ARID LANDS NEWSLETTER

Fall/Winter 1988

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Plants for Salty Soils

The University of Arizona ♦ Office of Arid Lands Studies

On the cover: *Distichlis* spp., a saltgrass cereal and forage crop, has great potential for putting some of the world's 3.8 billion acres of salinized land back into production.

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We'd like to hear from you. Address letters of comment, requests for future mailing, and items about projects that may be of interest to our readers to:

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Plants for Salty Soil

Nicholas P. Yensen

"The presence of an excessive amount of salts in irrigation or soil water has been considered a major threat to the permanence of irrigated agriculture throughout the world."

—P. J. Mudie

Historically, humankind has a record of devastating an area and then moving on to devastate another area. Indeed, one of the first agricultural areas on earth, the Fertile Crescent of the Tigris-Euphrates Rivers, was salted up field by field over a 2,000-year period until the civilization collapsed. The Incas of Peru, who originally inhabited rich coastal valleys, salted up one field after another until they reached the peaks of the Andes mountains. Today, salinization of agricultural lands is more widespread than is commonly realized—Brazil, China, Thailand, the United States, Canada, Mexico, Russia, India, much of Africa and South America, Arabia, Egypt, and Australia, are a few of the countries each with millions of salt-affected acres.

Where does all this salt come from? If you said it seems to come out of the air, you would be better than 80 percent right! Minute crystals of salt are picked up by the air moving over the oceans. These minute crystals then settle out across the continents. Because two-thirds of the continental surfaces do not readily drain to the oceans these salts tend to gather in interior basins.

Without proper agricultural and ecological practices salt problems and/or salt accumulation can occur under virtually any climate regime. Arid land climates, however, are particularly susceptible to salinization due to high evaporation rates in a hot dry weather coupled with little precipitation.

Because of limited rainfall in arid lands, irrigation of crops is a standard practice. While irrigation greatly assists the movement of the salt to a concentration point such as the ocean, the added evaporation also increases the relative salt level. In addition, the human activity of removing vegetation for firewood and field clearing frequently results in a rise in the water table, allowing saline water to reach the crop root zone and/or increasing surface evaporation.

At any given site there is a dynamic equilibrium between the loss of salt by drainage and the salt-concentrating effect of irrigation. In many areas the equilibrium level is above that at which conventional crops can be economically productive. This level, approximately 3,000 to 5,000 parts per million (ppm), is still far below that of seawater (35,000 ppm). Yet it is at this level that hundreds of billions of dollars are lost each year due to salt.

Worldwide, approximately one-third to one-half of all irrigated lands have salt problems; the majority of these lands are in lesser-developed arid regions. And, each year, millions of acres of irrigated lands go out of production due to salt. In fact, there is already twice as much salty land as there is irrigated land. Some scientists suggest that we have finally reached the point where there are no new "virgin" lands left to salinize.

SALINITY AND CLASSIC ARID LAND AGRICULTURE

Developed countries using energy-intensive agriculture through selection and breeding have created extensive monoculture crops that produce a remarkable ten times the amount that they produced at the turn of the century. That is to say, nine-tenths of the land may lie fallow and still produce the same amount of food. The miraculous "Green Revolution"-style crops are still giving us a world grain glut. For the moment, enough food is produced even though it is not well distributed. It is also clear that more and more land is going out of production and fewer "virgin" lands and fossil aquifers are available for future development. If, as some say, we are nearing our limit for "fallow-sighted" agriculture, when will we reach a moment of accountability? What with the vagrancies of the changing climate, the "greenhouse effect," and the continued salting of the earth, it appears that much of the world has reached that point.

On the positive side, significant strides have been made, principally by agricultural engineers. Agricultural engineers have developed carefully calculated drainage systems that, when properly managed, will keep the salts out of the root zone.

Produced from the halophytic grass Distichlis, *WildWheat grain is well adapted to hot arid climates where the majority of saline water occurs.*

While the "insurance policy" of good drainage and proper management is a relatively good one, it does have a few limitations. Creating a drainage system in many areas can be prohibitively expensive. After putting the system in place it must be maintained and something must be done with the salty drain water. Unfortunately, many arid nations do not have heavily subsidized agriculture. As for farmers in developing nations, an entire year's wages might not even buy a tire for a tractor much less a sophisticated drainage system. In such trying conditions, how then do we handle the salt problems?

The classic approach to creating a salt-tolerant crop has been selection, hybridization, back crossing, and other such methods, using conventional crops. Decades of work have resulted in crops that do indeed have an increased tolerance of salty conditions. Following are a few of the notable crops and a random listing of a few of the associated investigators (see bibliography): barley (Epstein et al.; Iyengar, Chikara and Sutaria), tomato (Mizrahi; Jones; Rick; Epstein et al.), wheat (Dvorak, Rose and Mendlinger; Gorham, McDonnell and Wyn Jones; Rana; Sajjad; Epstein et al.), asparagus (Robb; Nichols), rice (Akbar; Ponnamperuma; Wong, Woo and Ko), corn (Ahmad, Ismail and Khan; Totawat and Mehta), cotton (Ayars, Hutmacher, Schoneman, Vail and Felleke; Dean; Mantell, Frenkel and Meiri; Nawaz, Ahmad and Qureshi), alfalfa (McKimmie and Dobrenz; Allen, Dobrenz, Schonhorst and Stone; Ayers and Hayward; Carlson, Ditterline, Martin, Sands and Lund; Croughan, Stavarek and Rains; Smith, Conta and Dobrenz; Dotzenko and Haus; Noble, Halloran and West; Stone, Marx and Dobrenz).

The result of all this work is well illustrated by a discovery made while increasing the salt tolerance of barley, a plant that has an innate salt tolerance. Unfortunately, the optimal salt level at which the crop would do best could not be greatly increased. But, increasing the overall yield in fresh water does proportionally increase the yield at all salt levels. This allows the plants to survive and produce at fairly high salt levels, albeit still with reduced yields compared to fresh water.

SALINITY AND BIOTECHNOLOGY

Conventional crops are principally derived from "freshwater ancestors" and are called glycophytes. Some scientists have suggested that the genetic capability for optimal growth at higher salinities does not exist in glycophytes. Others hypothesize that the genes are there and that it is a matter of finding the "switch" to turn them on. Or, if the genes are not there, they can be found in wild plants that already have optimal growth in high salinities (halophytes) and then transferred to conventional glycophytic crops.

