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Aims and Objectives of the Society

The purpose of the Rio Grande Valley Horticultural Society is the advancement and development of horticulture. The Society's aim is to stimulate interest in research and its practical application to the production of fruit, vegetables, and ornamentals.

At periodic meetings subjects of interest are presented by specialists in their field. These presentations are followed by forums. The *Newsletter* announces and discusses these programs and brings other news of interest to Society members.

The Society sponsors an annual Institute featuring outstanding speakers from all parts of the world who present new developments in the field of horticulture. Panel discussions, social get-togethers, and a barbecue complete the all day program.

The *Journal of the Rio Grande Valley Horticultural Society* provides a continuing record of horticultural progress. Along with research reports, talks given at the Institute are published in the *Journal.*

Anyone interested in horticulture can become a member of the Society. The annual dues of $7.50 include a subscription to the *Journal.* Subscriptions by institutions and libraries are $10.00 a year. Applications for membership or subscriptions should be sent to the Secretary, Rio Grande Valley Horticultural Society, Box 107, Weslaco, Texas 78596.

Call for Papers

Papers are requested for inclusion in Volume 41, 1988 of the Journal of the Rio Grande Valley Horticultural Society. Manuscripts of a scientific or practical nature pertaining to horticulture will be considered for publication. All papers, including written versions of presentations from the Annual Institute, will be subject to review. Separate guidelines for the preparation of research and non-research papers are printed in the back of this issue. The deadline for submission of papers for Volume 41, 1988 will be January 31, 1988. Manuscripts for publication in the Journal may be sent to:

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GUIDELINES FOR SELECTING THE RECIPIENT OF THE ARTHUR T. POTTS AWARD

1. The Arthur T. Potts award is to be given to an individual for outstanding contributions to the Horticultural Industry of the Lower Rio Grande Valley. The recipient may be from Industry, State or Federal agencies and need not reside in the Rio Grande Valley nor have been a member of the Society.
2. The members of the selection committee are to be appointed by the President no later than 1 July. The committee will consist of at least four members from the membership of the Rio Grande Valley Horticultural Society. At least one representative from some phase of production horticulture, ie., chemical sales, consultant, producer or supplier, must be a member of the committee. In addition, one member must be a carryover from the previous year to insure continuity within the committee.
3. The committee is to select a candidate for the award and to submit the candidate's name to the Board of Directors for approval by 15 October so that pictures and biographical sketch of the recipient can appear in the Journal of the Rio Grande Valley Horticultural Society the same year the award is presented. In the event the Board of Directors rejects the candidate, the selection committee must then select another candidate and submit this selection to the Board.
4. The committee is to solicit names of candidates for the award from the membership each year. The newsletter may serve as a satisfactory agent of solicitation by including in it a statement indicating that the committee is accepting nominations for the award from the membership.
5. The committee is to keep records of all meetings; these records to include a list of candidates considered for the award and this list passed on to the selection committee the following year. These candidates may then be reconsidered for the award. The Secretary of the Society is responsible for maintaining a file of these records.
6. The committee is responsible for providing a biographical sketch of the recipient, determining the appropriate wording for the plaque and having it ready in time for the Annual Institute.
7. The committee is responsible for purchasing the plaque for the following year in order to insure that a plaque is always available for engraving. The Secretary shall be responsible for storing the plaque.
8. The Arthur T. Potts Award shall be presented to the recipient at the Annual Institute by the President or his appointed representative.

Stanley B. Crockett, Jr.

1988 Recipient of the Arthur T. Potts Award

Brad Crockett was born in Mercedes, Texas, but raised in Harlingen where he graduated from Harlingen High School in 1953. After obtaining his B.S. in Agriculture at Texas A&M University, he spent several years in the U.S. Air Force. After his Air Force Service, Brad joined his father in the citrus nursery and orchard care business. Within a few years, his energy, innovations and good business sense brought recognition and success in an increasing number of horticultural and community endeavors. He is a Valley pioneer in growing container citrus. He has constantly sought and adapted the latest information and techniques to the orchards he tends. His appreciation and awareness of the potential of horticultural plants resulted in his establishment of a successful foliage and ornamental nursery business. Here again, his management and production innovations, coupled with his reputation for fair and honest dealing, resulted in nursery products widely recognized for their quality and value.

