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Summer Solstice
& Fall Equinox

the Seedhead News

Plants and People of the Sonoran Desert: A New Trail at the Desert Botanical Garden

By Ruth Greenhouse

The Plants and People of the Sonoran Desert Trail at the Desert Botanical Garden in Phoenix opened to the public on March 20, 1988. This is a dream come true for me. Eight years earlier, I conducted workshops for children on the uses of desert plants where we ate cactus fruit, made mesquite pottery paint and enjoyed a variety of other desert plant-related experiences. It was clear then how nice it would be to be able to learn about the uses of the plants in their appropriate habitats. This trail makes it possible.

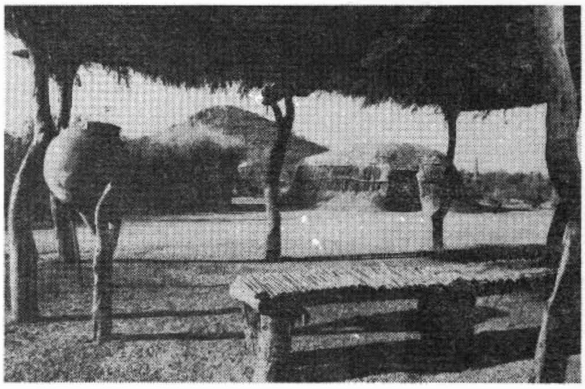
More than just a nature trail, Plants and People of the Sonoran Desert is a three-acre living exhibit about the ethnobotany of the Sonoran Desert region. Its one-third mile trail winds through five reconstructed habitats: desert, desert oasis, mesquite bosque, semidesert grassland, and chaparral, each containing its specific assortment of plants.

The major plants of each habitat were salvaged from the field: 50 saguaros from a new Mesa flood control basin, 25 mature velvet mesquite trees from a soon-to-be bank in north Scottsdale, soaptree yuccas from new development east of Carefree, and one-seed junipers and other chaparral shrubs from highway 87 expansion and a forest service burn area north of Seven Springs. A small portion of the plants we needed were available commercially from the local nurseries that specialize in native or desert-adapted plants. We were fortunate to receive generous donations of palo verde trees, desert willow trees, brittlebush, jojoba, turpentine brush, and other plants. And of course, the seeds for our crop gardens came from Native Seeds/SEARCH.

The habitats serve as settings for interpreting the relationship between people and the environment. Each one contains structures or other features that are either made out of native plants, used to process plants, or otherwise connected to the relationship between people and plants.

The Desert Habitat contains a saguaro fruit harvesting camp built by Ed Kisto from Sells, Arizona, and a cholla bud roasting pit.

Traditional crops like tepary beans and O'odham dipper



gourds are grown in the Native Crop Garden, located near the Desert Oasis.

The mesquite bosque contains rock mortar and pestles for pounding mesquite bean pods into flour.

A Pima roundhouse, kitchen and ramada were constructed between the mesquite bosque and the Native Crop Garden. It was built by Eric Rhoades, Miles Antone, Edwin Miguel, James Miguel and Benjamin Soliz, all of the Salt River Pima/Maricopa Indian Community.

Patsy Cassadore from Peridot, Arizona, built an Apache Wickiup between the Semidesert Grassland and Chaparral habitats.

A Salado House ruin, consisting of low rock walls, was salvaged from highway 87 about 65 miles north of Phoenix and reassembled in the chaparral habitat on the trail. Archaeologist Karen Atwell supervised the coding, mapping, dismantling and reconstruction of this site.

Agaves (*Agave murpheyi*) are growing in terraced hillside gardens and rock piles modeled after those built by prehistoric people for managing these useful plants.

The Hispanic Introductions compound contains a stacked mesquite stock corral and ramada, enclosed by an ocotillo fence,

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Seed Savers in Their Own Right

Bob Sullivan and Judy Goettert

Judy Goettert and her husband Bob Sullivan live in Sells, Arizona, in the heart of the Tohono O'odham Nation, about 70 miles west of Tucson. Originally from California, they've lived in the hospital compound there for three years. Others might feel isolated living in Sells, and in fact, many Anglos who work there choose to commute from Tucson. But Bob and Judy are quick to tell of the natural beauty of the desert that surrounds them there, and that their interest in gardening and native crops flourishes in that environment.

We first met Bob when he became a regular volunteer at the Native Seeds/SEARCH office about two years ago. He's one of those ideal supporters that every nonprofit group dreams about. Almost every Thursday he comes in, working our office hours into his weekly errands schedule. He's taken home lots of extra work, such as cleaning difficult seeds and constructing screens and isolation cages for the chiles. It's generally agreed that Bob can winnow seeds better than anyone else. Currently, he has taken over our demonstration garden maintenance from David Cleveland and Daniela Soleri while they are travelling extensively, literally around the world.

Judy is a General Medical Officer with the Indian Health Service; her appointment at Sells is why they are there. She received a Doctor of Osteopathy — the equivalent of a M.D. but with greater emphasis on more wholistic practices -- with the help of a National Health Service Corps scholarship which requires her to serve four years.

There are not many jobs in Sells, so Bob has continued small-scale market gardening such as he did in California. He consulted experts before starting who told him it would be near to impossible to grow anything in Sells worth selling in Tucson, but despite their discouragement he has become a regular supplier of organic produce to natural foods stores. He started with a 35 x 75 foot plot in the back of their house and has since added a 50 x 70 foot plot he shared with the former alcohol rehabilitation center, soon to be a teen center.

Their interest in heirloom, open-pollinated seeds led them to find out more about native crops that would do well in Sells. Always ready for something different, they have grown out several varieties as part of the Native Seeds/SEARCH growers network, including Cocopa Sweet Corn, Blue Speckled Teparies, Chimayo Melons, Hopi Black Dye Sunflowers, Ojo de Liebre beans, Chiltepines, Hopi Orange Mottled Lima Beans, Hopi Red Lima Beans, Devil's Claw. They keep records of minimum/maximum temperatures, rain and planting dates.

They have experimented with different types of growing beds, and have put most on drip irrigation. Basin beds work very well for them. In one area, they collect runoff from the roof, creating a miniature "charco" or low earthen dam to grow some crops without irrigation.

Bob Sullivan and Judy Goettert

Their gardening activities set well with their O'odham neighbors. Over their backyard low hurricane fence they have sold a few chiles and gained some advice. One O'odham farmer, for instance, told them their devil's claws were planted too close together and should be two feet apart. He said a lot of water helps makes the fibers black and thus better for basket-making. The best time to harvest them is just as the skin splits at the end of the claw and it's important to taken them out of the sun right away so they don't fade.

Some of the devil's claw they've grown has been sold to O'odham craftspeople to make into the world-famous Papago baskets. It's made into a ball or wheel by starting with a cross of four claws, tips toward the center and overlapping. Wheels that are about a foot across will get $20 to $25 depending upon the quality of claw — how black and long the fibers are.

Other O'odham friends have given Bob and Judy seeds for a prized variety of devil's claw, "Papago Pumpkin" squash, and watermelon. On the look-out for native crops, once on vacation they collected seed from a melon sold to them out of the back of a pickup truck at the Isleta Pueblo corn dance in New Mexico. During the same trip, they bought melons a roadside stand in Chimayo, NM. They grew out the melons and it is now a popular item in the NS/S Seedlisting.

Bob and Judy are popular with neighborhood children who they have encourage to help with gardening. Despite the interest in their garden, there's not much of a problem with pilfering, though they have discovered that anything growing outside of their fence is considered fair game. Surplus produce is taken to the hospital and it always disappears the same day.

Noting that not many O'odham farm as they once did, Bob and Judy are trying to learn why this is and encourage their friends to continue the traditions. They cite a lost incentive due to welfare and alcoholism. Water is costly and cows and rabbits ravage unprotected crops. To have a garden on the Tohono O'odham reservation means having a fence that is both cowproof and rabbit proof, which is two different kinds of fences.

1987-88 Annual Report

This year has been one of major innovations for Native Seeds/SEARCH. We have our first large scale growout project. The first annual Fiesta de los Chiles was enormously successful. Our second San Juan's day fiesta was almost too successful. A land fund was initiated and currently has more than $8,000 in it. This annual report covers our activities from July 1, 1987, through June 30, 1988.

Fiesta de los Chiles

Our Chile Fiesta on Oct. 17, 1987, was a first, an idea whose time had really come for Tucson and southern Arizona. Co-sponsored with our "host" organization Tucson Botanical Gardens, we succeeded in creating an atmosphere of fun (music, puppetry, chile cuisine from all over the world), fundraising (chile gifts, Indian crafts), higher profile for chiles folklore, food and nutrition (chile plants, chiles-in-the-arts show), and learning (book signing, info exchange with experts, garden tours). An estimated 3,000-plus persons attended.

San Juan's Day

The Feast of San Juan, June 24, 1988, was a native foods buffet dinner event designed to let the public know how tasty and nutritious and indeed how varied traditional cuisine can be. It was also to be an inspiration for gardeners to get in the traditional summer garden planting mood. There was such a response that the event (for which we had planned for 500 persons) was swamped. We fed an estimated 850 people in a crowded but enthusiastic atmosphere. Music, seed sales and displays rounded out the activities.

Seed Collections

Follow up collecting in the New Mexico Pueblos produced San Felipe teparies and chile, Santo Domingo Giant Blue Corn, and our first large scale collections for the farm project made by Linda and Dan Parker. Barney Burns made a new tepary collection from the Mormons of northern Chihuahua. Kevin Dahl obtained Hopi Blue Corn in enough quantity to list in the 1988 Seedlisting as we had been unable to offer it in 1987. He also got quantities of Hopi Greasy Hair (a pink corn). Gary Nabhan and Karen Reichhardt located a new wild scarlet runner collection, red Tuxpeno corn, and wild tomatoes in Mexico. Some new Tarahumara beans were obtained as well as some chiles from Chihuahua, Mexico, by Barney Burns and Mahina Drees.

Volunteer April Baisan has completed a two-year project of mapping the localities where our seeds were collected, producing a graphic representation of where in the Greater Southwest we have been able to collect crops from native farmers. The 57"x62" map is on display at our office. It will be used as both an educational presentation and as a tool for determining what areas need further collecting.

Seed Bank

Thanks to a grant from the Unity Avenue Foundation, our seed storage bank is being reorganized. New accession forms were designed that are much better suited to our needs than the previous forms which we had adapted from USDA forms.

Linda Parker has spent an average of one day a week sorting, reorganizing and accessioning our seeds. In some cases it has been like a giant puzzle, and a lot of detective work to match up information and seed lots. Some great "finds" of unusual and small quantity accessions are of interest for future grow-outs.

Our seeds are currently being stored in refrigerators or a freezer. Representative samples of most of our accessions are in a freezer. The larger quantities of seeds for sale are stored in bottles or plastic buckets in air conditioned rooms or a basement.

Seed Distribution and Research Evaluations

Seeds have been made available to UA researcher Rob Robichaux (see related article in this issue) for intercropping experiments. Some of our corns have been sent to Dr. Peter Bretting at North Carolina State Univ., who is studying the genetic diversity — in technical terms, an isozymatic survey — in maize of northwestern Mexico and the southwestern United States. Researchers at the University of Minnesota are using NS/S lima beans — Pima Beige and Hopi Orange — in trials to select for drought tolerance. Foodstuff quantities of several native crops were provided to the National Institute of Health for their diabetes study.

Seeds were donated to a number of Native American farmers and other worthy projects, including: Abundant Life Seed Foundation, Navajo Zoo and Botanical Garden, Desert Botanical Garden, Nigerian farmers, Tohono O'odham tribal farm, Pima farmers, Kickapoo Indians in Coahuila, San Xavier elderly project, Salt River Pima Indian Community, Echo, Topawa and San Simon Schools, Univ. of Calif. Riverside Anthropology Dept., and Pueblo Indian farmers.

The majority of our seeds are distributed by mail order sale through our catalogs. Last fall seeds were sold during our participation at two special events: the Harvest Bazaar at the

continued next page

Continued
Annual Report

Arizona-Sonora Desert Museum and the Santa Cruz County Fair in Sonoita, Arizona. In the Spring, we held a Seed Sales Day at our Tucson Botanical Garden office and seeds were available at the San Juan's Fiesta.

Growout

Our grower's network in 1988 includes approximately 25 gardeners who have dedicated a portion of their growing area for seed increase. The majority of these gardeners are in the Southwest, although some of our seeds that require "cool weather" are being grown in Wisconsin.

Any member who is interested in this program should contact Linda Parker. In January, those interested will receive a list of accessions, usually from our small seeds collections, that are in need of being increased and evaluated. Also included are varieties that have been in our catalog in the past but had to be dropped due to short supply.

Growout and Research Farm

On January 1, 1988, Native Seeds/SEARCH entered into a year-long cooperative growout experiment with a generous landowner near Safford, Arizona. Approximately 40 acres are available to NS/S for crop variety growouts and tests. This has allowed NS/S to undertake our largest field trials ever, thereby enabling us to evaluate them for commercial potential and increase our seed stocks at the same time. Dan Parker, Linda Parker's husband, is managing this most promising growout effort. We hope some produce (melons and squash) will be available at the Chile Fiesta. The San Juan melons are particularly tasty and aromatic. The acres of blue corn seem amazing to us urbanites and, I think, to the local cotton farmers as well.