How wild plants thrive in very salty water is not well understood by this bold new technology. The genetic mechanisms may be simple or they may be inordinately complex, precluding easy transfer to conventional crops. We do know that in some

Halophytic forage cultivars are similar to alfalfa in nutritional values.

halophytes over 100 genes may be involved. There is some inference that these genes operate in concert with other enzyme systems more like an orchestra than a solo. And, to complicate matters further, it may be that each species of halophyte has a specific "orchestra" to match its particular enzyme system—in this case the transfer of one "orchestra" might not work well with the host enzyme system. Still, the elucidation of halophyte mechanisms is an exciting field and someday the spinoffs could be of great significance. Clearly, biotechnology and "designer crops" have now arrived in the crystal ball of a revolutionary new kind of agriculture.

Each year millions of acres of irrigated land go out of production due to salt.

SALINITY AND RENAISSANCE AGRICULTURE

There is another road for the arid countries with vast quantities of salt water, be it water percolating through a salt dome, salty drainage water, saline intrusions, or surfacing saltwater tables. And, ironically, this avenue may emerge from knowledge that has been with us for centuries. This "grass roots" approach appears, on the surface, to be the antithesis of biotechnology, but to be successful it will undoubtedly require both biotechnology and classic agricultural techniques.

The "back to nature" movement, as it is sometimes called, has been gradually infiltrating the agricultural society. Some of the buzz words of this genre are "native crops," "polyculture," "organically grown," and "natural foods." Associated with this movement is the realization that some of the ancient crops fit the modern needs of a sustainable agriculture. Recent examples are jojoba, tepary beans, amaranth, quinoa, buffalo gourd, and guayule. Part of the philosophy involved is the broadening of the crop diversity of our agricultural base. Presently, the sustenance of modern society hangs in the balance of three foods: wheat, corn, and rice.

We are often asked, "How can an ancient crop possibly compete with wheat, corn or rice, the zenith of temperate-zoned agriculture?" The competition of glycophytes and halophytes might be considered analogous to the competition of apples and bananas. Apples are grown primarily in the temperate zone where their cold requirement is satisfied and bananas are grown only in tropical locals. To be fair, apples and bananas do compete on the international market. But, most importantly, they can first provide the producer with food and any extra may then be exported for profit. Likewise, halophytic crops could be grown in regions where there is an extensive supply of salt water without competing with glycophytic crops that require fresh water. Presently, many regions with vast quantities of saline aquifers are importing food at costs beyond their budget. Over a million people die each year due to starvation and malnutrition. Helping countries to become self-sufficient should be a principle goal of any halophyte crop program.

Within the last few decades the concept of developing economical crops from halophytes has gained significant momentum. Work in various countries, such as Australia, Egypt, India, Israel, Mexico, and the United States, has identified a number of potential halophytic crops, for example: *Atriplex*, *Avicennia*, *Batis*, *Cressa*, *Distichlis*, *Juncus*, *Kosteletzkya*, *Limonium*, *Maireana*, *Rhizophora*, *Salicornia*, *Spergularia*, *Suaeda*, *Xylocarpus*, and *Zostera*, to name a few. There may be as many as 250 potential halophytic crops. The question is not whether there are halophytic crops, but, rather, which of those crops will meet the needs of a particular area and can be grown economically.

In selecting a potential halophytic crop for development, the large field of potential plants needs to be screened. Because the bulk of human nutrition is derived either directly or indirectly from a grass (wheat, corn, rice, barley, oats, rye, pasture for beef, milk, etc.), it might behoove us to look for a halophytic grass. Further, we would want a grass well adapted to hot arid climates where the vast majority of saline water is found. Most likely, the desired halophytic grass would have C-4 metabolism to allow it to grow efficiently under these conditions. This narrows the field of potential halophytic crops. After examining thousands of halophytes from around the world, the author selected for initial development the arid halophytic grass genus *Distichlis*.

WildWheat grain is high in bran and fiber and has a good balance of essential amino acids.

WILDWHEAT GRAIN

One variety of *Distichlis*, according to several accounts and Indian legend, produced a delicious cereal grain. Unfortunately, human intervention disrupted the natural habitat of the plant. When several expeditions in search of the grain proved fruitless, the cereal variety was considered extinct. It was our good fortune to "rediscover" extant pockets of grain-producing *Distichlis* plants. Ecological studies of *Distichlis* were initiated by the author over 14 years ago. Subsequent studies showed that grain yield of these wild varieties was disappointingly low—a maximum of 10 pounds per acre.

The author and S. B. Yensen, however, continued research on *Distichlis* conducting crosses and selections of improved varieties. With the help of some Mexican farmers we learned to direct seed fields and were able to produce grain under cultivation. Meanwhile, growth studies at different salt levels demonstrated definitively for the first time that the grain variety of *Distichlis* was a true halophyte (euhalophyte).

With the aid of the Tinker Foundation, Engineering and Research Associates, the Mexican government, Consejo Nacional de Ciencia y Tecnologia (CONACYT), the University of Sonora, the Charles A. Lindbergh Fund, the University of Arizona, Saline Agricultural Technology, and a number of interested individuals, various test plots were established in Mexico and the United States. Studies of the agricultural aspects of the grain variety were initiated by J. Borboa. He noted that because the grain is a perennial it is able to build topsoil. Research indicates that fields do not require replanting for at least five years as long as salty conditions can be maintained. In a number of test sites the soil-salt equilibrium level became so low that the grain would not do well. This may be due partly to increased percolation rates and perhaps, to a lesser degree, to leaf salt being removed from the fields during harvests. These fields, however, could then be used for conventional crops. Certain varieties of the grain grow remarkably well without fertilizer or other chemical amendments.

Under the auspices of a joint venture called "Salt Weeds," selection and hybridization work was conducted by the author and J. Vasquez resulting in a ten-fold increase in grain yield. Yield of highly developed varieties is now similar to dryland wheat yields. Spin-offs from this work have resulted in forage varieties (next section), a lawn variety, and a reclamation variety. Three fundamental concept patents have been issued under the standard patent statutes and other patents are pending.