His contributions to both the citrus and nursery industries have been outstanding. He has served as president of the Texas Citrus Exchange, Citrus Nurserymen's Association, Texas Gift Package Shippers, Inc., Rio Grande Valley Horticultural Society, and Texas Citrus Mutual, who awarded him their TCM Special Award in 1987. Additionally, he has or is serving on the boards of the Texas Citrus and Vegetable Growers and Shippers Association, The Texas Valley Citrus Committee, Lake Delta Citrus Association, TexaSweet Citrus Advertising, Inc., and The Valley Ornamental Nurserymen's Association. At the time of this writing, he is also chairman of the Valley Agricultural Research and Development Corporation and the Texas A&I Citrus Center Advisory Committee.

As with most busy men, Brad still finds time for leadership and advisory roles in community and civic activities. He has been president of the Harlingen Rotary Club and Jaycees, who awarded him their Distinguished Service and Young Man of the Year awards. He is a member of the Texas Society of Professional Land Managers and Appraisers, Chairman of the Board of Tropical Savings and Loan and a director of the First Republic Bank of Harlingen. It is, however, not the number of ways, but the manner in which Brad has served--his willingness, his ability to define and solve the problem at hand and to motivate and inspire his colleagues, that has earned the Valley horticultural industry's esteem and gratitude.

In the personal vein, Brad lives with his wife, Nancy, near the original Crockett homestead outside Harlingen. His two daughters, Mynan and Julie are working in Dallas; his youngest son, Allan will graduate from Texas A&M this year; and Stanley, III, is following the family tradition as an associate with his father in the nursery and citrus business.

To close on a not insignificant historical note, exactly 24 years ago, the Society gave Stanley B. Crockett, Brad's father, the A.T. Potts Award, making them the first father-son pair to be so honored.

Journal Rio Grande Valley Horticultural Society, Vol. 40, 1987.

Long-Term Production Performance Of Four Principal Commercial Sweet Orange Cultivars in Texas

R.E. Rouse, Assistant Professor
H.A. Dean, Associate Professor, Retired
M. Gautreaux, Systems Analyst
Texas A&M University Research and Extension Center
2415 East Highway 83
Weslaco, TX 78596

Additional Index Words: *Citrus sinensis,* yield

ABSTRACT

Twelve-year mean and cumulative yields are reported for 'Marrs', 'Hamlin', 'Pineapple', and 'Valencia' sweet oranges (*Citrus sinensis* L. Osbeck). Cumulative and mean yields were highest with 'Hamlin' and 'Pineapple' and lowest with 'Marrs' and 'Valencia'. In all 4 cultivars, approximately 50 percent of the 12-year production was realized in the last 3-years. Fruiting of 'Marrs' was characterized by an alternating trend characterized by a good production year followed by a year of low yield. The coefficient of variation, a measure of the uniformity with which a cultivar yields fruit year after year, was similarly low for 'Hamlin', 'Pineapple' and 'Valencia', and high for 'Marrs'. Data presented helps in understanding why 6-7 years are required after planting before meaningful yields are obtained, and 8-10 years pass before returns equal expenditures and profits can be expected.

Citrus producers in the Lower Rio Grande Valley of Texas have observed for many years that yields of sweet oranges appear to be less than in other citrus producing areas of the United States. Research results documenting and comparing production from the 4 major sweet orange cultivars grown in Texas have been limited to a few trees on sour orange in rootstock evaluation plots. The observation of low yields is substantiated when comparing data from research reports evaluating similar cultivars from Texas (13, 15, 17, 19, 20) to reports from Florida (2, 3, 4, 9, 10, 11, 12) and California (1).