Mayo Blusher Squash (Cucurbita maxima) *has a sweet, delicious apricot-colored flesh.*

Publicity

These articles brought numerous inquiries and catalog requests: East West Journal, Sept. 87; Fine Gardening, May/June 88; American Survival Guide, May 88; Connoisseur, March 88; Modern Maturity, April/May 88. BBC World Radio and CBS radio did features spots on Native/Seeds SEARCH. NS/S staff put together chile recipes that appeared as an article in National Gardening (see article elsewhere in this newsletter).

NS/S appeared in the following directories and gardening books: Gardening By Mail, Blue Corn and Square Tomatoes, High Yield Gardening, Gardening By Mail 2, Healthy Harvest II, The Herb Garden Cookbook, The Whole Chile Pepper Catalog, and The New Seed Starter's Handbook.

Newspapers all across the southwest announced that our 1988 Seedlisting was available.

Other publications noted our efforts: Vegetarian Times, Ecology Action, Country Journal Magazine, Progressive Farmer, Harrowsmith, American Horticulturist, Organic Gardening, Arizona Daily Star, Arizona Republic, Seed Savers Exchange, and Countryside.

Slide Show Distribution & other presentations

Martha Burgess completed three copies of the traveling slide/tape program, "Planting the Seeds of Endurance." It started on its active traveling schedule in November and has reached such groups as: Zendik Farm Arts Cooperative, Boulevard, CA; Master Gardeners at UC Agricultural Extension, San Diego; Southern Calif. Dairy Goat Assoc.; gardening class at El Cajon; Organ Pipe Cactus National Monument; public programs and training park service personnel at Casa Grande National Monument; College of the Ozarks, Ark.; Arizona Native Plant Society; Desert Botanical Garden's Agricultural Field Day, Phoenix; macrobiotic classes in Los Angeles; 4th grade class in Tucson; grammar school in Topawa, Tohono O'odham reservation; Chiles to Chocolate Conference, San Francisco; at least six garden clubs in Green Valley and Tucson; St. Philip's in the Hills Church group in Tucson; Soil Conservation Service extension in Sells; 4-H Club in Bouse, AZ; Alternative Agric. classes in Santa Cruz, CA; American Association of Botanical Gardens and Arboreta 1988 convention in Scottsdale, AZ; docent classes at Tucson Botanical Gardens.

Gary Nabhan made presentations at the the Land Insititute, AAAAS Symposium on Tradtional Cultures and Conservation, the Univ. of Texas El Paso, the California Academy of Sciences "Chiles to Chocolate" Symposium, the Univ. of Minnesota, and a Native American Diabetes Conference. Many of these lectures will appear in his forthcoming book, Enduring Seeds.

Martha Burgess also maintained an active lecture circuit in Jan.-March 1988 to such groups as garden clubs, church groups, the Assoc. of University Women, reaching several hundred persons.

Demonstration Garden

In August 1987 Esther Moore, longtime NS/S gardener left to pursue new interests. Daniela Soleri and David Cleveland now share that position. During the past winter, we consolidated research and demonstration activities from two separated garden plots on the grounds of the Tucson Botanical Gardens to an expanded version of the east garden.

There is a new emphasis on demonstration and research of growing techniques, in addition to simply growing and demonstrating crops from our expanding collection. Toward this end, the Tohono O'odham floodwater field was renovated in the early spring. The field itself was redug, thanks to much volunteer help, and the soil improved. The field was also leveled to encourage even distribution of water flowing off of the catchment area, through the "arroyo" and onto the field, a demonstration of traditional late summer Tohono O'odham fields that use rainwater runoff as their water source.

Numerous tours of the demonstration gardens and our public outreach office display were given, including to the O'odham Elderly Program, Peace Corps trainees, garden clubs and school groups.

Membership

A net increase of 300 people have joined Native Seeds/SEARCH this year, bringing our membership to more than 1700 members. Within this total, 120 are lifetime members, 150 are contributing members. More than 125 Native Americans, media contacts and low-income participants receive their membership free-of-charge.

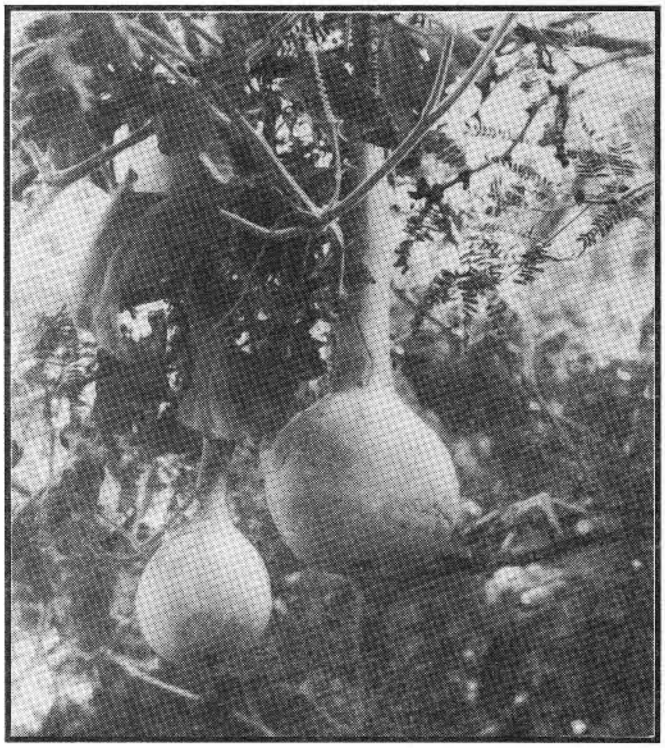
We experimented with a members workshop, the Cholla Cactus Bud Harvest, in April, co-taught by traditional O'odham Juanita Ahil and Martha Burgess, in which we combined interest in wild native foods and a feast of homegrown native crops. Such participation in context with a native family was a deeply meaningful experience for the members, and helped express the cultural depth of NS/S work.

Finances

Fiscal year, Jan. 1, 1987, through Dec. 31, 1987. Total income of $59,855.34 was exceeded by expenses of $65,157.51 due to grant money spent this year that was received the previous year.

Income came from following sources (rounded to hundreds, less than 100 not included): Sales (32,800), Grants (13,500), Associate Dues (12,900), General Contributions (600) and Interest (300).

Significant expenses (also rounded to hundreds were): Salaries and Labor (30,800), Cost of Goods Sold, Purchases (9600), Printing (7700), Freight Out (3000), Rent and Utiltities (2700), Postage (2500), Payroll Taxes (2100), Depreciation (1,100), Supplies (1,500), Travel (800), Telephone (300), Seeds Purchased (300), Repairs and Maintenance (200), Meetings (200), Dues, Subscriptions and Publications (100).



Apache Dipper Gourds hanging in mesquite branches at Native Seeds/SEARCH's demonstration garden.

It's interesting to note that when our expenses are broken out into the category of fundraising, we spent only $681.04, about 1 percent of our total expenses.

Grants

A grant was received from Pioneer Hybrid to survey modern Hopi seed sources. Dr. Alfred Whiting first conducted such a survey in 1938. A comparison of his results and modern seed acquisition should be very interesting and helpful in understanding seed distribution.

Unity Avenue Foundation, Tides Foundation and Wallace Genetic Foundation funds also supported NS/S activities over the 1987/88 interval.

Land Fund

Funds were sought in January 1988 for the eventual purchase of land which would permit perennial cultivation as well as greater quantities of seed increase. The fund was initiated at this time because of a need for office space. The plan is to purchase an urban building for this need and then later use the equity in it for the rural purchase. We are approaching enough for a down payment at more than $8,000, and we are proud that more than one-eighth of our membership has so far participated.

Environment and Edible Flora of the Cocopa

By Anita Alvarez de Williams

The Cocopa people of the Hardy River tell of a time when their ancestors lived in the Cocopa Mountains, when these mountains were a peninsula with a great freshwater lake wrapped around its foothills. A wide and mighty Colorado River, and her sister the Gila, flowed from the northeast into the lake that then covered the Imperial/Mexicali Valleys. The waters pushed against the foothills of the westerly mountains and up into the Coachella Valley, lapped along the sandhills below the Chocolate Mountains, and backed up into the Yuma and South Gila Valleys. The overflow from the rivers and lake drained south into the Gulf of California.

Then the climate changed. The rains diminished and the weather warmed. The waters of the vast lake receded until only the rivers were left, meeting and combining their waters near Yuma, and snaking down to the gulf in everchanging meanders.

The many folk who had lived along the shores of the lake went away, leaving a scattering of stone tools, potsherds and shell beads along the old beachline. Some went up into the mountains and many to the banks of the rivers. The ancestors of the Cocopa just moved down from their mountains to the lower delta, an environment which continued to provide generously for them. Spring floods covered broad expanses of flat land, depositing rich silts and enough moisture to establish and bring to maturity the wild foods and planted crops of the Cocopa. The latter included several varieties of corn, beans and squash. The Cocopa gathered and ground the fine clays deposited by the river, and with these formed thin-walled pottery bowls for cooking, large narrow-necked, fat-bottomed storage jars, and shallow trays for gathering and parching seed. The people made good use of the materials from the extensive floodplain forests of mesquite, screwbean, ironwood, cottonwood and willow (as well as the marsh tules and arrowweed) to build houses and make tools. Willow bark, animal skins, cordage made from wild hemp, and hillside agaves furnished the people with the scant clothing they required.

They hunted using bows, arrows, spears and nets, and made traps for mountain sheep, javelina, mule deer, rabbits and rodents. The thousands of birds that wintered in the quieter lagoons, and the many species of fish in the river were also utilized as food.

Around the time that the Cocopa were adapting to their new lives as river people, Europeans first appeared in the delta. The native folk were alarmed at first and were hostile towards Hermando de Alarcon and his exploring party as they sailed up from the gulf on that hot August day in 1540. But the Spaniards were not to be scared off.

When reassured that the newcomers posed no threat, the river people became curious about the Spaniards (and their trappings), eventually treating them as honored guests, offering them corn, mesquite cakes and finely tanned leathers. Led to believe that the Spaniards were children of the sun, the natives even pulled their boats up the river for them. The explorers described these river people as tall, strong and well built, still a fitting description of some Cocopa.

By the time Juan de Onate came to the delta in 1605, the Cocopa were occupying both sides of the river. Onate saw only those on the eastern side of the river and (without counting those on the western bank) estimated their population to be around five or six thousand.

Almost a hundred years went by before the Cocopa received their next visitors — this time missionaries: Jesuit Eusebio Kino in 1702 and 70 years later, Franciscan Francisco Garces, who loved the people and stayed. But neither the Cocopa nor their immediate neighbors were ready to be missionized. Or perhaps they were reacting to Spanish military men, some of whom behaved very differently from the religious men they accompanied. The Garces mission came to a disastrous end.

But from 1785 on, more and more new people came to the delta: military men, trappers, explorers, scientists and, by the last half of the 19th century, settlers. By then some of the Cocopa had moved north and were to be found near Calexico and Yuma. The newcomers began taking over Indian lands. They made political decisions that divided the Cocopa, leaving northern members of some families in the United States and southern members in Mexico. The newcomers began manipulating the rivers, directing them into irrigation systems, and eventually building dams upstream so that the time came when the important life-giving spring floods ceased. This brought an end to Cocopa floodplain farming, and as the delta dried, their traditional wild food sources began to disappear.

One result of these occurrences was that the Cocopa abandoned eating habits that had, through centuries, kept them tall, strong and healthy, and they began to eat like the newcomers. Some people believe that the new diet didn't do the Cocopa any favors. What was so good about their traditional foods? And what were those wild food plants? Although the Cocopa rarely gather wild food plants today, the older folk still remember them, and can provide interesting and valuable information about these plants. Let's look briefly at some of them, then focus on one particularly remarkable grain.

If we were to have looked in on the Colorado River delta 100 years ago in midsummer, we would have seen the dense forests of mesquite, *Prosopis glandulosa*, and the Cocopa gathering the pods because these comprised their most important staple food. These hardy trees also provided wood for building, fuel and tools, a black dye for coloring hair and ceramics, and *chukata* (tough little bits of dried mesquite sap used as Cocopa chewing gum). Mesquite flowers gathered earlier made a nice little snack. Dried mesquite pods, ground on stone metates or in deep wooden or bedrock mortars, yielded a tasty flour useful for food and drink. The protein-rich beans were also ground and utilized, but less often because they are very hard.

Later in the summer the pods of the screwbean tree, *Prosopis pubescens*, were similarly treated as were the seeds of the ironwood tree, *Olneya tesota*. The pods and seeds of all three of these trees stored well.

Shortly after floodwaters receded (and after summer rains), Cocopa looked for and gathered the young leaves of quelite, *Amaranthus palmeri*, as a choice green vegetable. Later they collected, threshed and winnowed large quantities of *Amaranthus* seed, to be ground just prior to being eaten raw, or added to hot water to make mush, or baked into cakes.

The planted crops put in earlier with digging sticks were up and thriving at this time. Perhaps they had been weeded and perhaps not. But August was the time for many of the Cocopa to leave the hot delta and go westward, up through the stream-fed canyons, gathering the tiny fruits of the *Washingtonia filifera* palm and the edible young shoots of the blue palm, *Brahea armata*. In the mountains they visited their Paipai and Kumyai friends and gathered or traded for pinon nuts, perhaps enjoying other mountain foods such as jojoba nuts or acornmeal mush, before heading back down through the canyons to the delta to harvest their crops.