S. B. Yensen and C. W. Weber initiated research into the nutrient content of *Distichlis*. Remarkably, even when grown in full-strength seawater, the grain is not salty. The total ash content is less than that of wheat or barley. The plant excretes the salt via salt glands, keeping the grain and tissues low in salt content. Thus, even the foliage can be grazed by cattle without ill effects (see NyPa Forage next section).

Trademarked WildWheat, the grain has excellent nutritional properties, some of which are unique. For instance, ordinary wheat and other cereals have phytates that bind to the essential minerals rendering them unavailable as nutrients. WildWheat grain has relatively low amounts of this anti-nutritional factor. It is, however, high in bran and fiber. The relative amount of bran exceeds 40 percent. The fiber content is also very high, nearly three times that of wheat. Studies of the starch characteristics are in progress by I. Tapia.

The grain protein has a good balance of the essential amino acids, twice the adult recommended daily allowance (RDA) in most cases. Interestingly, it is possible to make muffins even though there seems to be an absence of gluten. This may be a boon to those who like bread but have allergies to wheat proteins.

Nutrition studies aside, the bottom line is, "Does it taste good?" A taste test at the University of Arizona showed no significant difference between WildWheat muffins and wheat muffins. The panel especially liked muffins made from a mixture of wheat and WildWheat grain. The grain, when sauteed, has a "roasted" nut-like flavor akin to sunflower seeds or pistachios and goes well on ice cream or in salads. It may be cooked as a "rice" or used as stuffing. (The author's favorite, however, is as a cookie.)

Limited marketing of WildWheat grain has been conducted in the United States. Nieman-Marcus was the first to offer the grain. Presently, WildWheat is sold locally in Tucson, Arizona, through gourmet outlets and at special events. That WildWheat grain has been recognized as a gourmet grain in the United States may facilitate its acceptance by other peoples and cultures. And, fortunately, the broad genetic base assembled over the last 14 years may make it possible to breed for culturally more acceptable colors, textures, and/or flavors.

Helping countries to become self-sufficient should be a principle goal of any halophyte crop program.

NYPA FORAGE

The University of Arizona's College of Agriculture, the University of Sonora, and NyPa, Inc., a saline agricultural technology outlet, are presently working on a new series of forage cultivars. The term NyPa is derived from a word used by the Indians for the nearly extinct ancestors of the WildWheat grain. Work on WildWheat grain led to this remarkable series of unusually fast-growing, salt-loving, forage grasses.

NyPa Forage cultivars will grow in full-strength seawater, but grow best at salinities between 5,000 and 20,000 ppm. Because most saline land has salinities at this level the forage cultivars well fit the need.

The objective of NyPa, in the development of the forage cultivars, is to work with developing countries toward their self sufficiency via a strong autonomous agricultural base. J. Bedell has shown that, as a forage, the grain has an immediate appeal. Introducing new human foods sometimes poses a problem of acceptance by local cultures. Cattle, goats, sheep, and fish, among others, may be supported by NyPa Forage to produce products that local people are already familiar with, such as milk, yogurt, cheese, meat, wool, and leather.

The forages have alfalfa-like growth with similar nutritional values. C. Weber, D. Ray, R. Rice, and S. Yensen are currently studying these values for cattle, horses, and goats. J. Barron and P. Ortega are examining the value of the forage for fish and aquaculture. NyPa forages, like alfalfa, are perennial and do not require replanting. Surprisingly, even though the plants may be growing in full-strength seawater, the tissues do not accumulate salt as is the case with most halophytes being studied as potential forages. The leaf surfaces have bicellular salt glands that excrete the excess salt. Ash (salt) content of the tissue is similar to conventional forages grown on fresh water. How these plants can handle the salts, and even increase their growth in the presence of salt, is still a mystery. H. Bohnert's team at the University of Arizona is studying the molecular biology of *Distichlis* in hopes of discovering the genetic system(s) that orchestrate this remarkable physiology.

The NyPa forages have C-4 photosynthesis which assists their drought tolerance and growth performance in hot arid climates. After establishment, the forages may require irrigation as infrequently as once every three weeks during the hot dry summer.

CONCLUSIONS

Humankind has long dreamed of using the sea to irrigate crops on the vast stretches (20,000 miles) of coastal desert For the time being, most new halophytic crops will likely be grown inland for several reasons. First, while halophytes can grow in seawater, most have significantly increased productivity at lower salinities. Second, while 20,000 miles of coastal desert seems vast, inland there is more than 300 times as much land already salinized. Third, many inland areas already have canals, fields, farms, hungry people in residence, and infrastructure . . . but no crop. Lastly, and perhaps this is more of a long-term consideration, coastal regions contain our storehouse of halophyte species and the genetic information needed to develop future halophytic crops.

Agricultural engineering, biotechnology, the development of salt-loving glycophytes, and halophytes such as *Distichlis* have the potential for reclaiming salt-ruined land, stabilizing soil from wind and water erosion, providing pasturage, and helping developing nations feed themselves. The development of halophytic crops, however, must proceed in a balanced manner. Otherwise, developing these crops may actually add to to the destruction of estuaries and other coastal habitats. It is far more economical, and environmentally sound, to utilize the billions of acres of salinized farmland already in existence. The development of a useful halophytic crop from a nearly extinct plant, such as *Distichlis*, illustrates the importance of a balanced development of our coastal halophytes for human needs.

The first major harvest of WildWheat grain occurred in Mexico.

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Useful Desert Plants for Low-Input Polycultures

Gary Paul Nabhan, Robert Robichaux,
Mark Slater, and Suzanne Nelson

INTRODUCTION

Arid zones will serve as the home for about 850 million people by the year 2000, yet already much of the food consumed by desert residents is imported from other climatic regions. At the same time, we are at a turning point in the history of food production in arid zones because our ability to continue to expand high-input agriculture is severely limited (Nabhan 1987). Underground aquifers have been irrevocably depleted and contaminated to the point that the arable acreage irrigated by groundwater is likely to decrease, at least in the American deserts (Bowden 1977). Similarly, surface water supplies have been over allocated; in the United States, no major dam projects have been approved for more than a decade (Worster 1985). The richest arable lands in arid zones were long ago brought into cultivation, and much of the prime farmland has since been urbanized, salinized, or despoiled. Finally, increasingly greater inputs of water, fertilizer, and pesticides have made conventional agriculture economically unstable, with a greater risk of complete failure than low-input agricultural practices (Ehrenfeld 1987).

