

**GERMPLASM IMPROVEMENT AND AGRONOMIC DEVELOPMENT OF NEW
ALTERNATIVE INDUSTRIAL CROPS**

CONTENTS

Guayule Latex, Rubber and Resin F.S. Nakayama, T.A. Coffelt, D.A. Dierig, S.H. Vinyard, and A. Faber	124
Guayule Breeding and Germplasm Evaluation T.A. Coffelt, D.A. Dierig, F.S. Nakayama, G.S. Leake, S.H. Vinyard, A.Faber, G.H. Dahlquist, A.R. Kaiser, and P. Tomasi	127
Environmental Effects on Guayule Seed Production and Quality T.A. Coffelt, D.A. Dierig, F.S. Nakayama, G.S. Leake, S.H. Vinyard, A. Faber, G.H. Dahlquist, A.R. Kaiser, and P. Tomasi	129
Breeding Improvements of Lesquerella D.A. Dierig, T.A. Coffelt, F.S. Nakayama, P. Tomasi, G.H. Dahlquist, A.R. Kaiser, and G.S. Leake	130
Lesquerella Germplasm Collection and Evaluation D.A. Dierig, T.A. Coffelt, F.S. Nakayama, A. Salywon, A. Kaiser, G.H. Dahlquist, G. Leake, and P. Tomasi	134

GERMPLASM IMPROVEMENT AND AGRONOMIC DEVELOPMENT OF NEW ALTERNATIVE INDUSTRIAL CROPS

MISSION

To acquire and characterize germplasm of guayule, lesquerella, and other promising new, alternative crops. To evaluate and enhance germplasm of new crops for industrial raw materials. To develop knowledge of floral biology and seed production and plant responses to stresses. To develop economical cultural and seed production systems for new crops under various conditions. To develop methods for efficient guayule latex extraction and seed oil analyses for characterizing latex, resin, and oil properties.

GUAYULE LATEX, RUBBER, AND RESIN

F.S. Nakayama, Research Chemist; T.A. Coffelt and D.A. Dierig, Research Geneticists;
and S.H. Vinyard and A. Faber, Research Technicians

PROBLEM: Because all the harvested guayule shrubs cannot be processed for latex extraction at one time, the plants must be stored properly to avoid loss of latex. Thus, methods must be developed to assure that the quantity of the latex is maintained in these shrubs. In addition, shrub harvest is expected to occur throughout the year; therefore, information is needed on how the extractable latex changes throughout the season to optimize harvest scheduling. Less than 10% of the plant is used for latex production and ways must be found to utilize the waste plant material.

APPROACH: Because of the dramatic effect obtained in 1998, the experiment of maintaining the water content of the stored shrub was repeated. More careful water treatment was made where a timed misting system was provided to keep the plants from drying out. The ground shrub was immersed into treated antioxidant-pH-adjusted solution immediately after chipping to avoid loss of latex. Alternate-month harvests of four lines of guayule were continued and analyzed for latex content.

FINDINGS: The latex in the stored whole shrub could be maintained for at least two weeks when the shrub was kept moist (Fig. 1). The latex content of shrubs stored under a screen shade decreased

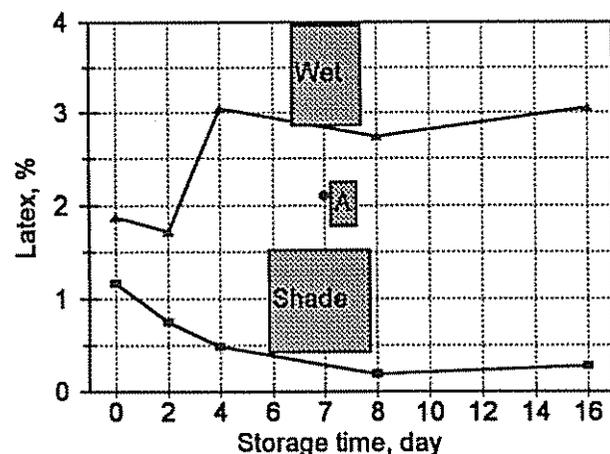


Figure 1. Effect of storage condition on latex extractability from shrub.

with storage time. This decrease in latex extractability was closely related to the water contents of the shrub (Fig. 2). Note that the water content presented here can exceed 100% because it is based on the plant dry weight. Under the misting system, the stored shrub actually gained water.

Shrub drying below the initial 60% water content greatly decreased the latex extracted. Drying occurred after only two days of storage in the shade. The experiment was conducted in August when dehydration is expected to be large. In contrast, by maintaining the shrub water content above 80%, latex extractability was maintained.

The importance of water in plant cells is shown by these results. Dehydration can cause the rubber particles in the cells to coagulate and no longer be in the emulsion or latex state. Thus, it is necessary to keep the plant in a moist condition before the extraction process. The point "A" in figure 1 represents a shrub that was stored in the shade for two days and then stored in the mister system for 5 days. The results show that rehydration can occur with an increase in extractable latex. For commercial purposes, adequate coordination between shrub harvest and the latex extraction process must be made to insure that the shrubs do not get dehydrated.