During September and October the Cocopa gathered seed from several wild grasses, including two species of *Echinochloa*, and two grasses that some would consider wild but that were domesticated by the Cocopa. These were *Panicum sonorum* (sown by blowing seed from the mouth and thus broadcasting it over mud) and *Dactyloctenium aegyptium*, a grass introduced from the Old World.

During the winter months the Cocopa relied upon stored produce. Dried pumpkin, squash and melons that had been cut into long strips were looped and hung over horizontal poles, dried and left there. Or they were broken up and placed in large covered baskets or clay ollas on high storage platforms, as were corn, beans and wild pods, seed and dried root-foods that had been collected during the summer and fall. These platforms protected valuable foods not only from hungry animals but from surprise floods. Sometimes a rooftop served the same purpose. These stored foods had to last until the early summer foods began maturing.

If the stored food supply became exhausted, March and April could be hungry months. This meant trips to the nearby arroyos and mountains to search for agaves, which were stripped of their leaves and baked in stone-lined pits. The people also went to the sand dunes in search of the prized sandfood, *Ammobroma sonorae*, now so rare that one celebrates just seeing it. A small domed lump of a plant, sometimes shaped like a rippled doughnut, sandfood is exactly the color of the dune it hugs, and eventually sports a crown of minute purple flowers. It is far too rare to consider eating it anymore, but when it was plentiful the Cocopa prized the plant's large fleshy root, toasting it on hot ashes.

One food that could be counted on during the hungry early spring months was the root of the tule (or cattail), *Typha latifolia*, edible raw when young, ground and cooked when mature. The inner part of the stalk is also edible, and the cattail pollen was added to other foods as a sweetener. Stalks and leaves of this plant also served in house and watercraft construction. Another marsh-loving plant known and used by the Cocopa was the tule-potato, a variety of *Sagittaria* with an edible root. It was, however, a non-storable food.

By late April the saltbush, *Atriplex lentiformis*, produced a seed that the Cocopa collected and toasted although they weren't particularly fond of this food. They did like and still do favor the buds of the biznaga or barrel cactus, *Ferrocactus peninsulae*. Gathered just before they open, the buds are blanched in two or three waters and then cooked with a little oil, or steamed briefly, or added to meat or fish dishes. The sturdy spines of the biznaga found many uses, as they could be heated and straightened (or curved more) and made into awls, needles or fishhooks.

Dock, *Rumex violascens*, was plentiful in the delta in the early spring and therefore an important food-plant for the Cocopa. They ate the young leaves. Then they waited for the seeds to mature, shelled them, washed them in several waters to remove bitterness, and ground them for use in cakes or gruel.

The last of the Cocopa wild foods we will look at is a saltgrass now known as *Distichlis palmeri* to scientists, and as *nypa* or *trigo gentil* to the Cocopa.

A Cocopa legend describes their discovery of *nypa* at the time when the great lake was receding. *Kinakul*, a mountain person, sent *Hiesh*, the horned lizard, to see if the land was dry yet. *Hiesh* went as far as the Laguna Salada and there he discovered *nypa* ready for gathering. He took some spikelets of the ripe wheat and stuck them into the top of his head. That was the sign that the waters had receded and that *nypa* was good for the people to eat. That horned lizard, the one that eats red ants, still today carries the signs of the spikelets of *nypa* on his head.

Normally it was in May that the Cocopa made saltgrass gathering trips to the mouth of the river in very large specially designed rafts formed of bundles of tule canes fastened together with tule leaves. Some rafts were large enough to accommodate a family for several days. They steered the raft with a long pole, and used a clay floor at one end or corner of the raft to build a cooking fire.

Jacobo Blanco, a Mexican mapmaker, described the *nypa* fields in 1863 as "lands ... bathed by the tides ... covered with a saltgrass which forms prairies extending beyond eyesight." He told of the native people coming to gather the seed, as did Edward Palmer when he watched the Cocopa people in 1889 sink nearly to

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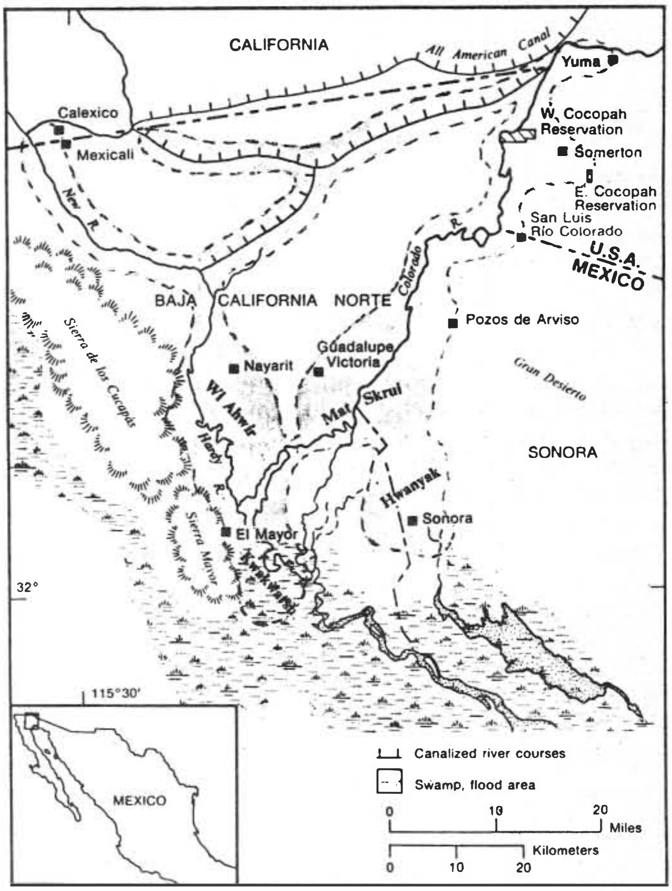


Tribal territory and band locations in the late 19th century.

Edible Flora of the Cocopa

their knees in soft adhesive clay as they cut off the *nypa* seedheads. They tossed them into baskets, later drying the spikelets by fires, threshing them with sticks, and then treading them with their feet to shell the seeds out. Palmer also noticed that the action of the tides served to carry the grain, floating it to dry land and depositing it in neat undulating rows which were also harvested by the Cocopa.

Distichlis palmeri and other vegetation of the Cocopa homeland were subjected to drastic change during the first half of this century. Dams and irrigation projects up-river controlled and diverted water. This, combined with prolonged periods of drought, reduced the vast green lands to arid desolation. By the 1950s the Cocopa saw the last great stands of delta vegetation disappear. never again to recover fully. The mighty Colorado had been reduced to an impotent trickle.

About ten years ago unusually heavy snows and rains drained into the Colorado and Gila Rivers, and in spite of all the dams and endless irrigation systems, the delta flooded once again. At about this time, when some of the region's vegetation was beginning to reestablish itself (the grasses always come first), scientists again became interested in the salt-grasses of the delta. Yet in a public lecture as recently as five years ago, a noted authority on the Sonoran Desert declared that *D. palmeri* was extinct. Indeed, to the Cocopa themselves, *nypa* had become just a remembered food, ungathered by them for two or three generations.

But two dedicated scientists, marine ecologist Dr. Nicholas Yensen and nutritionist Susana Bojorquez de Yensen, found *D. palmeri* and have been working with it for 15 years. They have located 53 varieties of the plant. Nicholas Yensen has used some of these in a successful breeding program domesticating this halophyte (salt-loving plant), developing high-yield nutritious varieties of it for use in alkaline lands and/or to be irrigated by salty water (even seawater). Susana de Yensen has found this traditional Cocopa grain to be low in salt, although the leaves and stems absorb salt and reduce soil salinity. The grain is high in fiber and bran content, low in antinutritional phytates, and contains slightly less protein than *Triticum* sp. wheat. Ms. Yensen has found *Distichlis* to be surprisingly free of gluten, a substance some people seem to be allergic to. Yet dough made from *Distichlis* flour is perfectly elastic and cohesive for baking purposes. *Distichlis* also tastes good — we have yet to find anyone who thinks it doesn't.

The Yensens quote the world Food and Agriculture Organization (FAO) as stating that 3.8 billion acres of the Earth's lands are too salty for normal farming. On this continent alone, thousands of acres per year are lost to salinization. Since halophytes not only grow in salty conditions but remove salts from the land, the Yensens believe that these peculiar plants are essential for future agriculture. Having tested over a thousand halophytes from around the world, they conclude that the varieties of the Cocopa's *nypa* have the combined characteristics which will permit it to become a basic food of the near future. It should be useful worldwide to man and animal, but particularly to third world nations with soil and water salinity problems.

Farmlands in certain parts of the world are highly productive, but they are a long way from most starving people. Since a fourth or more of the cost of supplying grain to the far corners of the Earth consists in paying for its transportation, we can appreciate the value of eventually being able to utilize now useless lands close to people who need food.

The Yensens may well have saved this valuable ancient food of the Cocopas from extinction. The floodwaters of the Colorado are receding again; if American engineers have their way, never to flood again. Will the original fields of the Cocopa *nypa* survive? We don't know. But the Cocopa are among those taking an interest in the domestication of their ancient food. The varieties of *Distichlis* the Yensens are developing can be planted and harvested either by machine or by hand, permitting people at all economic levels to grow this valuable old/new crop; they market them as WildWheat(tm).

We began this description of *D. palmeri* with one Cocopa legend and we shall close with another — one which could prove to be prophetic. In this story, *Kma.sut.malay*, one of two cannibal friends has come to a turning point in his life. He states that he has "worked at bad things," but that he has decided to quit, and to think about different things. After a while he announces that he is going to plant wheat that people will enjoy eating. He's going to quit doing bad things in order to say and do good things. He gathers the people and they all plant wheat at Makanymam, near the gulf, beside the Colorado River. Future generations will eat this wheat, he says. After the wheat ripens, the reformed Cocopa cannibal, *Kma.sut.malay*, gathers people together to harvest the wheat and grind it and make mush and tortillas. The legend ends with *Kma.sut.malay* inviting everyone to "come eat! Come and eat!!"

Second Annual Fiesta de los Chiles

By Muffin Burgess

Chiles are swelling on the pepper bushes and turning from green to wild shades of red, telling us it's time for the really hot season again — time for the second annual Fiesta de los Chiles.

Those who thought summer of 1988 was hot better get out their fire extinguishers and mark their calendars for Saturday and Sunday, Oct. 15 and 16. It's going to be a weekend sizzling with good fun, new spicy culinary delights and cool-off refreshments, creative chile crafts, a chiles-in-the-arts show, a continuous concert of the hottest music in southern Arizona, chile plants and seeds for the garden, and a harvest of information from experts about this marvel of southwestern horticulture — the chile pepper.

Co-sponsored by Native Seeds/SEARCH and Tucson Botanical Gardens, Fiesta de los Chiles will be at the Botanical Gardens grounds, 2150 N. Alvernon, Tucson (just south of Grant Road), from 10 a.m. - 5 p.m. Saturday and 11 a.m. - 4 p.m. Sunday. The admission of $3 for adults, $1 for children under 12, will include live music, puppetry and face painting for the kids, garden tours, and many free samples. Regular membership in Native Seeds/SEARCH entitles one person to free entry; contributing members may bring the entire family with no admission fee.

Native Seeds/SEARCH members who wish to help either before, during, or after the fiesta will have admission waived for their families. We would greatly appreciate your help! If you have talents and aptitudes to share in signmaking, art gallery work, gardening information exchange, sales, or if you'd just like to assist as a "gofer" your presence would be a boon to this educational and fundraising effort. Please leave a message for coordinator Muffin Burgess at 327-9123 or 622-1370 if we can count on you as a volunteer. There will be a briefing meeting for all fiesta volunteers Friday, Oct. 14, at 1 p.m. at the NS/S public education office.

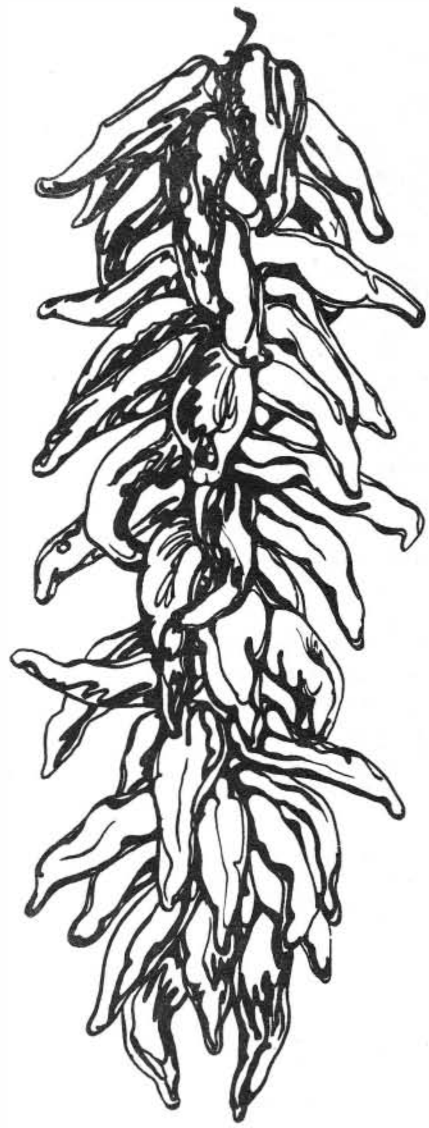
Of course, just coming for the fun of it and telling all your friends about the fiesta will be the greatest help. There isn't a better place to find holiday gifts which express so well the things Native Seeds/SEARCH members deeply believe. In addition to seeds and starts for your winter garden, there will be gifts for cooks with assortments of Native American foods, our own spices, heirloom soup mixes, and Native baking mixes, some of which will be packaged in Indian baskets or hand carved bowls. Both last year's "chile queen," Dr. Jean Andrews, and this year's "queen of chiltepines," Josefina Durah of Sonora will be present. In an atmosphere of an open air market you can find every kind of handmade craft from the natives of northwest Mexico, bright red *ristras* of red chiles, chile ceramics, baskets of Indian corn and colorful squash, important books about southwestern gardening and Native American cooking, zany chile wrapping paper, cards, jewelry, T-shirts and collectors' tapes of Indian music.