It follows, then, that there is a great need for arid land cropping systems that require less water than do conventional monocultures of humid-derived domesticates. Two major means are available for sustaining yields while reducing the inputs of water and nitrogen, the factors that most critically limit crop productivity throughout the world. First, alternative crops can be grown that are better adapted to environmental stresses, more tolerant of typical resource deficits, and higher in resource-use efficiencies (Theisen, Knox, and Mann 1978). Although this "new crop" strategy has been given considerable attention by the U.S. National Academy of Sciences and many other institutions, virtually all new-crop evaluations have been done in monocultures, many of them under high-input systems quite different from those that desert farmers in developing countries can afford to adopt. The vast majority of these farmers continue to multicrop the same acreage; those in arid, unpredictable climates are especially likely to do so as a risk-hedging strategy.

The second approach is to promote, on a large scale, the cropping systems that attain higher resource-use efficiencies; these may include polycultures, runoff-supplemented agroforestry designs, and drip-irrigated orchard-pastures. Peasant farmers have realized for centuries that intercropping is an inexpensive means of increasing resource-use efficiency and stabilizing yields. The simultaneous culture of two or more crops on the same plot of land has been demonstrated to produce more food in less area than can sole crops of the component species (Willey 1979; Francis 1986). Temporal and spatial complementarity in resource use may enable intercrops to capture and convert more water and light (Natarajan and Willey 1986), as well as more nitrogen (Liebman and Robichaux 1988), than can the respective sole crops.

Surprisingly, this collaborative project between the Desert Botanical Garden (DBG) and the University of Arizona may be one of the few in the Americas to evaluate the benefits of new desert crops in polycultures. By designing and evaluating new cropping systems that reduce stress and increase resource use for desert-adapted food plants, DBG hopes to offer models that can be adopted or refined by low-income farmers in desert zones.

RESEARCH

Over the last two years, the University of Arizona's Ecology and Evolutionary Biology Department has collaborated with the DBG's research staff in experimentally evaluating a number of two-species intercrops. In 1987, both groups evaluated intercrops of tepary bean (*Phaseolus acutifolius*) and pearl millet (*Pennisetum americanum*) under different water and nitrogen regimes. In 1988, DBG shifted its designs to examine the effects of water and plant density on the growth and yield of sole crops of tepary bean and Sonoran panicgrass (*Panicum sonorum*) and their intercrops. Both of these latter species are exceptionally heat and drought tolerant, and were prehistorically cultivated in the Sonoran Desert. In this sense, the so-called "new crops" are really ancient domesticates being evaluated in a new agricultural context. The same is true for intercrops of pearl millet and an O'odham land race of cowpea (*Vigna unguiculata*) being analyzed for yield components at the University of Arizona's Campus Agricultural Center; these species have long been grown in arid zones, but the particular land races are being studied together for the first time.

At the DBG Gentry Agroecology Project (GAP) Farm in Phoenix, wild chiles (*Capsicum annum* var. aviculare) are being overcropped by the nurse tree *Celtis pallida*, known as desert hackberry. The hackberries commonly are found as nurse plants for wild chiles on the Sonoran Desert margins, protecting the sensitive, scandent (climbing) chile bushes from frosts, drought, heat, and some predators. This intercrop is drip irrigated, supplemented by storm runoff concentrated in basins by microcatchments. For these experiments, yield components, phenology, irrigation time, and insect damage are being evaluated. Beneficial insects are being collected in case biological control measures need to be employed to reduce pest damage.

DEMONSTRATION

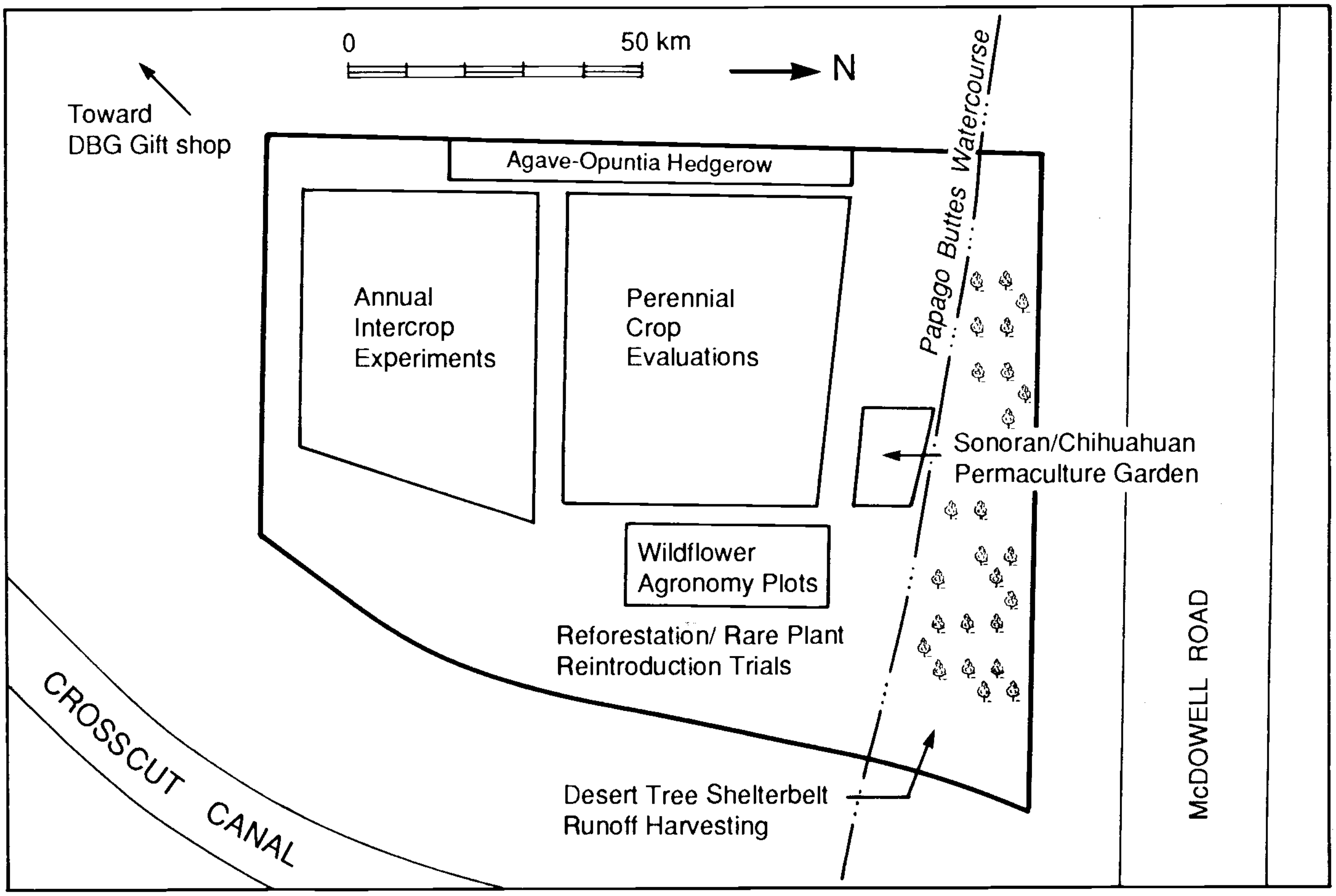
The GAP Farm also serves as a demonstration site for various other cropping systems. A dozen useful tree crop species are being evaluated in a water-harvesting microcatchment system. The system diverts storm runoff out of a watercourse draining the Papago Buttes one-half kilometer away, and distributes the flow between the various microcatchments using stone gabillon (checkdam) weirs and O'odham-style brush water-spreaders. Two centimeters of rain falling within two to three hours can activate the system. The trees will serve as a shelterbelt in addition to providing construction wood, medicinal products, and seed.