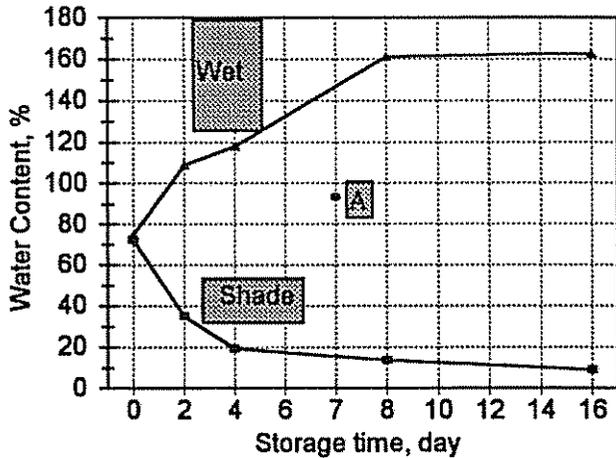


Figure 2. Effect of storage condition on water content of shrub.

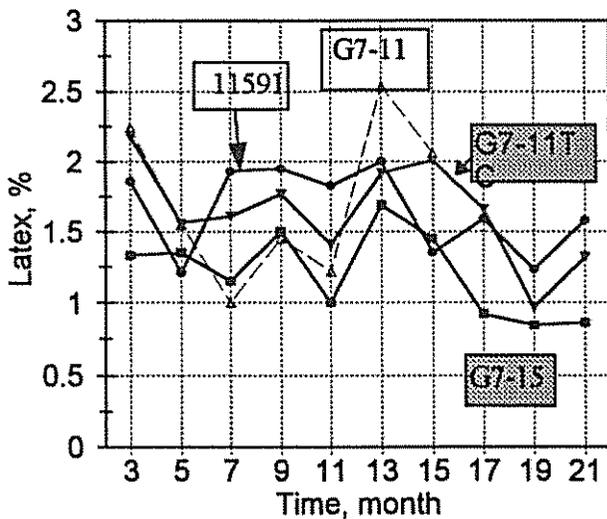


Figure 3. Relation between latex content and season.

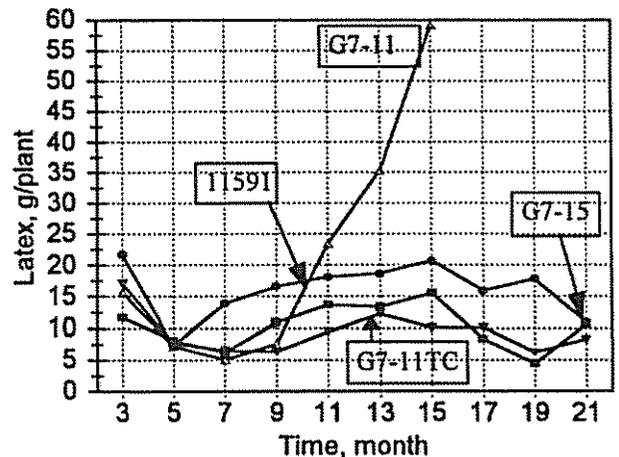


Figure 4. Relation between shrub latex content and season.

The latex content of the guayule shrub appeared to follow a seasonal pattern based on the bimonthly sampling (Fig. 3). Between November (Time = 11) and March (Time = 15), the latex of the whole plant tended to increase. The line 11591 had the highest latex content per plant. The 11591 is one of the original USDA lines developed during the Emergency Rubber Project of the mid-1940s. The total latex per plant (Fig. 4) did not show the large variation as did the latex concentration. An extraordinary high latex content was present in the line G7-11, but this was caused by a very large biomass of about four times that of the other lines. Plant number for this line was limited so that the nonuniform large plants were used.

Composite wood and resin extracts were prepared from the waste bagasse material. The composite wood and resin impregnated wood were placed at field sites in May and September and will undergo testing for approximately one year.

INTERPRETATION: Shrubs must be processed almost immediately after harvest or treated with water to maintain latex extractability, if there are chances for delays in the processing of harvested plants. This is particularly important in commercial application to commercial processing where adequate coordination must be made between shrub harvest and latex extraction.

Waste bagasse materials can be utilized by fabricating particle boards. The resin contained in them also could be used in a similar manner to treat other wood types.

FUTURE PLANS: We plan to continue the latex studies with the support of a Fund for Rural America grant, which includes determining the effect of season and variety on the latex content of shrubs, storage and chemical pretreatment of shrubs, and latex characterization. Experimental work includes shrub storage in the open atmosphere and in water, and the use of other antioxidants or completely eliminating them to decrease the cost of shrub preparation. Related investigations will be done on whole shrub latex extraction to test the hypothesis that grinding the shrub directly in the extracting solution without atmospheric contact would maximize latex extraction and stability.