An off-the-wall addition to this year's fiesta is a contest for the best original Chile Song. All songsters, poets and musicians are invited to send a cassette tape of their Chile Song creation to Chile Song Contest, c/o TBG, 2150 N. Alvernon, Tucson AZ 85712, by Sept. 15. There is no entry fee. Winning songs will be performed at the fiesta.

If you could join us any Thursday, 11 a.m. to 3 p.m., at the NS/S office for a lunch potluck and fiesta preparations, it would be great to have you with us.

Chiltepine enthusiasts take note. The day following the Chile Fiesta, on Monday, Oct. 17, there will be a wild chile symposium on chiltepine natural history and economic development at the Desert Botanical Garden in Phoenix. Call Mark Slater or Gary Nabhan for details at 602-941-1225; preregistration is $20.

Don't forget to come hungry on Oct. 15 and 16 for the spiciest time of your life!



Genetic Vulnerability, Genetic Erosion and How to Avoid Them

By Gary Nabhan

Since the early 1970s the spread of disease and pest epidemics through production agriculture has been touted as a matter of crop genetic vulnerability — the reduction of the gene pool and resulting genetic uniformity of any given crop. Yet this problem is just as much due to the increased ecological uniformity of modern agriculture. The loss of hedgerows, the consolidation of field patches into large tracts, the reduction in structural diversity inherent in intercrops and polycultures all ease the spread of diseases and pests. We must work to reduce genetic vulnerability by increasing complexity in our sustainable agriculture experiments.

Yet the gene pool reserves upon which our fields and gardens depend are drying up. In centers of diversity around the world, the loss of genetic resources has accelerated over the last forty years. Sometimes, this loss is termed genetic erosion, but actually there are three processes which collectively contribute to the loss of crop variability upon which all humankind depends. Let's look at these three processes.

Genetic erosion is a term for the sometimes imperceptible but increasing loss of plant diversity at the first level. First is the loss of genetic variability within one plant variety or seedstock. As farmers abandon a heterogeneously-colored maize variety for a more uniform one, "cleaned up" by a local agricultural experiment station, they may be inadvertently losing their crop's insurance against variable climate. Within the mix of traditional maize, there may be some seeds that do better in shorter, cooler seasons, and others with greater heat resistance. As a composite population, the overall yield may be more stable, with a higher average, than a uniform seedstock that outperforms the mixture in the best years, but otherwise fails.

The second kind of genetic loss is the "swamping" of traditional varieties by an introduced one which is cross-compatible with them. When Mammoth Russian sunflowers were introduced into areas where smaller seeded native American sunflowers had been grown by indigenous peoples for centuries, curious gardeners tried growing them alongside one another. The interbreeding of the two resulted in a bizarre mixture of progeny in subsequent generations, some with tall, thin stalks too weak to support large sunflower heads. Other segregates had lost their gene for a blue dye that Indians used for coloring their basketry. While the people who preferred the Mammoth Russian's large seeds could go out and buy them to replant, they had difficulty finding anyone who could share "pure seed" of the indigenous strain anymore. The number of Mammoth Russian sunflowers grown increased, overwhelming the number of native sunflowers grown in some villages. Since sunflowers are wind and bee pollinated, even farmers who decided to grow only the indigenous strain had their flowers "contaminated" by pollen of Mammoth Russians planted a quarter mile or so away. Maize, chile and melon varieties can be quickly "swamped" by large scale introductions of other varieties of these crops within short distances from traditional fields and gardens. Within three or four years, a farmer's seed may not look or taste like its "old self" any more.

The third kind of genetic loss, as Garrison Wilkes suggests, is perhaps best termed genetic wipeout. This is the wholesale replacement of a set of traditional crops with an altogether different kind of introduced crops. For instance, in the subtropical foothills of the Sierra Madre of Mexico, commercial safflower production is taking over land formerly used for growing intercropped fields of maize, beans, amaranths, panicgrass, melons, squashes, chiles and cowpeas. A few of these minor crops are now hardly grown at all, while the others are relegated to small garden plots where the reduced number of plants grown results in a narrowing of the population's genetic variability. This rapid turnover in crops is often associated with drastic alteration of the agricultural ecology and economy of a location. For instance, among the Lacandon Maya a cattle and pasture grass monoculture recently replaced a native intercropping system of more than 100 cultivated and wild edible plants on thousands of acres in tropical montane environments. This problem is not localized. It was estimated by John Carr that three quarters of the crop strains grown in the New World at the time of Columbus have since become extinct. Some crop species such as the tepary or escumite were at the turn of the century represented by 50 plus color types. Now only five are found in gene banks, and only two are in commercial cultivation.

No government program or policy explicitly attempts to reduce the genetic erosion of crop plants in the field; they simply try to rescue selected samples for gene banks. In truth, the problem of genetic erosion is too critical to be left up to government bureaucracies. It must be dealt with at both community and regional levels through monitoring agricultural change and foreseen potential impacts on the overall stability of areas harboring the remaining crop diversity. Native farmers must be contacted and encouraged to continue doing what they have done well for hundreds of years: saving, selecting and utilizing indigenous crop seeds. But to avert genetic erosion, we must also help traditional farmers face new threats to their crops, their fields, and their rural communities: government-funded irrigation or flood control projects that displace small farms; untargeted pesticide spraying; introduced weeds and pests; and contamination due to outcrossing with hybrid varieties produced nearby.

On the positive note, we need to provide new incentives for native farmers who wish to maintain diversified farms. We can offer to buy their surplus of rarer crops, but keep some on store to give back in case they have crop failure the next year. We can encourage community pride in native farming through festivals, fairs and workshops. We can develop new markets for their products, and fine-tune appropriate technologies to make harvesting and processing easier. In general, economic, cultural, symbolic and ecological reasons should all be advanced to support native crop conservation. It's an issue too important to be "left up to fate"; fifty percent of what we eat every day comes in the form of seeds. Let's keep them passing hand to hand, from one generation to the next.

Research on Low-Input Desert Agriculture

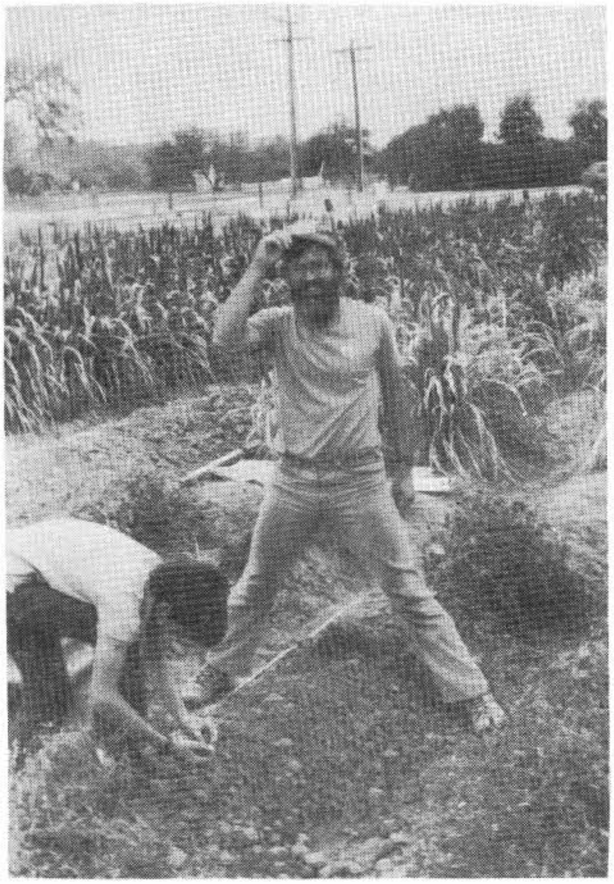
By Robert Robichaux and Gary Nabhan

More than 200,000 hectares of croplands in the Sonoran Desert region of Arizona and Mexico have fallen out of cultivation in the last 15 years as a result of groundwater depletion, salinization, and urbanization. This region epitomizes a global trend: 300 hectares of land in arid environments are being reduced to zero productivity every hour. While the land's carrying capacity is being depleted at an unprecedented rate, more people are trying to live in arid regions. By the year 2000, approximately 1.2 billion people are expected to live in these regions.

Two major options are available for restoring the land's productivity without exorbitant ecological and economic costs. First, desert-adapted crops that exhibit greater tolerances to high temperatures and low water supplies may be cultivated more widely. Second, alternative cropping systems, specifically legume/cereal intercrops, which promote higher resource-use efficiencies, may be adopted on a larger scale. In both instances, the traditional agricultural systems of the native inhabitants of desert regions may serve as our best source of seeds and insights.

Last year, this article's authors began a collaborative research program at the University of Arizona in Tucson and the Desert Botanical Garden in Phoenix to explore these options for increasing crop productivity. In one set of experiments, we are examining the effects of water availability and plant density on the growth and yield of sole crops of tepary bean and intercrops of tepary bean and Sonoran panicgrass. Both crops are exceptionally heat and drought tolerant, and were extensively cultivated by the indigenous peoples of the Sonoran Desert. In another set of experiments, we are examining the yield characteristics of sole crops and intercrops of Papago cowpea and pearl millet under irrigated and rainfed conditions. In these experiments, we vary plant spatial arrangement in addition to density. Cowpea/pearl millet intercrops have been cultivated widely by subsistence farmers in the Sahelian region of West Africa for centuries.

We hope the results of this research program will benefit the whole range of farming systems, from resource-limited to capital-intensive. If so, it will illustrate once again how the legacy of traditional desert agriculture offers a key to our sustainable agricultural future.



Robert Robichaux (standing) in his UA field of intercropped tepary beans and pearl millet.

Notes

GOURDS. The Ohio Gourd Show — the world's largest and 26th annual — will be held Oct. 1 and 2, 1988, at the Morrow County Fairgrounds in Mt. Gilead, Ohio. For details: O.C. Stevens, 4761 Twp. Rd. 116, Mt. Gilead, OH 43338; 419-946-3302. Its theme this year is Native American gourd crafts.

AGROECOLOGY. There will be a 6-month Apprenticeship in Ecological Horticulture, April 1-Sept. 30, 1989, at the Farm & Garden at UC Santa Cruz. Emphasis is on hands-on learning in organic gardens, orchards and row crops. Application deadline: Dec. 5, 1988. For details: Agroecology Program, Univ. of Calif., Santa Cruz, CA 95064; 408-429-2321.

NATIVE AMERICAN PERMACULTURE. A Drylands Permaculture Design Course for Native Americans only will be held near Tucson on Oct. 22-28, taught by Bill Mollison. For details: O'odham Nation, San Xavier District Office, Rt. 11 Box 640-A, Tucson, AZ 85746, (602) 294-5727.

ARID LANDS PERMACULTURE COURSE. Bill Mollison will lead a permaculture design course, Nov. 6-19, 1988, at the Sunglow Ranch in the Chiricahua Mtns. of southeast Arizona. For details, write Sonoran Permaculture Association, P.O. Box 27371, Tucson, AZ 85726 or call Tim Murphy or Vicki Marvick, (602) 792-4106.

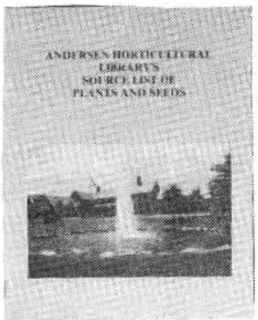
EXPIRATION DATE. In the upper right-hand corner of your mailing label is a four-character code that shows the current status of your membership. The numbers represent the year and month you should renew (for example, 8810 is October 1988).

Book Reviews

INDIAN AGRICULTURE IN AMERICA: PREHISTORY TO THE PRESENT by R. Douglas Hirt. 1987. Published by University Press of Kansas, Lawrence, KS 66045. 290 pp. $29.95, hardback. ISBN 0-7006-0337.

This scholarly survey of Native American agricultural history begins with an overview of what we currently know about prehistoric farming in the United States, focusing on methods and land tenure issues. Hirt's review of the literature is thorough and masterful as he goes on to examine the influences early European contact had on native farming. This in and of itself would have made a fine and useful book. Hirt's triumph, however, and his special contribution to the understanding of this subject is his history of how federal policy "caused the ultimate collapse of that economic endeavor [Indian agriculture]." Obviously, the acquisition of Indian lands as this country grew westward had significant impact on the Indian farmers east of the Mississippi River. Many tribes were relocated to lands marginal at best and some, with no agricultural traditions of their own, found sedentary farming life unacceptable. But the demise of Indian farming is more than just the story of relocation. Hirt documents how government policy over the last century to encourage Indian acculturation and assimilation through farming failed miserably. He cites such factors as insufficient education and financial support; neglecting the role of women as native agriculturists; allotment of individual landholdings that were too small to support individual farmers; inheritance policies that further subdivided small plots; and outright prejudice many white people have exhibited toward Indians.

