneider will participate in the USDA-ARS Congressional Briefing Conference in Washington, D.C., on Mar. 20-23, 2000.

Water Management Research Unit

http://www.cprl.ars.usda.gov

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