We plan to produce large quantities of purified latex in order for our cooperators to make latex medical products for conducting physical and chemical tests.

We will continue to find ways to utilize the waste materials for pest control. These include the fabrication of composite and resin impregnated wood products. We plan to develop cooperative testing in a more humid climate. Existing cooperative projects will continue with the possibility of establishing a Cooperative Research and Development Agreement (CRADA) to develop uses for the waste bagasse to make blends and other types of high-valued, commercially useful wood products.

COOPERATORS: K. Cornish, USDA-ARS-PWA, Albany CA; J.A. Youngquist, USDA-Forest Products Laboratory, Madison WI; Poo Chow, Natural Resources and Environmental Sciences, University of Illinois, Urbana IL; D.T. Ray and D.K. Stumpf, Plant Sciences, The University of Arizona, Tucson AZ.

REFERENCES:

Nakayama, F.S.; Coffelt, T.A.; Dierig, D.A.; Vinyard, S.H.; and Eggemeyer, K.D. 1998. Guayule Latex, Rubber, and Resin. USWCL 1998 Annual Report.

GUAYULE BREEDING AND GERMPLASM EVALUATION

T.A. Coffelt and D.A. Dierig, Research Geneticists; F.S. Nakayama, Research Chemist;
and G. S. Leake, S. H. Vinyard, A. Faber, G. H. Dahlquist, A. R. Kaiser,
and P. Tomasi, Research Technicians

PROBLEM: Latex allergies caused by Heavea latex are becoming a serious health problem, and so alternative sources of hypoallergenic latex are needed. One possible source is guayule, but higher yielding, faster growing, and easier to establish germplasm is needed for it to be successful as a viable new crop. The objectives of this study have been (1) to evaluate the amount of variation within germplasm lines due to environment and genetics; (2) to establish new breeding plots for making interspecific crosses to produce higher yielding lines; and (3) to transfer technology to cooperators for wider germplasm evaluations and successful commercialization.

APPROACH: Field plots have been established at the Maricopa Agricultural Center and the U.S. Water Conservation Laboratory to provide plant material for accomplishing these objectives. Experimental designs include randomized complete block designs, completely randomized designs, and non-randomized designs depending upon the specific objectives of the experiment.

Objective 1: To estimate the genetic and environmental components of variation within germplasm lines, a novel approach was used. Open-pollinated (op) seed derived plants were compared with clonally propagated (cp) plants of the same line. Total genotypic plus environmental variance was assumed to be the variance observed among op plants; environmental variance was assumed to be the variance observed among cp plants; and genotypic variance was the difference between the total variance and environmental variance. Traits evaluated included plant height and width as well as rubber, resin, and latex contents. Heritabilities of these traits were estimated by dividing the genotypic variance by the total variance.

Objective 2: To establish new field plantings for breeding and crossing studies, plants of selected lines were transplanted at the U. S. Water Conservation Laboratory.

Objective 3: To transfer technology to cooperators, material transfer agreements and trust agreements were developed.

FINDINGS:

Objective 1: We found that a large portion of the variation is attributed to genotypic variation in years one and two of plant growth, but in the third year environmental variation is predominant. Heritability of the traits studied also decreased with increased plant age.

Objective 2: Plots were successfully established at the U. S. Water Conservation Laboratory for use in breeding and crossing studies next year.

Objective 3: Material transfer agreements were signed with cooperators in Australia and South Africa. A trust agreement was signed with Yulex Corporation.

INTERPRETATION: Currently, plant breeding strategies in guayule have been to wait until plants reach maturity at three or more years of age before making selections. Results from our studies indicate that this may not be the most efficient way to maximize selection for genetic variation. A more effect strategy appears to be to make individual plant selections during the first year or two of plant growth for the traits studied. Then breeders could mass select lines over several generations following the single plant selections. This strategy for plant improvement offers a quicker and more efficient alternative to current methods. The results also suggest one reason why progress in guayule breeding has been slow in the past. These results will benefit both public and private researchers developing guayule into a viable commercial latex crop.

FUTURE PLANS: Selection will continue both within and among lines for improved characteristics. Superior lines identified from these experiments will be considered for possible release as improved germplasm. Additional studies also will be conducted to try better to identify how much variability within lines is due to genetic vs. environmental factors. Studies to improve the chances for direct seeding of guayule also will continue. Both interspecific and intraspecific crosses will be attempted in 2000 to increase the variability for desired traits. Selections in these new populations should lead to higher yielding more uniform lines. Cooperation with industry partners and other researchers will continue to help advance the chances for commercialization of guayule.

COOPERATORS: D.T. Ray and D. Stumpf, Plant Sci. Dep., Univ. of Arizona, Tucson AZ; M.A. Foster, Texas Agric. Exp. Station, Texas A&M Univ., Pecos TX; J. Fowler, New Mexico State University, Los Cruces NM; A. Estilai, Dep. Botany and Plant Sciences, Univ. of California, Riverside CA; K. Cornish, USDA-ARS-PWA-WRRC, Albany CA; W.W. Schloman, Jr., Dep. Chemistry, Univ. of Akron, Akron OH; F.J. Adamsen and D.J. Hunsaker, USWCL, Phoenix AZ.