—Kevin Dahl



ANDERSEN HORTICULTURAL LIBRARY'S SOURCE LIST OF PLANTS AND SEEDS compiled by Richard T. Isaacson. 1987. Andersen Horticultural Library, minnesota Landscape Arboretum, 3675 Arboretum Dr., Box 39, Chanhassen, MN 55317. 163 pp. $29.95, paperbound.

This is a tremendously helpful book for anyone in a position of having to answer questions like, "Where can I get seeds for ________?" More than 20,000 plant varieties available commercially in North America are listed, keyed to more than 1,000 seed and nursery catalogs. Native Seeds/SEARCH and other heirloom seed suppliers are noticeably absent from this source list, but the reader is referred to the *Garden Seed Inventory* as another good source of finding plants.

—Kevin Dahl

GARDEN SEED INVENTORY, SECOND EDITION complied by Kent Whealy, 2nd ed. update by Arland Braaten-Lee. 1988. Seed Saver Publications, RR 3 Box 239, Decorah, IA 52101. 422 pp. $17.50 paperbound, $25 hardback.

This inventory of 215 mail-order seed catalogs from the U.S. and Canada describes all the non-hybrid vegetable seeds still available from commercial sources. As a sourcebook for gardeners looking for particular varieties, this reference is invaluable. The *Garden Seed Inventory* is also a preservation tool against seed industry consolidation that threatens the loss of many excellent vegetable varieties. The first edition of this inventory was published in 1985 and covered up to 1984 (including Native Seeds/SEARCH's first catalog); this edition updates through 1987. It's startling to discover that during those three years, 54 seed companies have quit business out of a total of 230, and 943 varieties were no longer available.

Among the varieties the inventory identifies as having been dropped from catalogs, 28 Native Seeds/SEARCH offerings are included. This deserves an explanation. Of course, because we are a conservation organization and not just a seed company, each of these varieties remains in our seedbank. Of the 28, 9 are still not available in our 1988 catalog; one (Mayo Azufrado Beans) we have been unable to obtain due to the Mexican drought and one (Tarahumara Pink Lentils) because is just doesn't grow very well in conditions different than where it was collected. Four varieties we were unable to offer in 1987 due to limited supply were back in the 1988 catalog. The other 15 represent name changes, for instance from Wild Narrow Leafed Tepary to Wild Willow-Leaf Tepary. Included in the name changes are instances in which we combined two similar varieties (Tarahumara Maiz Colorado was included with Tarahumara Prieto and is now called Tarahumara Prieto/Maiz Colorado) and in which we now offer two varieties in the place of one (Hopi Sweet Corn is replaced with Hopi Early Sweet Corn and Hopi Bantam Sweet Corn). Five of the name changes are due to our discontinuing the use of the word called Papago. On January 18, 1986, the people who for many years have been Papago voted for a new constition naming their government the Tohono O'odham Nation. They have always referred to themselves as Tohono O'odham which means desert people. Papago is still widely used both on and off the reservation, and it was interesting to note that Papago Peas (which we now call O'odham-Adapted Import) are still offered commercially under their old name by Plants of the Southwest.

—Kevin Dahl

Fall-Winter Crops for Low Desert Areas

By Kevin Dahl and Mahina Drees

While it's true most low desert native crops were grown during spring and late summer seasons, a few introduced crops perform excellently in fall-winter gardens. Here's some from our 1988 Seedlisting, with planting times based on Tucson conditions. If you'd like to order without consulting the catalog, submit a list of the packets you'd like, along with $1.25 plus $.25 shipping for each one, to Native Seeds/SEARCH, 3950 W. New York Dr., Tucson, AZ 85745.

FAVA BEANS (*Vicia faba*). Also called broad beans, or horse beans, and *habas* in Spanish, the large seeds are used both green and dry. The beans are delicious in soups, or can be ground and made into tortillas. The slender plants, which set off side shoots, are a bush-type bean and are self pollinating. A good cover crop, favas are the highest nitrogen fixer of all the legumes. About 30 seeds/packet. In Tucson, plant Sept.-Oct. or Jan. **FVI. Tarahumara Habas** or **FV2. San Ildefonso Favas.**

GARBANZOS (*Cicer arietinum*). This legume is used to prepare the Middle Eastern dish "hummus," but was cooked like beans by American Indians. Traditionally dry farmed, often in rows next to wheat. About 50 seeds/packet. In Tucson, plant Sept.-Oct. **U1. Mayo Winter Bean.** Plump, beige, dry farmed in Sonora with winter rains. **U3. Tarahumara.** Fall crop from the bottom of Copper Canyon, Mexico.

MUSTARD GREENS (*Brassica campestris*). These wild mustards have mild, tender leaves when young that can be used in salads. Later growth is tasty cooked like spinach. About 25 seeds/packet. In Tucson, planted Sept.-Feb. **GR4. Tarahumara Espinica.** Cultivated 6 feet tall. **GR5. Tarahumara Mostasa/ Mocoasali.**

CILANTRO (*Coriandrum sativum*). This tangy herb is used green in both Mexican and Chinese dishes and is also called Chinese Parsley. Many consider it an essential ingredient of salsa. The dried seed is coriander. About 30 seeds/packet. In Tucson, plant Sept.-March. **HB1. Cilantro.**

CHIA (*Salvia columbariae*). A wild protein- and oil-rich seed with high fiber mucilage of medicinal value. About 30 seeds/ packet. In Tucson, plant Sept.-Oct. The seeds need moist soil to germinate, so it might be easier to start them in pots. **HB2. Desert Chia.**

ONIONS (*Allium* sp.). A prolific multiplier onion, this shallot-like plant was probably an early introduction but reputed by some sources to be a gift to the Tohono O'odham from their creator. It rarely flowers, but produces many offsets for increasing. About 10 sets/packet. In Tucson, put in sets Sept.-March. **B1. Tohono O'odham I'itoi's.**

PEAS (*Pisum sativum*). The dry seed is eaten in soups or cooked like beans. Staking or trellising is helpful in growing this self-pollinating, nitrogen-fixing legume. About 50 seeds/packet. In Tucson, planted Sept.-Oct. or Jan.-Feb. **Q1. O'odham-Adapted**

Collection Sites Map

By April Baisan

Where the heck is Cerocahui, Chihuahua, anyway, and what sort of crops has Native Seeds/SEARCH collected there? This, and other similar questions, are readily answered by looking at our recently completed Collection Sites Map. The map, is displayed at NS/S's public education office at the Tucson Botanical Gardens. It presents the "boundaries" of Southwestern native peoples and locations where seeds have been collected on an acetate overlay of "Biotic Communities of the Southwest," a map by David E. Brown and Charles H. Lowe, 1980.

The "boundaries" in the United States consist of official reservation boundaries. In Mexico, the *Handbook of North American Indians* (vol. 10, Alfonso Ortiz vol. ed., 1983, Smithsonian Institute) provided the more general political "boundaries," some historical than recent, as explained in detail on the map itself.

In compiling the information to create this map, seeds were grouped into 19 categories, much as they are in the 1988 Seedlisting. Each is represented on the overlay by a small appropriate graphic symbol.

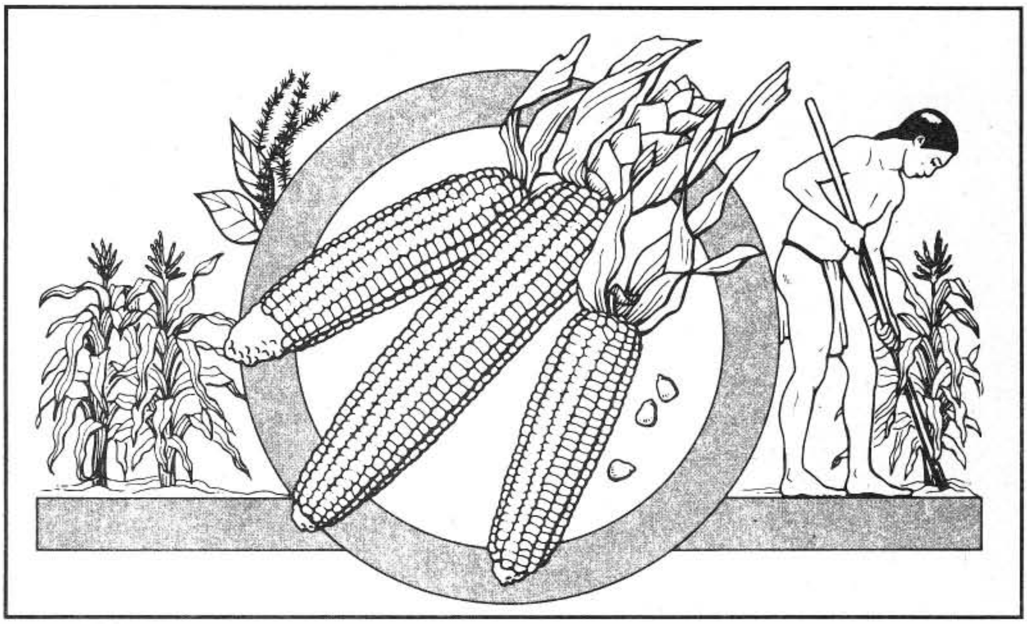
The map should prove useful in imparting a general visual overview of what NS/S is all about. It will also give our dedicated collectors a visual sense of which areas have been extensively collected and which need more attention. All of this is displayed within the vegetational and elevational contexts provided by the Biotic Communities map.

Next time you are in our office, maybe during a special event, I hope you will get a chance to enjoy this map and perhaps find out where the crops you've grown were originally cultivated.

Editor's note: the staff and board wish to thank April for her herculean effort on this project.

DBG Ethnobotanical Garden

all built by Ed Kisto. Within this area are a small fig and Papago pomegranate orchard and a garden consisting of some of the other desert-adapted crops brought by the Spanish, such as Mayo melons, O'odham sugar cane, and Sonoran wheat.



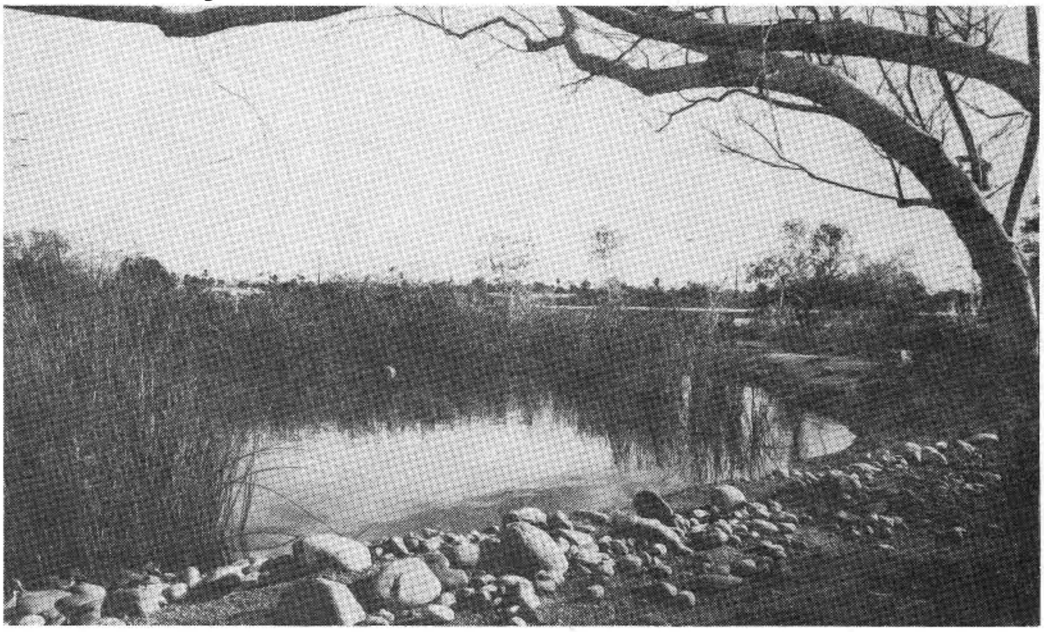
Our Future Resources Garden contains plants under study or in cultivation for their current or future use. The plants in this garden have interesting origins. The guayules came from Agrotech Labs in Sacaton, Arizona, the chiltepines from Native Seeds/SEARCH, the resinweed from the University of Arizona's Department of Arid Land Studies, the prickly-pear from Boyce Thompson Arboretum, and the oregano from the Garden's Gentry Agroecology Project farm. Lechuguillas and candelillas are from the Garden collections.

The Plants and People of the Sonoran Desert trail is perfect for seasonal events and workshops such as saguaro fruit harvesting, cholla bud roasting, or basket-weaving. We also use it as a setting for ethnobotanical classes and as a source for useful plants and plant parts for local artisans and craftspeople.

Visitors to the trail can read the illustrated graphic panels which explain the features and the ecological, domestic, and social roles of the plants. They can also participate in the hands-on activities provided around the trail such as making agave rope or feeling jojoba oil. An optional trail guide is available which provides additional ethnobotanical information.

Visitors might even encounter "touch carts" along the trail where Garden staff and volunteers provide information, demonstrations, and hands-on activities such as making yucca soap or tasting mesquite tea. The Desert Botanical Garden is open every day of the year from 9 a.m. to sunset and from 7 a.m. to sunset during the months of June, July and August.