Robert Robichaux, UA Department of Ecology and Evolutionary Biology, examines intercrops of cowpea and pearl millet grown at the UA Campus Agricultural Center.

Another demonstration site at the GAP Farm features the Permaculture edible landscaping strategy promoted by Australian Bill Mollison (1979). In this case, however, the dooryard garden design uses native Sonoran and Chihuahuan desert plants that provide food, fiber, and shelter. Thirty species of useful drought-tolerant plants are grown around a living shade shelter of ocotillo (*Fouquieria splendens*) covered by vines of Merremia and Passiflora.

Farmers have realized for centuries that intercropping is an inexpensive means of increasing resource-use efficiency and stabilizing yields.

A third demonstration area features perennial crops, including prickly pears (*Opuntia*), century plants (*Agave*), gourds (*Cucurbita*), Mexican oreganos (*Lippia*), squill (*Urginea*), and Jerusalem artichokes (*Helianthus*). Management studies and genetic investigations are being undertaken on several of these crops. There is particular interest in perennials that can be grown in no-tillage cropping systems while yielding high-value products.



The Gentry Agroecology Project, located at the Desert Botanical Garden in Phoenix, was founded by Howard S. Gentry in 1984. The GAP is used as a training center for Mexican and Native American desert dwellers.

TRAINING

Foster and Varady (1987) have proposed a regional center for new crops and agrisystems for dry lands in Mexico. Through support from the Jessie Smith Noyes Foundation and the U.S. Forest Service/U.S. Agency for International Development office in the U.S. Embassy in Mexico, the DBG has begun to serve as an interim center for training Mexican scientists, farmers, and development workers on alternative systems of desert crop production. Over the last two years, 26 Mexican agronomists, economic botanists, foresters, and agriculturists have been among the 150 participants in DBG workshops ranging from a day to a week in length. Technical skills taught include microcatchment and gabillon construction, propagation methods, physiological evaluation of new crops, and germplasm maintenance. Concepts covered include agroecology, permaculture, strategies for increasing wildlife diversity in agroecosystems, intercropping designs, and socioeconomic assessment of new crops.

The DBG also has sponsored summer-long internships for Native American students from Indian reservations in the U.S. Southwest. River Pima and Tohono O'odham youth interested in agriculture have participated in this program. Visiting scholars have also been accommodated for stays up to one month, assisting with fieldwork as well as with data analysis.

There is a great need for arid lands cropping systems that require less water than do convential monocultures of humid-derived domesticates.

Finally, scientists working in the following countries have visited the GAP Farm for one to several days to exchange information: Canada, Mexico, Ecuador, Argentina, Colombia, Peru, Great Britain, West Germany, Belgium, Ethiopia, Burkina Faso, and the Philippines. Readers of the *Arid Lands Newsletter* from outside the United States are encouraged to contact DBG if they plan to visit the U.S. Southwest in the near future.

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For further information on the Gentry Agroecology Project contact:

Gary Nabhan
The Desert Botanical Garden
1201 North Galvin Parkway
Phoenix, Arizona 85008 U.S.A.

Horticulture—An Interest that Binds the University of Arizona, Morocco

Linda Smith

Tucson—noon August 2, 1988. A sizeable crowd momentarily forgets the Tucson heat, lunch, errands and other tasks normally associated with that time of day to attend a program about Moroccan horticulture at the University of Arizona's Office of Arid Lands Studies (OALS).

Plants and people of another land weren't the only topic. The meeting was further evidence of the strong ties developing between the University of Arizona and a Moroccan research center, Institut Agronomique et Veterinaire Hassan II, located in Rabat on the coast of Morocco.

One of the institute's researchers, Redouane Choukr-Allah, visited Tucson to tour the University of Arizona campus, meet with various University researchers, and give talks on the horticulture research and training occurring in Morocco.

Choukr-Allah, head of the institute's horticulture department in Morocco's lush Agadir Valley south of Rabat, explained that the horticulture complex was formed in 1981 for two main purposes: to train technician-, bachelor's- and master's-level students, and to respond to the growing needs of the Moroccan horticulture industry.