ENVIRONMENTAL EFFECTS ON GUAYULE SEED PRODUCTION AND QUALITY

T.A. Coffelt and D.A. Dierig, Research Geneticists; F.S. Nakayama, Research Chemist;
and G.S. Leake, S.H. Vinyard, A. Faber, G.H. Dahlquist, A.R. Kaiser,
and P. Tomasi, Research Technicians

PROBLEM: Data on optimal harvest time for seed production in guayule with respect to seed quantity and quality is lacking. This information is needed to maximize seed production of the highest germination. Obtaining sufficient quantities of seed is the first step in increasing the acreage of guayule for successful commercialization.

APPROACH: Seed from seven guayule lines is being harvested on a monthly schedule beginning in June 1999 and continuing until seed production is completed. So far harvests have been made through November 1999. Harvested seed is being shipped to cooperators at the University of Arizona in Tucson for weighing, cleaning, quality evaluation, and subsampling for germination testing. Subsamples will be sent to cooperators at New Mexico State University in Los Cruces for germination tests. Similar harvests are being conducted in California, New Mexico, and Texas.

FINDINGS: Evaluation of the seed samples for quality and quantity has not been completed. However, seed has been successfully harvested at each of the scheduled harvests this year. Preliminary observations indicate that the most seed was produced at the first harvest. We observed that the first harvest was approximately one month later than it should have been. We also observed significant seed loss due to shattering during summer windstorms, which affected the amount of seed harvested in July and August.

INTERPRETATION: Preliminary observations suggest that seed harvest should be started in Arizona in May or possibly earlier depending on the growing season with respect to quantity of seed produced. Results are not complete yet to know if this also applies to seed quality. Weather patterns can adversely affect the seed harvesting. Care needs to be taken when seed production is a major objective to be able to harvest seed when storms are forecast to prevent seed loss.

FUTURE PLANS: Seed will continue to be harvested for the remainder of this season and as early as possible in 2000. Seed quality and quantity will be determined for all samples from the four locations. Data will be analyzed to determine the optimum harvest date(s) for each location as well as the effects of environment and germplasm line on seed quality and quantity.

COOPERATORS: D. Ray and D. Stumpf, Plant Sci. Dep., Univ. of Arizona, Tucson AZ; M. Foster, Texas A&M Univ., Pecos TX; A. Estilai, Dep. Botany and Plant Sci., Univ. of California, Riverside CA; J. Fowler, New Mexico State University, Los Cruces NM.

BREEDING IMPROVEMENTS OF LESQUERELLA

David A. Dierig and Terry A. Coffelt, Research Geneticists;
Francis S. Nakayama, Research Chemist; and Pernell Tomasi, Gail Dahlquist,
Aaron Kaiser, and Greg Leake, Research Technicians

PROBLEM: *Lesquerella fendleri* (Gray) Wats., *Brassicaceae*, is a potential oilseed crop native to the southwestern United States. The seed oil contains hydroxy fatty acids, similar to castor. Unique properties of the oil, along with coproducts, allow additional applications that would not be in competition with castor.

Other species of *Lesquerella* produce higher quantities of hydroxy fatty acid (HFA) than *L. fendleri*, but none are as productive in seed yield. There are over 70 species from the western half of the U.S. that do not cross pollinate in the wild, or by controlled crosses, due partially to self incompatibility and incongruity between species. This also prevents plants from producing seed from their own pollen (self-pollination). Selfed plants are desired in studies requiring genetic ratios, in developing probes for molecular markers, and in breeding for plant uniformity. Bud pollination is a method used to circumvent self-incompatibility in other *Brassicaceae* by applying pollen from the same plant to the stigma before the flower opens. However, for optimum amounts of selfed seed to be produced, the correct stage of floral development must be defined. This technique could allow hybridization between *L. fendleri* and other species with more desirable oil profiles as well as allow plants to produce selfed seed.

Little information is known on variability of lesquerella for salt tolerance. Previous research indicated that high salinity caused significant plant mortality, reduced growth rates, and decreased seed yield. Selection of plants for germination, survival, and seed yield in high saline treatments could allow lesquerella to be produced in areas with saline problems.

Lesquerella could be more profitable for farmers if seed-oil traits were improved. Public releases of seed have been made in the past by this laboratory with higher oil and lesquerolic acid contents, and reduced oil pigmentation. Yield trials must be conducted to identify progress of new lines.

APPROACH: Floral buds of four different lines were self pollinated in the greenhouse between eight days and one half a day before flowers opened. The lengths of the buds also were measured at the time of pollination. Seed was obtained from the controlled pollinations, and seed yields were correlated to the number of days before anthesis and bud lengths. Plants of *L. fendleri* and five other *Lesquerella* species listed in Table 1 were reciprocally crossed by bud pollination.