Rootstock is known to influence fruit yields in citrus. Sour orange (*C. aurantium* L.) remains the dominant rootstock used in the Lower Rio Grande Valley of Texas (5). Its adaptability to Valley conditions of salinity, alkalinity, disease, cold, heavy and often times poorly drained soils have encouraged exclusive use of sour orange even though it is susceptible to tristeza virus (6, 7). Tristeza is not considered to occur in commercial citrus orchards in Texas (8). While rootstocks are not easily changed, numerous research reports have shown that other higher-yielding rootstocks can be successfully grown on selected soils of the Lower Rio Grande Valley (14, 16, 17, 18, 19).

Results presented are for 12 years of production from 16-year-old trees of 'Marrs', 'Hamlin', 'Pineapple', and 'Valencia' sweet oranges grown in large plots and are expected to be comparable to those from commercial orchards.

MATERIALS AND METHODS

'Marrs', 'Pineapple', 'Hamlin', and 'Valencia' sweet orange trees on sour orange rootstock were planted in February, 1964, at a spacing of 3.96 × 7.62m (13 × 25 ft) in a latin-square design, with 4 replications of each cultivar and 48 trees per plot. The soil type was Willacy fine sandy loam with a pH of 7.5. Cultural practices included annual application of 168 Kg/ha (150 lbs/acre) N as ammonium sulfate or ammonium nitrate, application of insecticides, flood irrigation and spot treatment with contact herbicides as needed.

Harvesting began in the 1968-69 fruit season. Results reported for a given year refer to the year bloom occurred, thus 1968 results refer to the 1968-69 crop season. Fruit of 'Marrs', 'Hamlin', and 'Pineapple' was harvested in November and December, and 'Valencia' was harvested in late February or March of each year. Data from each cultivar included the early production years when yields are increasing; as a result, individual cultivar mean and cumulative yields reflect the low-yielding years.

RESULTS AND DISCUSSION

Mean yields for each cultivar during the first 12 years of production are presented in Table 1. 'Valencia' yields increased during the first 4 years followed by an alternating pattern for the next 8 years, with the exception of 1975. All cultivar yields were reduced in the 1975-76 season because of the freeze in January, 1975. In addition to the 1975 freeze, the freeze occurring in January, 1979, caused some fruit damage to 'Valencia' in the 1978-79 season. 'Marrs' showed an alternating pattern for production all years. The low yields of 'Marrs' in the 1979 season can not be explained by the freeze because fruit were harvested before the freezing temperatures occurred. The low yield was due to the acute alternate bearing problem of 'Marrs'. Generally, yields of 'Pineapple' and 'Hamlin' showed an increasing trend during the 12 years, except for freeze losses in 1975 and additionally for 'Hamlin' in 1972.

Twelve-year mean and cumulative yields were greater for 'Hamlin' and 'Pineapple' than for 'Marrs' and 'Valencia' (Table 2). Yields of 'Valencia' and 'Marrs' were not significantly different. Cumulative yields for 'Marrs' were only 112kg (247 lbs) per tree greater than 'Valencia' after 12 years of production. In this test the difference was not great enough to be statistically significant. However, to the Texas grower that has observed from field experience a trend of greater yield from 'Marrs' than from 'Valencia', this mean of 9kg (20 lbs) per tree per year greater than the production of 'Valencia', and about 26kg (57 lbs) less than 'Hamlin' or 'Pineapple' may be important. To the grower in Texas these figures translate to 'Marrs' production averaging about 1 ton/acre more fruit per year than 'Valencia', and 3.3 tons/acre less fruit than 'Hamlin' and 'Pineapple'. Realizing that 1 ton/acre difference is not statistically significant at the 5% level but is significant at the 20% level, may be important to the grower when considered over the life of an orchard.