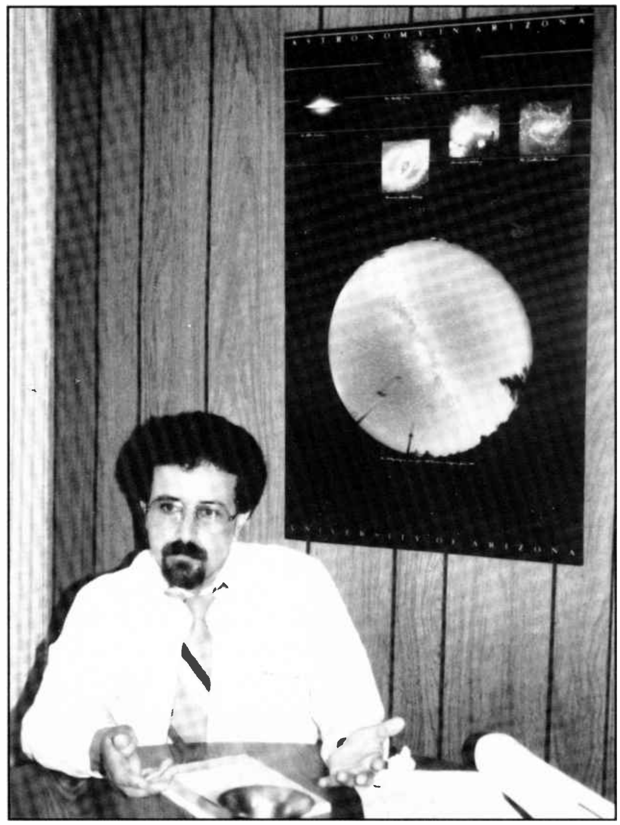
The department's research includes producing disease-free fruit and vegetable varieties when demand is high to obtain the best market price. Many of the varieties are being grown in special greenhouses.

"Intense agricultural competition exists in the Mediterranean countries," Choukr-Allah said. "The greenhouses have allowed us to shift our production time and ship produce when the value is high." More than half of Morocco's agricultural production is tomatoes (57%); bananas are the second most-produced crop (33%). Other products include peppers, strawberries, dates, potatoes, and roses.

One of Morocco's agricultural success stories is its banana production. The country has been able to stop expensive importation of bananas by growing a thriving crop in-country. Research at the Institute on different banana varieties, many of which are drip-irrigated types grown in humid greenhouses, has aided this effort.

The success stories are not without setbacks. Choukr-Allah said salinity—the seepage of seawater into the aquifer—is one problem the Institute is trying to reduce by improved cultivation practices, including freshwater irrigation. It is also developing salt-tolerant plant species.

The Institute's work in horticulture and other disciplines is applicable to Arizona's arid regions. In turn, Choukr-Allah said the Institute is eager to learn more about the University's research. A project is currently under way to send UA researchers from a number of departments to Morocco to develop cooperative work plans. Targeted campus units include OALS, Department of Plant Sciences, College of Architecture, and the Environmental Research Laboratory.



Redouane Choukr-Allah, head of the Institut Agronomique et Veterinaire Hassan II in Morocco, exchanged information on horticulture with University of Arizona researchers during a recent visit.

The Moroccan research institute's interest in the University of Arizona remains keen. Institute agronomists and faculty members Tayeb Ameziane and Ahmed Bouaziz were late-August campus visitors hosted by OALS and the Office of International Programs. They toured the Campus Agricultural Center, Environmental Research Laboratory, and several departments. Another colleague, Abdallah Ait-Tihyaty of the Institute's food technology group, spent August and part of September as a guest of the Agricultural Economics Department, College of Agriculture.

African Country Winning Nutritional Battle

The sugarcane industry in Swaziland has transformed large portions of land that were formerly bush.

Swaziland, like many countries in Africa, is working to achieve self-sufficiency in its food supply. In 1988, it came close.

According to Swaziland's Minister of Agriculture, Hezekiah Sipho Mamba, who visited the University of Arizona on September 29, the country has increased agricultural production from 40,000 tons/year in 1985 to 170,000 tons/year in 1988. Swaziland is approaching its goal of self-sufficiency and, in fact, would have exceeded that goal, said Mamba, had there not been a drought last December. Eventually the country would like to create a surplus for export as well.

Mamba attributed much of the success to a revision in the country's approach to agriculture. Before acquiring independence in 1968, Swaziland's agriculture was heavily influenced by non-local agencies and organizations. Oftentimes, these organizations were not sensitive to the particular problems the country faced. After attaining independence, the country realized a need to revise its agricultural policies and practices.

As a result, agricultural policies have changed, and the involvement of local people has become fundamental to the success of the country's agricultural improvement. The government now encourages a community-decision approach and has designed relevant policies and guidelines to promote that concept within the agricultural sector. Communities themselves identify programs, focusing assistance where it is most needed. The results of this new strategy have been favorable. Communities are responsive and donor agencies have a clearer picture of the needs of the people, therefore making decisions more quickly.

One of the priorities for Swaziland's agricultural program is to develop its irrigation scheme. To exchange information on agricultural projects, and irrigation in particular, Mamba and his assistant, Magalela Ngwenya, visited various University of Arizona departments, including the Office of Arid Lands Studies, International Programs Office, Agricultural Engineering Department, Agricultural Economics Department, Dairy Research Center, and the Environmental Research Laboratory. Mamba explained that his country is interested in both small-scale irrigation activities—which produce results quickly and are important for community participation—and in larger-scale projects.

Mamba feels that the agricultural potential in Swaziland is excellent. The climate of the country is good as are the soils. Swaziland currently has a very efficient sugarcane industry—this crop is the country's leading export earner. Based entirely on irrigated agriculture (which incorporates flood, sprinkler, and drip methods) the sugarcane industry has transformed large portions of land that were formerly bush. Woodpulp also is an important export as are pineapples, citrus fruit, and cotton.

An important component in developing Swaziland's agriculture will be additional training for students. Currently many of the country's students are trained at the master's level; a goal is to train more students at the Ph.D. level. Mamba stated that it is important for students from Swaziland to visit other arid countries so they know that the problems of their own country are not unique.

Mamba said that he is happy with the support his country has received from donor agencies and land grant institutions in the United States. He is hopeful of strengthening ties with these organizations and working for the mutual benefit of both countries.

OALS Researcher Renews South American Ties

University of Arizona arid lands scholar, Barbara N. Timmermann traveled to South America recently to confer with colleagues about the potential creation of a South American Center for Arid Lands Studies and to promote collaboration among South American arid lands scientists.