Three lesquerella lines, a salt tolerant selection, the parent to this selection, and a test line for comparison, were planted in sand-filled lysimeters on October 28, 1998, at the U.S. Salinity Laboratory, Riverside CA. Irrigation solutions were salinized on January 21, 1999, and plants were harvested on June 10, 1999. Experimental design was a split plot with seven irrigation water salinities (3, 7, 11, 15, 18, 21, and 24 dSm⁻¹), 3 genotypes, and 3 replications (24 plants/rep). Plant biomass and seed yields were measured at harvest. Seed also was obtained from selected plants of the 21 and

24 dS/ m⁻¹ treatments by controlled bud self pollination where pollen from a surviving plant in one of two treatments was transferred to the stigma of another plant within the same treatment before the flower opened.

Half sib families selected for plant height and seed yield were grown in a yield trial at Maricopa Agricultural Center (MAC) and Tucson AZ. Six additional lines, three previously released germplasm lines, and three further improved descendent lines also were planted for comparisons (Table 2). One of the three lines was selected for oil, one for lesquerolic acid content, and one for the combination of oil and lesquerolic acid content. All were compared to the three released lines (WCL-LO1, WCL-LH1, WCL-LY1) and an unselected control.

FINDINGS: The best seed yields were obtained from plants that had been bud pollinated between one and three days before flowers opened. The best bud length for this method was between five and seven mm. No differences were found among the four lines tested. Limited numbers of seeds were obtained from crosses between *L. fendleri* and *lindheimeri*, *gracillis*, and *pallida* species listed in Table 1. Hybrid plants are being grown for confirmation of hybridity and evaluation.

Table 1. Chromosome number, oil, lesquerolic acid, and auricollic acid of *L. fendleri* and five other species used for interspecific crosses.

Lesquerella species	<i>n</i> = x	Oil content	Lesquerolic acid (C20-1OH)	Auricollic acid (C20-2OH)
<i>fendleri</i>	6	23.6	50.2	trace
<i>lindheimeri</i>	6	21.6	81.7	0.35
<i>mcvaughiana</i>	6	17.1	46.3	1.23
<i>gracillis</i>	6	28.9	68.8	trace
<i>auriculata</i>	8	33	8.1	17.4
<i>pallida</i>	6	na	81.4	3.68

The selected salt tolerant line had significantly higher rates of survival than the parental line after three weeks salination and the test line after six weeks. Vegetative growth also was reduced more by salinity in the parental and test lines than in the salt tolerant line. Seed yield (g / plant) increased in all lines up to 11 dS/m. The salt tolerant line out-yielded the parental line by about 2:1 (Fig. 1). At higher salinities, seed yield of the salt tolerant line was greater than both other lines combined. Salinity treatments of 11 dS/m and higher resulted in increased oil and lesquerolic acid content compared to the low salinity treatments.

Performance in seed yield and other yield related traits were better in Maricopa compared to the Tucson location (Table 2). Oil and lesquerolic acid content of WCL-LY2 were higher than the unselected control and released lines. Seed yield was not directly selected but was improved in WCL-

LY2 compared to the unselected control. No significant difference was found for plant height and seed yield from the half sib lines at either location.

Table 2. Comparison of six lines and a control line for oil, lesquerolic acid, and both oil and lesquerolic acid grown at Maricopa and Tucson AZ. The lines starting with 98 are new lines being tested, the WCL lines are previously released, and the control is unselected.

Line (sel. basis)	Oil content (%)		Lesquerolic acid (%)		Seed yield (g/plant)	
	Maricopa	Tucson	Maricopa	Tucson	Maricopa	Tucson
98LO (oil)	29.0 a	25.4 ab	53.9 bc	52.6 ab	na	na
98LH (lesq acid)	25.2 c	23.8 b	54.9 a	53.8 a	na	na
98LY(WCL-LY2)(both)	29.41 a	26.7 a	54.1 b	53.1 ab	35.5 a	24.1 a
WCL-LO1 (oil)	26.4 b	24.4 b	52.6 d	52.4 ab	28.6 b	23.9 a
WCL-LH1 (lesq acid)	26.8 b	24.5 b	53.9 bc	51.6 b	32.4 ab	23.9 a
WCL-LY1 (both)	27.1 b	25.1 ab	53.5 c	52.7 ab	31.8 ab	19.7 a
Control	24.85 c	24.0 b	53.5 c	52.9 ab	27.1 b	22.0 a