With each new season it is exciting to see the changes in the plants as they become established and go through their life cycles. We are already seeing some natural reseeding and volunteering of plants in the appropriate habitats. Most of the plants look established now instead of that stiff, awkward look of fresh transplants. One wonderful thing about a living exhibit — it continues to grow and improve with time.



Photos by Steve Priebe. Illustration by Carla Simmons and Elizabeth Morales Denny.

Letters

Editor:

I enjoy *The Seedhead News*, especially articles like that of Stephen Lewnadowski about native gardening techniques.

Last year I tried to grow a "three sisters" garden using authentic Native American crops. I used Connecticut Field pumpkin (which is supposed to have been grown in pre-Columbian New England), Genuine Cornfield beans (grown in the Ohio Valley since 1200 AD), and Paiute sweet corn. Even though Paiute is not a pre-Columbian crop I chose it because I thought sweet corn would be more acceptable to my family than flint or dent corn.

I had 25 hills of 3 corn and 2 beans each with two hills of pumpkin in a 25' by 5' bed. Much of the Paiute corn failed to germinate. This may have been because it is a crop for semi-arid regions which are very different from Lansing, Michigan. I soon discovered that Paiute is short (about 4') while the beans are very long (about 8'): the corn was overwhelmed by beans. I had to uproot one bean in each hill to keep the corn from being strangled. The pumpkin very nicely covered up the floor of the bed and set fruit in both the interior and at the edges.

Based on my experience, an interplanted bed of corn, beans and squash works best if left unharvested until the corn and beans dry in the field giving one easy access to the pumpkin. It would have been difficult to regularly harvest the beans and corn at the eating stage.

Having hand-pollinated the corn and pumpkin to save pure seed, I planted the same crops again this year. However, the beans have been planted to grow on poles instead of the corn. I hope that more of the corn germinates, the seed having come from Northern grown plants.

I was distressed to see, however, that Paiute sweet corn was not offered for sale this year. Since I don't have room to grow enough corn to insure genetic diversity I had hoped to be able to supplement my own seed with "reinforcements" from Native Seeds/SEARCH. Will it be offered for sale again in the future, or am I the only person saving it?

—Alan S. Bobowski

Editor's note: We plan to offer Paiute sweet corn in our 1989 Seedlisting. It was omitted in 1988 because our seed stock was low after very good sales of it 1987. We had been concentrating on growing out other sweet corns from the Homer Owens collection and hadn't planned for the great interest in these varieties. Varieties are dropped from our catalog (and you'll note that not really very many have ever been dropped) either because low seed supplies need to be grown out or because there is not much interest in that particular variety. In both cases, adequate samples are being saved in our seedbank. And by the way, Paiute Sweet Corn is probably a pre-Columbian crop.

Editor:

I would like to exchange information with any of your members who have experience in growing, curing or using any of the native tobacco species.

—Frank Tehan
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Growout Farm Report

By Linda Parker

Native Seeds/SEARCH's Growout Farm project near Safford, Arizona, is progressing and growing. As was reported in *The Seedhead News* No. 20, a generous landowner in the Gila River Valley has donated the use of approximately 40 acres for growout trials of NS/S cultivars. This arrangement will allow us the opportunity to evaluate some of our varieties for possible use by commercial growers and also increase our seed stocks.

The early spring plantings included Santo Domingo Blue Flour Corn, Isleta Blue Flour Corn, and Hispanic Red Flour Corn. Cucurbit plantings include Hopi Cushaw (*Cucurbita argyrosperma*), Sinahuisa Mayo Blusher, *C. pepo* from Nabogame, Sonora, and *C. moschata* from Magdalena, Sonora. San Juan Pueblo Melons, Tohono O'odham Yellow-Meated Watermelons, and Hopi Bottle Gourds are also growing in the cucurbit patch. The lima bean crops include Hopi Red, Hopi Orange and Pima Beige varieties.

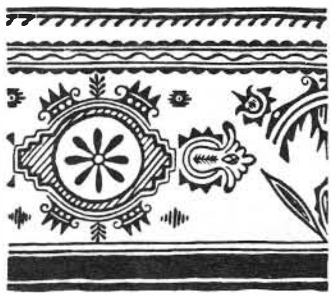
The Pueblo corns began to tassel approximately 75 days from planting. The fields demonstrate the great diversity within these varieties — there are many tillers, tall stalks and short stalks.

The San Juan Pueblo Melon is a honeydew type. The vines are relatively short, and fruit set has been heavy due to a lot of honey bee activity. The first fruit was harvested 90 days from planting.

Tohono O'odham Yellow-Meated Watermelons are the prize-winners in our trials so far. The oval, green-striped fruit average nine pounds. The rich yellow, almost apricot colored flesh has a wonderful sweet taste. The first harvest was 80 days from planting. The Food Conspiracy Co-op on Fourth Avenue in Tucson is selling these melons.

The other cucurbits have all begun to set fruit, but there is a disease (probably fusarium wilt) that is decreasing the population of *C. maxima* and *C. argyrosperma*. There has also been some javelina damage to the melons. An electric fence installed by the landowners has halted this damage.

In late June, Chapalote Corn and Cochiti Pueblo Popcorn were planted. On July 6, six varieties of tepary beans were planted: Black, Pinacate, Menager's Dam, Yaqui, Sacaton Brown and Hopi White.



SAN JUAN

Germination Requirements for Wild Crop Relatives

By James A. and Cheryl G. Young

Editor's note: Some of these instructions may be confusing to the lay gardener. That's because they are designed for the very exacting work of germination testing. We offer this technical article both for those readers interested in this level of information, but also because it contains some helpful germination tips for the rest of us.

We compared the list of plant species in the 1987 Native Seeds/SEARCH catalog to the standards for seed germination published by the Association of Official Seed Analysts which are known as the "Rules for Testing Seeds". In using this material you should be aware that the rules for testing seeds apply to the seeds of domesticated plants and often refer to specific cultivars which by definition and design have restricted variability. When you apply these standard procedures for germination to seeds collected from wild populations, even though the plant species are technically the same, there may be considerable variability present in wild forms that have been lost in cultivars. This is, after all, a major reason for working with native crops.

In addition to the AOSA standards, we checked the germination requirements for each species in Genebank's Handbook No. 3, Volume II, "Compoundium of Specific Germination Information and Test Recommendation" compiled by R.H. Ellis, T.D. Hong, and E.H. Roberts and published by the International Board for Plant Genetic Resources (IBPGR) Rome, Italy. The handbook was published in 1985. The purpose of the handbook was to describe the best methods of growing seeds of rare and valuable seeds. We received our copy directly from the authors who are located at the Dept. of Agriculture and Horticulture, University of Reading, U.K. IBPGR is an autonomous international scientific organization for conservation of germplasm resources that is associated with the Food and Agricultural Organization of the United Nations.

Several definitions will help you understand the rules for testing seeds.

Substrate. Generally the tests are conducted in petri dishes with the seeds on top of one thickness of germination paper. This paper is an absorbent paper that does not contain any biologically active chemicals. Occasionally, other substrates are recommended and when these are called for they are explained in the list. You will probably want to start your seeds in or on soil or a soil based planting mix. Specific substrate requirements serve as a guide that you should be aware of in planting your seeds.

Light. If light is required it must be from cool-white florescent sources. This light will largely be near red light which enhances germination. Avoid exposure to light from incandescent bulbs which will inhibit germination of seeds of sensitive species. The light source should have an intensity of 75 to 100 foot candles (750 to 1250 lux).

Potassium nitrate (KNO_3). Nitrate ion enrichment can break dormancy for some seeds. Potassium nitrate is a convenient way to provide the nitrate source. The rules for testing seeds prescribe a two tenths percent (0.2%) aqueous solution. This can be prepared by dissolving 2 grams of potassium nitrate in 1000 ml of distilled water.

Optimum temperature. This refers to the temperature where the seed analysis can get a rapid test for potential germination. This temperature is a guide only and not necessarily the optimum temperature for germination and seedling growth in a field seedbed. Alternating temperatures are given as __/__degrees C (__hr/__hr). The numbers in parenthesis indicates hours at each temperature in each 24 hours.

Scarification. This terms refers to treatments that either chemically or mechanically break down the impermeable coats of seeds.

Stratification. Placing dormant seeds under incubation temperatures that do not permit germination in order to break the dormancy before placing the seeds under favorable temperatures for domination.

GA_3. Aqueous solutions of gibberlin or gibberlic acid. This growth regulator is very effective in enhancing germination of some seeds. The GA_3 refers to a specific form of the gibberlin molecule, the "3" form. Usually added to the substrate in the range of 100 to 250 parts per million (ppm).

Time for germination counts. These are standards for the use of seed technologists to determine how long to conduct germination tests. These provide a guide to determine how soon you can expect seedlings to emerge from seedbeds.

Specific Plants

Amaranth (*Amaranthus* sp.). AOSA: Germinate on top of blotter paper in a closed petri dish. Optimum temperature is an alternative 20/30 degrees C (16 hr/8 hr). Final count in 8 days. Light required for germination.

Genebank's Handbook No. 3: Given the wide differences among accessions of *Amaranthus* in the level and nature of seed dormancy, it is difficult to make precise recommendations. Best suggestion for obtaining germination is quite complicated:

1. Wet seed in dark and allow them to imbibe for 4 days in complete darkness. Add 0.2% KNO_3 to solution. 2. Expose briefly to near red light ($1 x 10^{-9}$ mol cm^{-2}). 3. Constant incubation temperature of 35 degrees C or alternating temperature of 25/35 degrees C (12 hr/12 hr). 4. If maintaining darkness and filtering light is not possible, try cool-moist stratification (14 days 3 to 5 degress C), then 35 degrees with light. Considerable literature with variety of treatments for specific species.

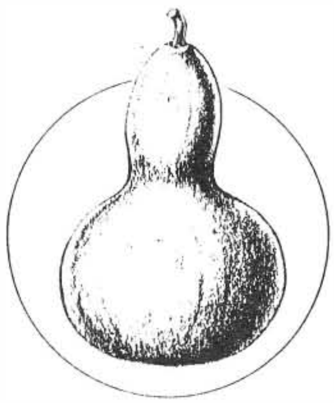
Cotton (*Gossypium* sp.). AOSA: As with most of the Malvaceae, seeds of *Gossypium* can have both hard seedcoats and embryo dormancy. Major problems with cotton (*G. hirsutum*) is getting the lint covered seeds to take up water. Placing seeds in a jar partially filled with water and shaking for a few minutes is recommended. Seeds can be germinated on top or rolled in germination paper or placed in sand for germination. Optimum incubation temperature is 20/30 degrees C (16 hr/8 hr). First count can be made in 4 days with the final count in 12 days although the length of the test may be extended.

Genebank's Handbook No. 3: Provides details of acid delinting process and its influence on seed germination. Low incubation temperatures may induce dormancy.

Devil's Claw (*Proboscidea* sp.). Not covered by AOSA standards.

Genebank's Handbook No. 3: Gives standards for *P. louisianica*. Germinate seeds on top of germination paper in closed petri dishes. Incubate at 20 degrees C. Light required for germination. May be necessary to excise embryos for germination.

Gourds (*Cucurbita* sp.). AOSA: Seeds of large and small seeded species of *Cucurbita* should be tested on the top of germination paper or rolled in blotters or toweling. Optimum temperatures for incubation is an alternating 20/30 degrees C. First counts should be made at 3 or 4 days and final counts at 7 to 10 days. The seeds of some cultivars are highly dormant and may need radicle end of seed clipped for prompt germination response.



Genebank Handbook No. 3: There are standards for nondormant seeds similar to those of AOSA. An alternate method of incubation is constant 30 degrees C in moist sand. For dormant seeds, predrying seeds at 75 degrees C for 3 to 9 days followed by incubation at a constant 30 to 35 degrees in moist sand.

Buffalo gourd (*Cucurbita foetidissina*). AOSA: Seed germination can be conducted on top of blotter paper or rolled in paper or toweling. Optimum germination 20/30 degrees C (16 hr/8 hr). Germination complete in week.

Genebank's Handbook No. 3: Similar to AOSA standards. Substrate should not be saturated with moisture. Press dry blotter against substrate to remove excess moisture. Suggest that constant incubation only partially successful in enhancing germination of seeds.

Wild luffa (*Luffa operculata*). AOSA: no standards. Genebank's Handbook No. 3: Does not include *Luffa operculata*, but has information on other species. In contrast to other genera of the family, the germination of seeds of *Luffa* appears to be enhanced by light and alternating temperatures. Light requirement variable among seedlots.

O'odham Onk I:waki (*Chenopodium murale*) and Southern Huazontle (*Chenopodium berlandieri*). Neither of these species are specifically mentioned by either AOSA or Genebank's Handbook.

Seeds of *Chenopodium* species are highly variable among and within species. Polymorphic seed can be produced on the same plant with radically different dormancy systems. Generally the most important factors in the promotion of germination of dormant seeds of this genera are light, KNO_3, alternating temperatures and cool-moist stratification. Cool-moist stratification is the most consistent factor in enhancing germination. If all other requirements are fulfilled, cool-moist stratification may not be necessary.