The center is being proposed because some parts of South America are experiencing many of the same problems as other arid areas of the world—desertification, elimination of natural resources, and ecological imbalance. "If something is not done soon, and in an integrated manner, areas of South America may become another Sahel," says Barbara N. Timmermann, assistant professor of Arid Lands Studies, Office of Arid Lands Studies, and adjunct assistant professor of Pharmaceutical Sciences, College of Pharmacy. The center would enable a cooperative approach to these problems, a necessity if they are to be dealt with effectively.

A well-integrated, multinational center would serve to coordinate the research efforts of scientists involved in arid lands research in South America. The proposed multidisciplinary unit would include research, teaching, and development components. The center would originally include Argentina and Chile and eventually would incorporate Brazil, Bolivia, Colombia, Paraguay, Peru, and Venezuela.

While in Cordoba, Argentina, to discuss the proposed center, Timmermann also participated in the "First International Workshop on Genetic Resources and Germplasm Conservation in *Prosopis* (mesquite)," which was attended by scientists from Argentina, Brazil, Chile, Italy, Mexico, Niger, the United States, and Uruguay. Mesquite trees play a very important role in desert ecosystems as sources of food, forage, wood, and fuel. Germplasm from mesquite has been exchanged among different countries, with exchanges worked out between Argentina and Chile, and Brazil and Niger.

After leaving Argentina, Timmermann traveled to Santiago, Chile, where she served as a panelist in the symposium, "The University, Science, and Development," held at the Chilean Academy of Sciences. She also delivered a paper titled "University and Scientific Research." Attending the symposium were representatives from the Food and Agriculture Organization, the United Nations, and the U.S. Agency for International Development in addition to Chilean and U.S. scientists. Many subjects of mutual interest for both countries were

Attending the October 10 meeting, "Universidad, Ciencia y Desarollo" (The University, Science and Research), are (from left to right), Jorge Mardones Restat, Universidad de Chile; Barbara N. Timmermann, OALS; and Igor Saavedra Gatica, Universidad de Chile.

discussed including exchange of scientists, acquisition of scientific instrumentation and different strategies for research, education, and development.

Timmermann's work in South America will continue. She has been invited by the United Nations through the Corporacion Nacional Forestal (CONAF) in Santiago, Chile, to travel to Chile and contribute her knowledge on arid lands. While there she is scheduled to deliver a paper titled "Challenges for the Future in Arid Lands" and to discuss ongoing projects being conducted at OALS and its Bioresources Research Facility.

In addition, Timmermann begins field studies in central and northwest Argentina in December and January. She will be collecting arid-adapted plants for research on biologically active molecules and for chemotaxonomic studies of the resinous genus *Grindelia*.

Timmermann is well-acquainted with South America, having lived in Cordoba and Buenos Aires, Argentina, and also in Sao Paulo, Brazil. She obtained her bachelor's degree in zoology and biology from the Universidad Nacional de Cordoba (National University of Cordoba) in Argentina, continuing her studies at the University of Texas in Austin where she graduated with a master's degree and doctoral degree in botany (phytochemistry). Timmermann has worked and traveled extensively in South American deserts studying the flavonoid chemotaxonomy of the genus *Larrea* (creosotebush) in the Monte and the Patagonia region.

HALOPH: Salt-Tolerant Plants of the World

By James A. Aronson

Compiled and edited by James A. Aronson of the Rudolf and Rhoda Boyko Institute for Agriculture and Applied Biology at the Ben Gurion University of the Negev, this computerized data base of halophytes focuses on economic uses of the plants.

According to recent estimates, well over 220 million hectares of land currently are irrigated worldwide, and approximatley 25-40 percent of that land is affected by salinization. Salt-tolerant crops are one way of dealing with this rising salinity. The use of halophytes in appropriately designed systems holds out promise as a sustainable approach to crop production under saline conditions, near the sea and in inland salt-affected regions as well.

The data base contains more than 1,560 species in 550 genera and 117 families indexed alphabetically by family, genus, and species. *HALOPH* is organized alphabetically by botanical family, and within each family, by genus and species. Categories include: life form, plant type (which refers to the primary habitat in which a taxon is normally found in nature), geographic distribution, maximum reported salinity tolerance, photosynthetic pathway, economic uses, and pertinent references.

HALOPH is the most extensive and referenced listing of halophytic, and salt-tolerant plants available to date and should be of interest to anyone growing or planning to grow halophytes. It should help direct readers to the plants most relevant to their particular problems and indicate at least a starting place in the available literature.

Scheduled for publication in early 1989, *HALOPH* will be available from the Office of Arid Lands Studies for US$10.00. To order, contact: Publications, Office of Arid Lands Studies, University of Arizona, 845 North Park Avenue, Tucson, Arizona 85719 U.S.A.

International Short Course on Desert Resource Integration and Utilization

May 14-26, 1989

Tucson, Arizona

Sponsored by the College of Architecture and the Office of Arid Lands Studies, University of Arizona, this short course is designed for professional consultants, managers, architects, ministry employees, and planners in arid and semiarid lands. Topics include the design and operation of systems for food production, alternative energy, shelter, water utilization, water conservation and waste recycling for family and small-scale village level development.

In addition to course sessions, several field trips will be offered to experimental solar residences, the Arizona-Sonora Desert Museum, the Avra Valley Water Harvesting Agrisystem and Water Hyacinth Wastewater Treatment Project.

The registration fee of US$5,000 includes all materials, lodging, food, and local transportation. The course is limited to the first 25 registrants. A $500 deposit is required.

To obtain further information, contact: Kennith E. Foster, Office of Arid Lands Studies, University of Arizona, 845 North Park Avenue, Tucson, Arizona 85719. Telephone: 602-621-1955; telex: 1561507.

Conferences

Restoration: The New Management Challenge
Oakland, California
January 16-20, 1989

The first annual conference of the Society for Ecological Restoration and Management will feature sessions on restoration in the national parks and on setting standards for the evaluation of restored ecological communities.

The meeting is the first major event for the recently formed, international society, and will be the first professional meeting for restorationists working with a wide range of ecological communities. The program will include papers, poster sessions and special lectures and workshops on subjects related to restoration and management.