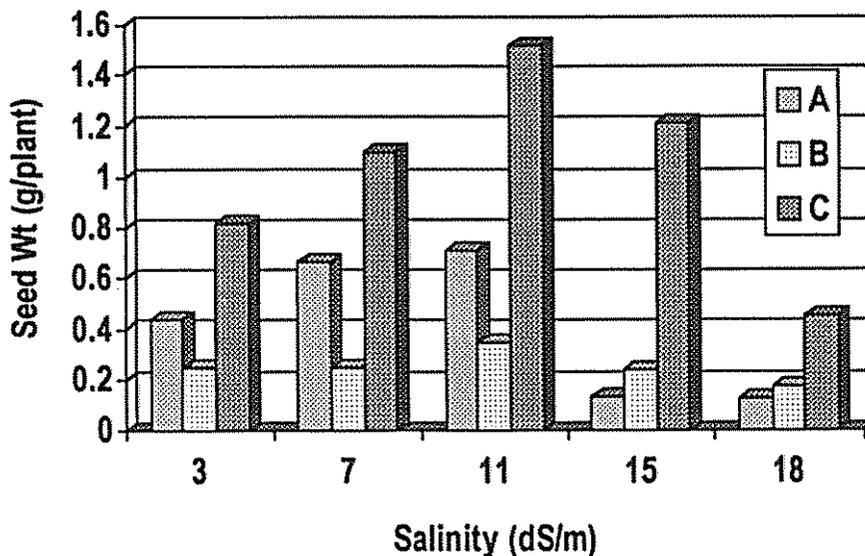


Figure 1. Comparison of three lines growing under different salinity treatments. Line A is an unselected control, B is the parent line of the selection, and C is the salt tolerant selection.

INTERPRETATION: A method for bud pollination has been defined for lesquerella. This breakthrough has allowed seeds to be produced from a plant with its own pollen and produce a segregating generation. Ratios reported in last year's U.S. Water Conservation Laboratory Annual Research Report indicated male sterility in lesquerella is controlled by two epistatic genes can be verified using this method of seed production. This also has allowed interspecific hybrids to be produced with potentially much higher levels of lesquerolic acid contents.

The salt tolerant selection outperformed the two comparison lines in vigor, growth, and seed yield. This germplasm is now in the process of a public release under the name WCL-SL1 and seed will be available to researchers by written request. This germplasm should be suitable for planting in saline problem areas of Texas, New Mexico, Arizona, and California.

The WCL-LY2 was significantly higher in oil, lesquerolic acid content, and seed yield when grown at MAC. MAC was a superior location to Tucson for this germplasm. This germplasm is also in the process of a public release and seed will be available to researchers upon written request. The Tucson location has potential as a growing site but selection would need to be done there. These results also indicate the need to test germplasm at multiple locations in order to select lines that are stable for high yield in multiple environments, in order to insure that growers will receive the highest yielding germplasm for their growing conditions.

FUTURE PLANS: Interspecific progeny from *L. fendleri* X *pallida*, *gracillis*, and *lindheimeri* are being evaluated. Backcrosses and self pollinations will be made, and oil and fatty acid contents measured. Selfed seeds of five plants will be grown and selfed for another generation. This will continue for several more generations in an attempt to produce near isogenic lines. Seed from the past male sterility study that resulted in 1:3 ratios will be planted and selfed to obtain a 1:1 generation that would confirm the 13:3 epistasis hypothesis.

Crosses from the 21 ds m⁻¹ treatment will be planted again in the same treatment for further salt tolerance selection. Plants will be direct seeded into sand tanks.

The seed from the WCL-LY2 will be planted in a field at MAC for continued recurrent selection. The number of plants harvested will be increased, and selection will be based on oil content and seed yield. Lesquerolic acid content will not be a selection criteria because progress has been poor for that trait.

COOPERATORS: R.L. Roth, University of Arizona, Maricopa AZ; Catherine M. Grieve and Michael C. Shannon, ARS, US Salinity Lab., Riverside CA; D.T. Ray, University of Arizona, Tucson AZ.

LESQUERELLA GERMPLASM COLLECTION AND EVALUATION

D.A. Dierig and T.A. Coffelt, Research Geneticists; F.S. Nakayama, Research Chemist; and A. Salywon, A. Kaiser, G. H. Dahlquist, G. Leake, and P. Tomasi, Research Technicians

PROBLEM: Lesquerella seed could provide U.S. industrial markets with a source of hydroxy fatty acids. In the past, these markets have been satisfied by imports of castor for many types of industrial applications, such as paints, coatings, lubricants and greases. Imports of castor oil and derivatives amount to more than 65,000 tons per year at a value exceeding \$100 million per year. The unique chemical structure of the oil from Lesquerella, although similar to castor, offers distinct advantages for development of other applications, as well as being a partial replacement for castor oil.

There are some lesquerella species native only to Mexico that have not previously been collected or evaluated. Species such as *L. fendleri* occur both in the U.S. and Mexico; however, different biotypes are location specific. Increasing genetic diversity improves potential plant breeding progress.

Only limited amounts of seed from germplasm collections are able to be obtained from the wild. Seed increases, evaluation, and passport information are necessary to successfully utilize these accessions in our breeding program. It is also necessary to make seed available to other researchers through the National Plant Germplasm System (NPGS).