Separating the 12 years of production into 4-year periods allows the evaluation of each cultivars production by tree age (Table 2). Production increased significantly in each succeeding 4-year period, and could be expected to become profitable about 8 years after planting. In the first 4 years of production (tree age 4½ to 8½ years) returns could be expected to only partially offset production costs. During production years 4 through 8, yields in most years could exceed expected production costs. It could be concluded that about 10 years are required from planting before orange cultivars in Texas become profitable. Beginning in the ninth production year, yields remained high enough to exceed expected production costs. In 'Marrs', any year with high production might be expected to be followed by low production, regardless of tree age. Such low production could fail to meet production costs if prices are also low that year. This alternating production pattern would be expected in the 'Marrs' orange because it originated as a budsport from navel orange, which is known for its alternate bearing tendency in tropical and subtropical climates.

The coefficient of variation (CV) gives a measure of the uniformity with which the cultivar yielded fruit season after season. Consistent yields will result in a low coefficient regardless of the actual yields. The lowest CV combined with a high mean yield is most desirable. By these criteria the most desirable cultivars in this test were 'Pineapple' and 'Hamlin'. 'Valencia' may appear to also be advantageous because of its low CV, but lower yields and the risks of loosing the crop during winter freezes must be taken into account.

Yield and CV are not the only factors considered. In Texas, oranges are grown for fresh market sales and 'Hamlin' oranges often do not offer desired size for commercial fresh fruit shipment. 'Pineapple' oranges are seedy, but seedless cultivars are preferred by the fresh market consumer. Processing brings lower prices for the grower and many of the 'Hamlin', 'Pineapple' and 'Valencia' oranges are processed each year as fresh market sales are limited and orders from fruit buyers before Christmas are often filled by the 'Marrs' cultivar.

Cumulative yields of the 4 cultivars during the 12 production years were greatest for 'Hamlin' and 'Pineapple' (Fig. 1). 'Valencia' yields were lowest in the early production years and cumulative yields remained lower than the other cultivars. 'Marrs' production began similar to 'Pineapple' and 'Hamlin' in the first 3 years, but then was not as productive as tree age increased. Trees of 'Marrs' were observed to be smaller than other cultivars. This fact should be considered when growers evaluate tree density for new plantings. Production per acre could be increased with 'Marrs' planted at closer spacings.

The percentage distribution of total cumulative crop production over 12 years for the 4 cultivars is shown in Figs. 2-5. As tree age increases, annual production constitutes a greater percentage of the cumulative 12-year yield. When evaluating the 12 years of production from trees 4-16 years of age, the first 4 years represent only 10% of the production of 'Marrs' (Fig. 2), 'Hamlin' (Fig. 3), and 'Pineapple' (Fig. 4), and 7% of 'Valencia' (Fig. 5). Production years 5 through 8 account for 32% of the cumulative production from 'Hamlin', 'Marrs', and 'Pineapple', and 30% from 'Valencia'. Production years 9 through 12 represent approximately 60% of the cumulative yields of any of the 4 orange cultivars, with 50% being realized in the last 3 production years. Data presented in this manner illustrates why 6-7 years are required after planting before meaningful yields are obtained, and 8-10 years pass before sufficient yields would allow expected returns to equal expenditures. A general observation that may be useful to the grower in predicting yields is that over a 12-year production period, yields for oranges in Texas could be expected to increase about 2% of the cumulative total each successive year.

Table 1. Mean yields of 4 orange cultivars in Texas, 1968-79.