Tarahumara Espinaca (*Brassica campestris*). Seeds of *Brassica* both from cultivars and wild collections can show considerable dormancy. AOSA: Does not specifically mention *B. campestris*, but for most of the species of *Brassica* for which standards exist there is a cool-moist stratification requirement of 3 days at 5 to 10 degrees C. Light and KNO_3 enrichment is also required. Germination test can be conducted on top of germination or blotter paper in closed petri dishes. First germination counts should be made in 3 days and final counts in 7 to 14 days.

Genebank's Handbook No. 3: Suggest that for *B. campestris* incubation at an alternating 20/30 degrees C (16 hr/ 8 hr) in the dark with KNO_3 enrichment produces satisfactory germination.

Cilantro (*Coriandrum sativum*). AOSA: Standards include conducting germination tests on top of blotter paper or rolled in toweling. Incubation temperature should be 15 degrees C in the dark with first counts at 6 days and final count at 21 days. This is a long incubation period.

Genebank Handbook No. 3: Delayed germination and dormancy is a frequent problem for commercial cultivars. Incubation temperature should be above 10 and below 30 degrees

Continued on Page 20

The Importance of Wild Genetic Resources in Sunflower Breeding

By Joseph Laferriere

Editor's Note: Native Seeds/SEARCH, over the years, has provided both wild and cultivated sunflower germplasm to seed banks and plant breeders, some of which has already been used in crosses and published studies. We are grateful to biologist Joe Laferriere for giving us a perspective on sunflower resources, since this is one of the true Native American crops that have influenced world agriculture. This is an abridged version of an article recently published in Outlook on Agriculture, Volume 15, No. 3, 1986, pp 104-109.

A great deal of success has been made in recent years through hybridization between different species of plants, since this has become easier with the advent of newer techniques. The genus Helianthus offers a prime example of the potential these methods can hold for plant breeders, and serves to illustrate the importance of the preservation of wild germplasm as a source of breeding material.

The sunflower genus contains some 49 species, all native to the Western Hemisphere, adapted to a wide variety of habitats and exhibiting a great diversity of morphological and physiological characteristics. Several members of the genus are cultivated as ornamentals, and two have contributed food crops to human agriculture. *H. annuus*, the common sunflower, is widely cultivated on six continents for its achenes, which are high in protein and in edible oil. *H. tuberosus*, the Jerusalem artichoke or topanimbur, is grown for its edible tubers, which are used as food for both humans and livestock. These wild species, while themselves unsuitable for large-scale seed-oil production, do nonetheless represent a significant source of genetic diversity from which the plant breeder can draw important characteristics.

Many of the species hybridize readily with one another, both in nature and in cultivation. *H. annuus* crosses most easily with other diploid annuals, less easily with the polyploid and perennial species.

Attempts at using interspecific hybridization in sunflower breeding date back to 1916, but the use of these methods have been gaining impetus as the techniques themselves have improved. This article examines the past and potential benefits of using such methods as a tool for improving the cultivated *H. annuus*.

Pest Resistance

The first area in which interspecific hybrids have proved useful in sunflower breeding has been in increasing the resistance of the plants to pathogens and other pests. The sunflower is the known host for over 35 pathogenic micro-organisms, which collectively are responsible for an estimated 12% yield loss of this crop throughout the world. Major diseases include downy mildew, rust, white mold, and verticillium wilt. The crop is also attacked by broomrape (an angiospermous root parasite) and by a number of insect pests, most notably the sunflower moths. *H. tuberosus* is attacked by many of the same pests, as well as by various forms of pre- and post-harvest tuber rot. These pests have been the subject of considerable attention by plant breeders.

Evidence indicates that resistance to many of these diseases is controlled by a very small number of genes. For instance, resistance to *Verticillium* is reportedly conferred by a single dominant gene, resistance to downy mildew by three dominant genes, and to broomrape by one gene. Many of these genes have been successfully transferred to the cultivated species.

Rogers & Thompson tested 28 species of *Helianthus*, both perennial and annual, plus the closely related *Viguiera porteri* for resistance to an important aphid carrier of viral sunflower mosaic diseases in Europe and South America. Eight of these species they recommended for breeding resistance into the crop plant. More recently, they have examined resistance to carrot beetle and sunflower beetle larvae.

Resistance to sunflower moth may be obtained in either of two ways. Increased levels of diterpenoid acids may be responsible for resistance of wild sunflower species, especially *H. occidentalis*, to aphids and to sunflower beetle larvae. Resistance to seed predation by adult moths has been shown to be correlated with the amount of phytomelanin in the achene wall. This form of resistance has been successfully transferred from *H. petiolaris* and *H. tuberosus* to *H. annuus*.

Part of the problem with breeding pest resistance into crop plants is that the pests represent living, evolving populations as well, making the plant breeder's job a never-ending battle. New pests can arise from seemingly innocuous species, or old pests can mutate into virulent new forms capable of decimating populations once thought resistant. Several new diseases and new strains of old diseases have appeared in recent years to which none of the known cultivated races have proved immune.

Wild species of *Helianthus* are attacked by many of their own pests, which might also conceivably mutate to forms which could attack the domesticated species. Such a transition from scattered wild populations to domesticated monocultures would greatly enhance the immediate biological fitness of the pest species, causing great increases in population size. If any of these pests of the wild species were to mutate into strains which posed a serious threat to the cultivated crop, it would be several years before plant breeders could locate resistance genes and successfully breed them into the crop plant.

Male Sterility

A second way in which interspecific hybridization has been useful has been in the formation of male-sterile hybrids, which have revolutionized the sunflower industry by making possible the production of high-quality hybrid crops. Hybrid sunflowers are desirable for two reasons. First, the increased vigor associated with distant hybrids is well known and widely used for other crops such as maize, and, second, the early Russian varieties were highly variable with respect to height and maturation date, thus making mechanical harvest difficult. Highly inbred lines, by contrast, were notoriously low-yielding.

A cytoplasmically male-sterile sunflower was obtained by crossing *H. petiolaris* x *H. annuus* and repeatedly crossing the hybrid strain with *H. annuus*. This produced a plant with *H. annuus* nuclei but *H. petiolaris* cytoplasm. Analysis of the anthers showed that the developing pollen degenerated shortly after meiosis.

Once the male-sterile lines had been produced it was necessary to find genes which would restore fertility so that the hybrids could set seed. Apparently, such genes were rare among cultivated *H. annuus*, but common among wild populations of both *H. annuus* and *H. petiolaris*.

The system of using cytoplasmically male-sterile hybrids spread rapidly. By 1976 it was estimated that as much as 80% of the U.S. crop was produced from hybrids which yielded approximately 20% more per acre that the open-pollinated Russian varieties. The sterile hybrids themselves are reported to be higher in oil content and in seed yield due to the absence of pollen production.

Agronomic Traits

A wide variety of agronomic traits and resistance to environmental stress have been examined among wild *Helianthus* species for possible use in improving the hardiness and productivity of the cultivated crop. It has been suggested that the branching habit of wild species might be transferable to *H. annuus*, producing a multi-headed crop. It is unclear, however, whether this would in fact result in higher yields or simply in smaller heads.

Jain et al. recommended *H. exilis*, a rare species endemic to serpentine outcroppings in northern California, as a potentially useful source of genes for cold tolerance, and for elimination of seed dormancy. Several of the wild species are also better-adapted to poor soils than required for most of the current cultivars; perhaps some aspects of the lower nutrient requirements could be transferred to the cultivated crop as well.

Blanchet & Gelfi tested ten southwestern species of *Helianthus* for various aspects of drought tolerance. They examined stomatal resistance, leaf water tension, photosynthetic activity, leaf structure, and number of stomates. They recommended *H. argophyllus* as the most likely source of drought resistance, because 1) its pubescent leaves reflect sunlight and reduce water loss; 2) it exhibits low transpirational rates but yet is also low in stomatal resistance, especially at high temperatures; 3) it has a powerful taproot; and 4) it hybridizes easily with *H. annuus*. *H. niveus* ssp *canescens* was their second choice. Water stress has also been shown not to reduce seed yields or to reduce the water content of *H. nuttallii* or *H. petiolaris* to the same degree as for the cultivated *H. annuus*. *H. anomalus*, a rare endemic native to northern Arizona and southern Utah, has also been recommended as a source of genes for drought resistance.

Some attempts have been made to use *H. argophyllus* to breed drought resistance into *H. annuus*, with some success. Two strains of hybrids of *H. annuus* x *H. argophyllus*, were selected, one for traits resembling each of the parent species. When these were subjected to drought conditions, the strain selected to resemble *H. argophyllus* had lower water potential and wilted earlier, but had higher net photosynthetic assimilation rates for a given water potential.

Chemical Composition

In the area of the chemical composition of the seeds, too, we find potential in wild species for improving the harvested crop.

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Sunflower. From the herbal of Mattiolus, 1586

SUNFLOWER, Continued

One factor of interest is the percentage of protein in the seed, important if the seeds are to be used as human or livestock feed. Defatted kernels of *H. rigidus*, for example, are reported to contain 71% protein, compared to commercial sunflower meal which is approximately 44% protein dehulled, 28% when made from whole achenes. Protein compositions among 39 species of *Helianthus* range from 29-35%, oil content from 22-27%, and hull content from 39-44% of the achene by weight, while achene weight ranges from 3 to 19 g. Higher protein and mineral contents are also reported among several perennial species. In any breeding work addressing the problem of protein content, it is of course important to maintain or improve the balance of essential amino acids; in the long run this may be more crucial than the percentage of crude protein. It is possible that the high protein content of the seeds of the wild species is related to their smaller size.

Since sunflower is grown primarily as an oil crop and only secondarily for protein production, much attention has been given to the oil composition of the seeds. Seiler and Thompson have made extensive examinations of the oil content of various species of *Helianthus*.

Conclusions

It can thus be seen that, while wild species of *Helianthus* have already contributed important characteristics to the cultivated crop, there still remains much potential to be exploited. The foregoing discussion is hardly exhaustive of all the potential uses to which interspecific hybridization techniques could be put, but it should give some idea of the possibilities available. Continued improvement in hybridization technologies may help to overcome some of the difficulties in hybridization. Genetic engineering also promises to become an important tool in transfering traits from one species to another, widening the range of possible donor species, possibly even allowing transfer of genes across kingdom boundaries. *H. annuus* has already been used in some of the pioneer studies in this area.

A comparison of older literature on this subject with more recent studies illustrates the effects of advancing technology on breeding work. Whereas workers in previous eras had to be content with listing which species could and could not be crossed with the cultivated crop, newer studies examine the cytogenetic and ultastructural aspects of hybridization to determine why two particular strains cannot be crossed. This is, of course, the first step in discovering ways around the barriers. Recent workers also search out biochemical mechanisms behind plant pest resistance rather than merely accepting resistance as an innate genetic trait. This can make the characterization of a plant as "resistant" or "susceptible" easier and more reliable. Attention to relative amounts of fatty acids or amino acids likewise would not have been possible a few decades ago.

This article should also serve to illustrate the continuing importance of wild plants in human society and the utility of preserving these wild popula-tions. Some of the species discussed above as possible sources of new germplasm, such as *H. exilis* and *H. anomalus*, are rare endemics; *H. anomalus* is known from fewer than 25 locations and might be more endangered than it is except for the protection afforded it by the Hopi. *Helianthus nuttallii* ssp. *parishii* may already be extinct, having been lost to the urbaniza-tion of the Los Angeles Basin, while several other species are endangered. Conservation of genetic resources, both wild and domesticated, is essential for providing the raw materials on which plant breeding can operate.

GERMINATION, Continued

C. An intermediate, alternating temperature somewhere between extremes is probably more effective than constant 15 degrees C. Dormancy is not fully understood.

Desert Chia (*Salvia columbariae*) and Tarahumara Chia (*Salvia tiliaefolia*). Neither species is specifically mentioned in germination standards. In AOSA, seeds of other species of *Salvia* frequently require acid scarification followed by cool-moist stratification before germination will occur. The Genebank Hanbook suggests that removing the seed covering structures, cool-moist stratification and enrichment with GA_3 are required for germination.

Mrs. Burns' Lemon Basil (*Osimum basilicum*). AOSA: Seeds should be tested on top of blotter paper in petri dishes. Incubation temperatures should be 20/30 degrees C (16 hr/8 hr). The germination substrate should be enriched with KNO_3. Germination should be complete in 14 days. No entry in Genebank's Handbook.

Mt. Pima Oregano (*Monarda austromontana*). AOSA: No entry. Only the family, Labiatae, the mint family, is mentioned in Genebank's Handbook. Seeds of this family generally exhibit dormancy. Low incubation temperatures and cool-moist stratifica-tion often enhance germination.

Tarahumara/Mt. Pima Anis (*Tagetes lucida*). AOSA: The specific species not mentioned, but marigolds in general should be germinated on top of blotter paper in closed petri dishes. Seeds should be incubated at 20/30 degrees C (16 hr/8 hr) or a constant 20 degrees C. Seeds should completely germinate in 7 days.

Warihio Conivari (*Hyptis suaveolens*) and Indigo (*Indigofera suffruticosa*) are not mentioned in either standards.

Panicgrass (*Panicum sonorum*). AOSA: The species *P. sonorum* is not mentioned specifically. For species of *Panicum* in general, germination requirements are complex. Light and KNO_3 enrichment are required for seeds of many species. Cool-moist stratification at 5 degrees C for 2 weeks often enhances germina-tion. One alternative method for germination is to incubate the seeds at temperature regimes with extreme diurnal fluctuation. A second alternative method is to predry the seeds at 30 degrees C with circulating air for 1 week before testing. Seeds should be tested on top of germination paper in closed petri dishes. Germina-tion rates are slow with first counts in 7 days and final counts at 28 days.