APPROACH: Plant permits for collection in Mexico were obtained through the U.S. Embassy in Mexico City, Office of Environment, Science and Technology Affairs. A database of plant localities was assembled by visiting Herbaria at Missouri Botanical Gardens in St. Louis, Arizona State University, and Universidad Autonoma Agraria Antonio Narro in Saltillo Mexico. Harvard University's Gray Herbarium sent information from their collections and Kathryn Rollins donated the field book of the late Dr. Reed Rollins from his Mexico collection to us. Our cooperators in Mexico were Dra. Diana Jasso de Rodriguez. The states visited for collection in Mexico included Coahuila, Nuevo Leon, Tamaulipas, Durango, Zacatecas, and San Luis Potosi. Sites were visited; and, if plants were found, seeds were collected, voucher specimens taken and pressed for herbarium mounting, and the location recorded from a GPS reading. In many cases, we located plants while in flower and returned when seed was ripe.

Seeds originating from past collection trips between 1993 and 1996 from the U.S. were field or greenhouse grown at the U. S. Water Conservation Laboratory (USWCL) for seed increase and evaluation. When only limited seed quantities were available, seeds were started in the greenhouse in October and transplanted into the field in November and December. When plants began to flower, screen cages were placed over individual field plots and supplied with housefly larvae which then emerged for pollination. Houseflies were effective pollinators and are very inexpensive compared to honey bees. The pollinators within cages prevented cross pollination with other accessions. Plants also were grown in greenhouses if the accession of a species was not adaptable to an Arizona climate. Plants of different species could be grown together since they will not cross-pollinate. Flies also were placed in the greenhouses on a weekly basis during the flowering period. Larvae were incubated at room temperature for one day before placing in the greenhouse. Plant growth measurements were taken throughout the season. After harvest, seeds from each accession were analyzed for oil content

and composition. Following harvest, seeds of increased accessions were sent to the Agriculture Research Service (ARS) Curator in Pullman, Washington, to be entered in the NPGS.

FINDINGS: Sixty-five accessions from 26 species were increased this year at the USWCL (Table 1). Some accessions could not be successfully grown outdoors in this climate and, as a result, had to be grown in the greenhouse. Seed yields in the greenhouse were improved this year due to the addition of houseflies (*Musca domestica*) as pollinators. In past years we have had to pollinate flowers by hand to obtain seed because of self-incompatibility. We tried unsuccessfully using blue orchard bees, *Osmia lignaria*, and leaf cutter bees that we obtained from cooperator ARS Scientist Vince Tepedino. Some accessions were grown in the field and in the greenhouse. The trend was that oil and lesquerolic acid contents were higher in the field. Descriptive data on plant growth also were collected. There were adequate amounts of seed harvested from many of these accessions so they could be sent for entry into NPGS.

Table 1. Results of evaluation of *Lesquerella* species increased and evaluated at the USWCL, 1998-99.

	Collection Number	<i>Lesquerella</i> Species	Oil (%)	Lesquerolic Acid (%)	Seed Weight (g)
1	A1800	<i>gordonii</i>	20.54	59.21	118.28
2	A1834	<i>fendleri</i>	22.24	48.58	8.59
3	A1835	<i>purpurea</i>	19.44	59.88	4.51
4	A1854F ¹	<i>fendleri</i>	25.44	52.14	105.95
5	A1859	<i>pinetorum</i>	21.85	56.81	76.03
6	A1869F	<i>cinerea</i>	24.98	54.57	47.57
7	A1873	<i>rectipes</i>	19.37	48.48	5.24
8	A1875	<i>rectipes</i>	23.54	50.48	48.76
9	A1879	<i>intermedia</i>	23.81	47.12	10.98
10	A1882F	<i>intermedia</i>	24.75	50.18	3.18
11	A1894F	<i>arizonica</i>	26.78	52.66	12.18
12	A1902	<i>kaibabensis</i>	16.06	48.69	4.54
13	A1903	<i>rectipes</i>	24.25	52.46	23.19
14	A1911	<i>ovalifolia</i>	na	na	3.12
15	A1922F	<i>ovalifolia</i>	26.79	50.19	3.88
16	A1923	<i>rectipes</i>	16.22	44.78	4.60
17	A1927	<i>intermedia</i>	20.24	52.27	19.36
18	A1930F	<i>intermedia</i>	23.83	53.27	11.61
19	A1931	<i>cinerea</i>	22.25	49.58	3.61
20	A2202	<i>densiflora</i>	16.29	59.56	43.35
21	A2203	<i>recurvata</i>	16.87	68.92	6.49
22	A2205	<i>recurvata</i>	17.81	67.99	8.52
23	A2208	<i>recurvata</i>	13.49	66.75	6.49
24	A2210	<i>argyraea</i>	15.92	70.77	34.90
25	A2212	<i>argyraea</i>	13.53	53.55	26.85
26	A2225	<i>argyraea</i>	17.13	60.66	85.77
27	A2239	<i>argyraea</i>	23.62	58.34	133.89
28	A2258F	<i>fendleri</i>	23.90	52.29	12.14
29	A2279F	<i>mcvaughiana</i>	21.22	55.20	80.97