For further information on the conference, contact:

S.E.R.M. Annual Meeting
Society for Ecological Restoration and Management
The University of Wisconsin Arboretum
1207 Seminole Highway

Fourteenth International Congress on Irrigation and Drainage
Rio de Janeiro, Brazil
April 29 - May 4, 1990

Organized by the Commission Internationale des Irrigations et du Drainage, the congress will address topics that are believed to reflect the greatest concerns of the world irrigation community at this point in time. They are:

- o The influence of irrigation and drainage on the environment with particular emphasis on impact on the quality of surface water and groundwater.
- o The role of irrigation in mitigating the effects of drought.
- o Socioeconomic and technological impacts of mechanized irrigation systems.
- o Real-time scheduling of water deliveries.

Information on submission of papers may be obtained from:
The Secretary
International Commission on Irrigation and Drainage (ICID)
48 Nyaya Marg, Chanakyapuri
New Delhi 110 021 INDIA

Publications

Water Resource Assessment Activities: Handbook for National Evaluation. *1988. UNESCO, World Meteorological Organization. 116 pp. Free-of-charge while supplies last.*

Assessing the quantity and quality of available water is essential for all water-resource management and/or development projects. Water-resource assessment is a national responsibility and any evaluation of the extent to which it is being undertaken adequately in a country is also the responsibility of the country concerned. Internationally developed guidance on the subject can be of great assistance to the experts charged with undertaking such an evaluation. Use of this guidance can also lead to a certain degree of uniformity in approach among countries, something that can be very helpful in the development of regional and international cooperation with regard to water-resource assessment.

UNESCO and WMO developed a draft methodology for evaluating national water-resource assessment activities. This draft methodology was tested in Australia, the Federal Republic of Germany, Ghana, Malaysia, Panama, Romania, and Sweden. It was also reviewed at regional meetings in Africa, Asia, and Latin America. The methodology was revised in light of the experience gained and comments received and is presented in this handbook for use by all charged with evaluating the adequacy of water-resource assessment activities in any country.

Agroecology: The Scientific Basis of Alternative Agriculture. *1987. By Migquel A. Altieri. Westview Press/Intermediate Technology Publications, Croton-on-Hudson, New York. 235 pp. US$19.95.*

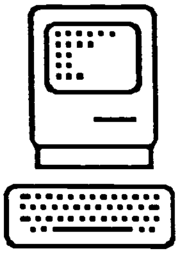
This book combines traditional farming knowledge and modern agroecological principles to offer an integrated approach for designing systems with effective soil conservation features, nutrient restoring capabilities, and built-in biological pest control mechanisms. It also describes methods for developing technologies to meet the needs, ecological and socioeconomic circumstances of low-resource farmers.

International Technology Flows and the Technology Gap. **CMEA Experience in International Perspective.** *1988. By Jan Monkiewicz. Westview Press, Boulder, Colorado. 220 pp. US$33.50.*

International technology flows are of particular interest to all developing countries as they provide the means for less developed regions and industries to catch up technologically. The thrust of this book is to assess under what conditions and to what extent international technology transfer has succeeded, with a particular focus on the socialist countries of Eastern Europe and their joint efforts through the Council for Mutual Economic Assistance. Arguments are based on empirical data collected by the author from 1984 to 1987.

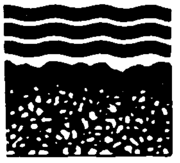
Cutting Edge Technologies and Microcomputer Applications for Developing Countries. 1988. *BOSTID. Westview Press, Boulder, Colorado. 489 pp. US$29.95.*

Written by practitioners this book illustrates high-tech microcomputer uses—such as artificial intelligence, computer-aided design and manufacturing, applied expert systems, and geographic information systems—for developing countries. The contributors are members of an ad hoc committee of the Board on Science and Technology for International Development (BOSTID), Office of International Affairs, National Research Council.



Computers in Africa. 1988. *Africal File Ltd. Issued bimonthly, 6 issues/year. Subscription rates for 12 editions: Africa: £32, rest of the world: £38.*

Computers in Africa is the only specialized medium for advertising computer products and services, telecommunications equipment, and office equipment throughout Africa. Edited in London by journalists who are specialists in computer news and have "hands-on" experience, the magazine is useful for all those actively engaged in the computer sector, whether they are responsible for major decisions in terms of mainframe operation, and/or office computerization, or whether they are just considering buying a home computer. Printed in English.



Winning with Water. Soil-Moisture Monitoring for Efficient Irrigation. *1988. By Gail Richardson and Peter Mueller-Beilschmidt. INFORM, New York, NY. 192 pp. US$24.95.*

Irrigated farming uses 85 percent of the U.S. West's water supplies. INFORM's latest study demonstrates how farmers can cut their water use by as much as half, save money on pumping costs, and even increase crop yields while so doing.

Winning with Water documents results of INFORM's research on 32 commercial fields in California over a three-year period. The study shows how farmers can detect and correct uneven and inefficient irrigation by using an old tool—small gypsum blocks—in a new, systematic way to monitor soil moisture. The gypsum blocks are buried at several locations and depths in crop root zones and are meter-read to monitor changes in soil moisture caused by irrigation and crop water consumption. INFORM's tests of this simple, low-tech method show many benefits. The report details individual farmer's experiences and is liberally illustrated with photographs and charts explaining methods and results.

(INFORM is a nonprofit research organization that identifies and reports on practical actions for the preservation and conservation of natural resources and public health. Current research focuses on some of the most critical environmental problems faced by the U.S. [and other countries] including industrial toxic waste generation, municipal solid waste management, and threats to land and water resources.)

The following publications are available from the Organization for Economic Cooperation and Development, OECD Publications and Information Center, 2001 L Street, NW, Suite 700, Washington, DC 20036-4095:

Register of Development Research Projects in Africa. *1987. 523 pp. US$48.00.*

Contained in this register are detailed descriptions of 1,109 development research projects recently carried out in 44 African countries.

Directory of Development Research and Training Institutes in Africa. *1987. 262 pp. US$29.00.*

This directory provides detailed information on 497 development research and training institutes in 46 African countries.

Economic Policies and Agricultural Performance of Low-Income Countries. *By J. Lecaillon, C. Morrisson, H. Schneider, and E. Thorbecke. 1987. 208 pp. US$25.00.*

This report examines how and to what extent policies and other exogenous factors have enabled or hindered the agricultural sector to meet competing claims for food, foreign exchange, and the fueling of the development process by generating and transferring resources to the rest of the economy.