Genebank's Handbook No. 3: Despite data for germina-tion on 18 species of *Panicum*, the species *P. sonorum* is not listed. Extremely long afterripening is listed as major problem in obtaining germination. Dissection of embryos is not recommended because they are easily damaged.

Tobacco (*Nicotiana* sp.). AOSA: Cultivated domestic tobacco, *N. tabacum*, seeds need to be tested on top of germination paper in closed petri dishes. The seeds require light for germina-tion. Optimum temperature for germination is 20/30 degrees C

SALVIA

Some Like 'Em Hot!

National Gardening's May 1988 issue featured a collection of chile recipes gathered from NS/S staff and volunteers by Linda Parker. Here's a sampling of the "flammable favorites." When the recipe calls for roasted and peeled chiles, here's a simple way to do it: put them in a 350 degree F oven for about 10 minutes, until they're evenly browned, take them out and put them in a paper bag for a few minutes; the skins will slip off easily.

CHILE POTATO SOUP

2 medium to large potatoes
2 cups milk
1 cup grated cheddar or Swiss cheese
2 to 4 roasted green chiles, peeled and chopped
1 Tablespoon margarine

Chop, steam and drain potatoes. Add milk, cheese, chiles and margarine. Simmer on medium to low heat, stirring often until cheese and margarine melt (15 to 20 minutes).
From April Baisan.

CHILE RELLENO CASSEROLE

6 to 10 green chiles, roasted and peeled
1/2 lb. cheddar cheese, grated
2 large eggs
1/2 cup flour
2 cups milk
1 teaspoon salt (optional)

Line buttered casserole dish with chiles. Cover with cheese. Blend other ingredients and pour over chiles and cheese. Bake at 350 degrees F for one hour.
From Linda Parker.

BLUE CHILE CORNBREAD

1 cup cornmeal (blue is best)
1 cup whole wheat pastry flour
1 Tablespoon baking powder
1 teaspoon salt
1 beaten egg
1 cup milk
1/4 cup oil
2 Tablespoons honey
1/2 cup chopped onion
1 cup whole kernel corn
2 Tablespoons chopped green chiles
1 teaspoon crushed dried red chiles
1 cup grated cheese (optional)

Mix dry ingredients together. Blend egg, milk, oil and honey until combined. Stir wet ingredients into dry ingredients and fold in onion, corn, chiles and cheese. Bake at 375 degrees F for about 30 minutes.
From Esther Moore.

GREEN CHILE STEW

6 cloves garlic, minced
1/4 cup butter
1/4 cup chopped cilantro
pinch oregano
2 Tablespoons flour
3 to 4 green chiles, roasted, peeled and chopped
salt to taste
water

Saute garlic in butter. Add cilantro and oregano. Stir flour into mixture and cook briefly. Add green chiles and heat through. Salt to taste, and add water as necessary to create a thick soup-like consistency. This dish is good served over a small bowl of black beans.
From Judy Goettert and Bob Sullivan.

AVOCADO AND GREEN CHILE SOUP

1 large avocado
1/4 cup freshly chopped green chiles
1/2 cup half-and-half
1-1/2 cup clear chicken broth
garlic
finely chopped fresh green chiles for garnish

Blend avocado and green chiles until smooth. Add the half-and-half, broth and garlic. Garnish with remaining green chiles and hot chips. Serve well chilled.
From Stephanie Meyer.

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PEPPER
Capsicum annuum

Biotechnology and Indigo Dye

Editor's note: The Rural Advancement Fund (P.O. Box 1029, Pittsboro, NC 27312) released in July 1988 an information sheet we think will interest readers concerned with biotechnology issues as well as growers of our indigo plant, *Indigofera suffruticosa*. We reproduce it in part with permission.

ISSUE: Bio-synthesis of indigo dye.
PRODUCT: Indigo is a blue dye used primarily for coloring denim jeans.
IMPACT: Biological production of indigo dye has potential to eliminate chemical production in U.S., Germany and Japan; may result in process which is less energy intensive and more environmentally sound.
PARTICIPANTS: Amgen Corp. has collaborative effort with Eastman Kodak Co.
ECONOMIC STAKES: Estimated (US) $250 million world market ($125 million U.S. market).
WHEN: Commerical product likely in early 1990s.

Biotechnology offers a new means of production which will someday make synthetic production of certain chemicals, dyes, pigments, etc. obsolete. This examines how biotechnology may be used to displace synthetic production of indigo dye.

Indigo dye was traditionally a plant-derived product which was replaced by a technique for synthetic production around the turn of the century. Now, using biotechnology, the production of indigo dye has come full circle. Using genetic engineering to modify cells, Amgen Corp. is now producing indigo dye in the laboratory. If commercially successful, bio-synthesis of indigo dye will someday make chemically-produced indigo obsolete.

History of Indigo Dye

The blue dye, indigo, has been used since ancient times. The dye was traditionally derived from *Indigofera*, a genus of leguminous plants found in tropical regions. Over 40 species of *Indigofera* are indigenous to India, where large-scale indigo plantations were established in the 1800s as a primary source of indigo for the European textile market.

In 1897, when a German chemical company first marketed a synthetically-produced indigo dye, there were some 574,000 hectares of indigo cultivated in Bihar and Bengal states of India. By 1911, only 86,600 hectares remained, and by 1920, the region's industry had virtually disappeared.

The rapid demise of indigo cultivation was devastating to the economy of Bihar and Bengal. British imports of indigo dye fell from 1.8 million (British pounds) in 1876 to only 48,000 (British pounds) in 1913. Many former indigo workers, unable to find alternative sources of income, were vicitims of famine which struck the region. In 1984, a group of U.S. sociologists observed that, "the parts of India that formerly were most dependent on indigo cultivation still have not recovered from the effects of this technological innovation."

Chemical Production of Indigo Dye

Today, synthetic indigo dye is produced in Germany, the United States and Japan. The vast majority of the blue dye is used for coloring cloth — especially blue denim jeans. The world's largest producers of indigo dye are BASF (Fed. Republic of Germany), Imperial Chemical Industries (UK), Buffalo Color (USA) and Mitsui Toatsu Chemicals (Japan). Worldwide, the market for indigo dye is valued at an estimated $250 million.

Bio-Synthesis of Indigo Dye

In 1983, scientists at Amgen Corp. (Thousand Oaks, CA) were experimenting with enzymes engineered to eat moth balls. Purely by accident, the scientists discovered that the enzymes were excreting a blue, indigo-colored dye.

According to Amgen, the bio-synthesis of indigo dye is "a trick of nature." The company's patented technique involves the growth of genetically-altered *E. coli* cells in a special nutrient medium which results in the excretion of indigo dyes. (The process does not involve the use of plant germplasm.)

Even though the process does not involve *Indigofera* (or any other plant), Amgen is confident that their product will be regarded as "natural indigo" because it involves fermentation.

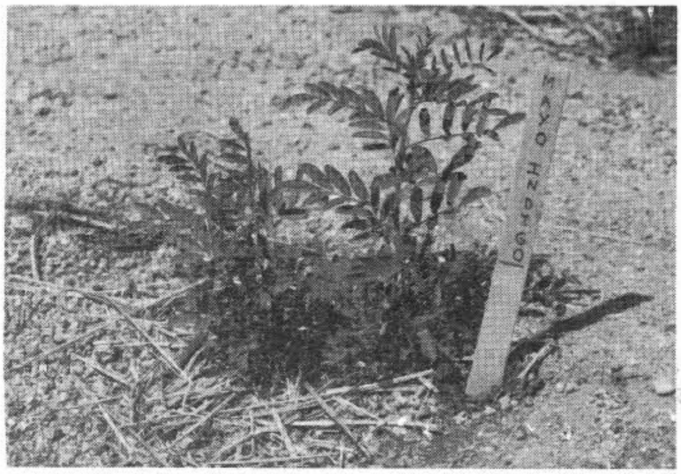
According to Amgen, bio-synthesis of indigo dye has significant advantages over synthetic production. In contrast to the standard chemical production of "indigo," Amgen's biological approach is much less energy intensive, is non-toxic, and does not result in harmful by-products. Amgen is now working collaboratively with Eastman Kodak Co. (Rochester, NY) to see if indigo can be economically produced on a commercial scale.

Amgen's Director of Strategic Planning, Dr. Phil Whitcome, describes the company's work with indigo as a "test case." Indigo, the single biggest dye used in the United States, is just one of many chemical products that may be the target of future biotechnology research. According to Dr. Whitcome, "Environmental pressures will force people to look for alternative production... In the future, we will take for granted that you can engineer cells to produce specialty chemicals."

Conclusion

Traditional methods for chemically-produced indigo dyes result in a product which is heavy (80% water) and thus difficult and costly to transport over long distances. If commercially viable, biological production of indigo dye will make it possible to decentralize indigo production and result in easier access for textile manufacturers.

The case of indigo dye illustrates how biotechnology will dramatically transform industrial production of certain chemicals — replacing synthetic production with a biological means of production which (in some cases) is less toxic and more environmentally sound.



Indigofera suffruticosa *in the Native Seeds/SEARCH garden.*

Mexican Drought Update

By Barney T. Burns

Northwestern Mexico's recent severe drought appears to have been broken by widespread summer rains. Mahina and I returned recently from a ten day trip through much of the most stricken region. This reports on what we saw and were told by local residents.

The summer rains were a bit late this year in much of the high Sierra Madre mountains of Chihuahua and Sonora. They began this year around June 24 (San Juan's Day). Native Seeds/SEARCH doesn't take complete credit for this year's downpour, but our very successful San Juan's Day Fiesta at the Tucson Botanical Gardens, along with countless other local and familial ceremonies, appears to have at least influenced the timing of this year's rains. The normal late April through May Sierra Madre planting season was very dry so many of the Tarahumara's corn fields had very poor germination. As we traveled through the now green valleys and hills we noted that most of the corn fields were very spotty. Even in the lowest or wettest portions of the fields, the corn plants were rarely more than two-and-a-half to three feet tall. Many Tarahumara and Mexican farmers told us that they were unable to replant those areas of their fields that did not initially germinate because of the normal timing of the fall frosts. The mountain farmers have, however, planted numerous bean fields since the delayed onset of this year's rains. We also noted that an unusually large number of potato patches had been planted.

The rains began in the western foothills of the Sierra Madres around July 1. This area of Mayo and Warihio Indians has been particularly hard hit by the drought during the past three years. The Mayo Indian subsistence farmers around Alamos, Sonora, began plowing their dry farmed fields shortly after the first of July and continued plowing and planting their scattered fields with the locally popular "San Juan's corn." Many of the farmers commented that this year's rain seem especially favorable since the area has received rain almost daily since July 1 and on many days has had up to three different rains. Almost all of the rains have been slow soaking rains so the field run off has been minimal. By July 8 the thorn forest had already begun to green up and was beginning to be transformed into emerald green.

The Sonoran and Sinaloan coastal plains are usually the last areas of those states to experience the summer rains. This year has been no exception. Rains began around July 5, but were very spotty up through our trip. Our Mayo farmer friends around Masiaca, Sonora, were preparing for planting, but the huge banks of dark clouds remained slightly to the east, even though we could clearly hear the loud reports of thunder while standing next to the dry unplanted fields. We noticed several pickup trucks dropping off seed corn at Mayo houses. Just south of Masiaca we were caught in a downpour that filled many of the local arroyos and that did affect a number of scattered Mayo rancherias.

The advance of rains onto the Sinaloan coastal plain was also underway during our early July visit to that area. At that time the rains had reached as far west as Las Capomas, Sinaloa. East of there we saw hundreds of Mayo Indians plowing their fields and planting corn. Oftentimes two or more horse drawn plows were working side by side with boys and/or women following behind dropping seed corn into the damp earth. Interestingly, we saw only one small modern tractor at work in the more commercial agricultural areas of the Rio Fuerte valley and its adjoining thorn forest "monte." From the amount of labor being expended by the Mayo, we realized how positive they are about this year's prospects. Hopefully, the cooling rains will persist and break the string of bad luck the Mayo farmers have endured for the past three years.

The Rio Fuerte river was running bank to bank where we crossed it above the dam. The reservoirs are obviously filling once again, but the local authorities are still restricting irrigation water since many canals were either empty or terribly low. The amount of irrigated land being cultivated in early July was even less than in early May. Vast stretches of Mexico's northwestern breadbasket still lack sufficient irrigation water. We hope these vitally important lands will be planted soon — if the promising rains continue for a prolonged period of time.

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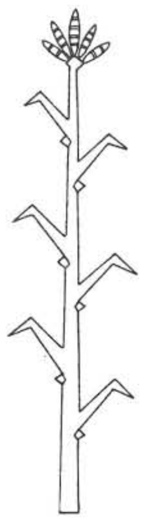

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I've been planting ever since I was a small boy. In those days everybody helped with farming... We all worked together. We knew to start planting by the full moon in Taat-sho (May). We'd all get together and start with one corn field and plant that and then move on to the next...

My family never planted corn in exactly the same spot every year. The plants grew better that way... A farmer cannot be lazy and he must be strong. He must always be at his farming.

-Yellow Man's Brother (Navajo)
from a display at the Museum of Northern Arizona

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