	Collection Number	Lesquerella Species	Oil (%)	Lesquerolic Acid (%)	Seed Weight (g)
30	A2297	<i>angustifolia</i>	na	48.61	43.92
31	A2401	<i>douglasii</i>	15.27	42.97	1.94
32	A2402	<i>douglasii</i>	17.17	48.17	33.90
33	A2403	<i>douglasii</i>	20.48	46.71	22.12
34	A2404	<i>douglasii</i>	na	na	0.10
35	A2405F	<i>douglasii</i>	24.08	48.99	1.04
36	A2406F	<i>douglasii</i>	24.03	49.17	3.20
37	A2894	<i>densipila</i>	17.41	1.56 [27.4]*	3.55
38	A2914	<i>gordonii</i>	15.21	52.72	2.51
39	A2919F	<i>ovalifolia</i>	16.18	52.37	8.96
40	A2920F	<i>ovalifolia</i>	18.15	54.84	11.88
41	A2921	<i>gracilis</i>	17.43	63.13	0.64
42	A2922	<i>ovalifolia</i>	9.80	50.45	23.66
44	A2926	<i>gracilis</i>	17.72	63.56	129.50
45	A2933	<i>angustifolia</i>	na	na	0.30
43	A2934	<i>ovalifolia</i>	12.34	49.05	28.22
47	A2935	<i>ovalifolia</i>	15.44	55.50	78.39
48	A2939	<i>gordonii</i>	27.80	59.91	23.64
49	A2997F	<i>fendleri</i>	24.48	47.17	0.76
50	A3000	<i>lyrata</i>	18.98	19.89	2.92
51	A3010	<i>gordonii</i>	14.68	56.04	1.01
52	A3009	<i>auriculata</i>	19.33	4.35	24.77
53	A3003	<i>gordonii</i>	na	na	19 seeds
54	A3011	<i>auriculata</i>	16.37	2.63	81.51
55	A3029	<i>intermedia</i>	18.84	49.26	1.31
56	A3042	<i>ludoviciana</i>	20.10	47.63	5.12
57	A3060	<i>ludoviciana</i>	18.84	28.43	1.27
58	A3062	<i>ludoviciana</i>	na	na	168 seeds
59	A3079	<i>montana</i>	na	na	0.19
60	A3103	<i>parvifolia</i>	na	na	0.20
61	A3132	<i>ludoviciana</i>	20.81	na	3.55
62	A3178	<i>montana</i>	24.83	50.36	43.37
63	A3179	<i>hemiphysaria</i>	25.88	56.58	2.67
64	A3219	<i>pallida</i>	17.37	79.69	2.35
65	A3220	<i>hanford</i>	21.57	46.06	28.39

* bracket [] indicates a value for densipolic acid, C18:2OH;

**bracket [] indicates a value for auricollic acid, C20:2OH;

na indicates data not available;

¹an F following the collection number indicates it was field rather than greenhouse grown.

Thirty accessions of four species of lesquerella were collected in Mexico. Two of these, *L. mexicana* and *L. schaffneri*, have never been in the NPGS before. Sixteen of the collections were *L. fendleri*, which was emphasized because this is the primary species identified for domestication. Some of the

collection sites need to be revisited for more seed because some did not germinate. The inviable seed was likely due to seed immaturity.

INTERPRETATION: Breeding *L. fendleri* with wild relatives may yield offspring that bear bigger seeds with more oil and higher amounts of hydroxy fatty acid. It also may expand the growing region outside the southwest U.S. Considering the cost of obtaining seed from germplasm collection trips, the seed from this project is very valuable. Special care must be taken to assure that seed is increased without contamination from other accessions, evaluated to obtain usable information about the accession, and properly handled from harvest to storage. The seed deposited into NPGS benefits researchers nationally and internationally. It also has a long term benefit to our breeding program.

It is unknown at present how the seed from the Mexican collection will impact breeding of lesquerella. These plants need to be characterized and compared to US collections. This will be carried out next year.

FUTURE PLANS: A service contract is in place with the cooperator in Mexico to continue collecting from October 1, 1999, until September 30, 2000. There were some locations where plants were not flowering, and we were not able to return in time for seed or there was not enough rain for plants to reach the full flowering cycle. Seed will be obtained from these accessions and other localities not visited this year. The germplasm collected in Mexico will be evaluated and increased next season.

COOPERATORS: K. Williams and A.S. Stoner, National Germplasm Resources Laboratory, Beltsville MD; R.H. Lawson, ARS-NPS; D. Jasso de Rodriguez, Raul Rodriguez, and Jose Angel Villarea Universidad Autonoma Agraria Antonio (UAAAN), Saltillo, Mexico; Ignacio Moreno Murrieta, ITESM, Monterrey, Mexico; D.T. Ray, University of Arizona, Tucson AZ; Vicki Bradley and Steve Clement, Plant Germplasm Introduction Station, Pullman WA; Vince Tepedino, ARS, Logan UT.