Season	Mean yield (kg/tree)[z]			
	Valencia	Marrs	Pineapple	Hamlin
1968-69	19 j[y]	62 h	48 i	53 i
1969-70	37 i	59 h	79 h	83 h
1970-71	55 h	95 e	105 f	98 g
1971-72	82 e	86 f	114 e	133 e
1972-73	77 f	111 c	114 e	106 f
1973-74	95 d	83 fg	137 d	137 d
1974-75	85 e	104 cd	137 d	137 d
1975-76	67 g	77 g	95 g	80 h
1976-77	141 b	162 a	155 c	159 b
1977-78	114 c	100 de	154 c	148 c
1978-79	149 a	155 b	166 b	174 a
1979-80	141 b	80 fg	177 a	174 a

[z]Multiply by 2.2 to convert to lb/tree.

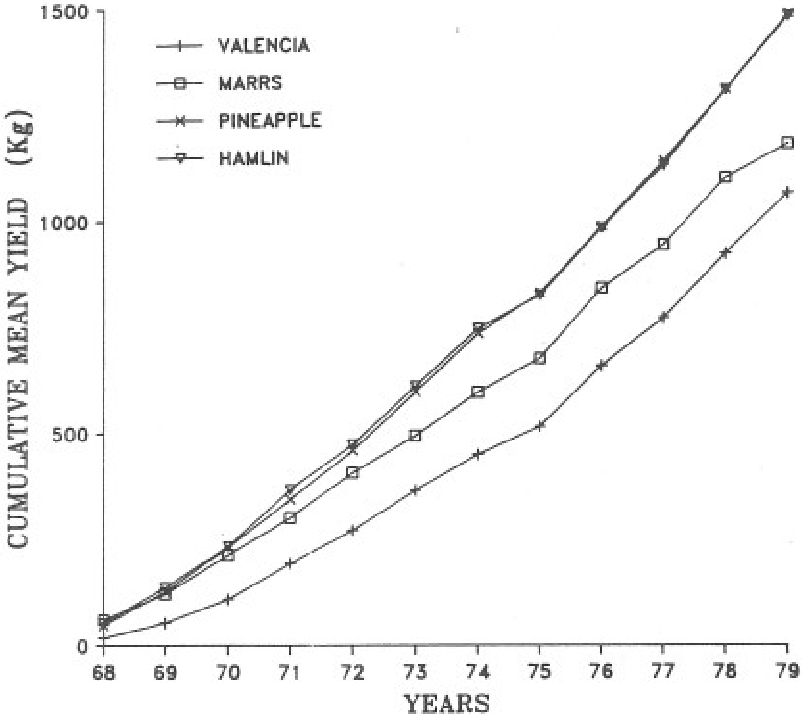
[y]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 2. Twelve-year mean yield, cumulative yield, coefficient of variation (CV), and 4-year mean yield of 4 orange cultivars in Texas.

Yield	Cultivar yield (kg/tree)[z]			
	Valencia	Marrs	Pineapple	Hamlin
12-yr mean	89 b[y]	98 b	123 a	124 a
Cumulative	1062 b	1174 b	1481 a	1482 a
1-4 yr mean	48 c	76 ab	87 ab	92 a
5-8 yr mean	81 c	94 bc	115 ab	121 a
9-12 yr mean	136 abc	124 c	164 a	163 ab
CV	25.6	46.8	23.4	27.5

[z]Multiply by 2.2 to convert to lb/tree.

[y]Mean separation in rows by Duncan's multiple range test, 5% level.



In summary, there is a need to increase production from the existing sweet orange cultivars in Texas. This goal may be accomplished by increasing productivity of existing cultivars and/or introducing new cultivars. Increased production from existing cultivars might be realized by identifying more productive selections and by use of different rootstocks on soils where they are adapted. Additional increases may be realized through improved cultural practices including better water management to reduce plant stress and increase fruit size. It is unlikely that superior new cultivars will be found to replace existing ones. However, there is the possibility that a seedless 'Pineapple' orange being tested in Florida may be available in the future. The availability of such a selection is not likely to solve the problem of low production from orange orchards in Texas, but it would be a valuable addition.

MARRS
PERCENTAGE DISTRIBUTION OF CUMULATIVE YIELD

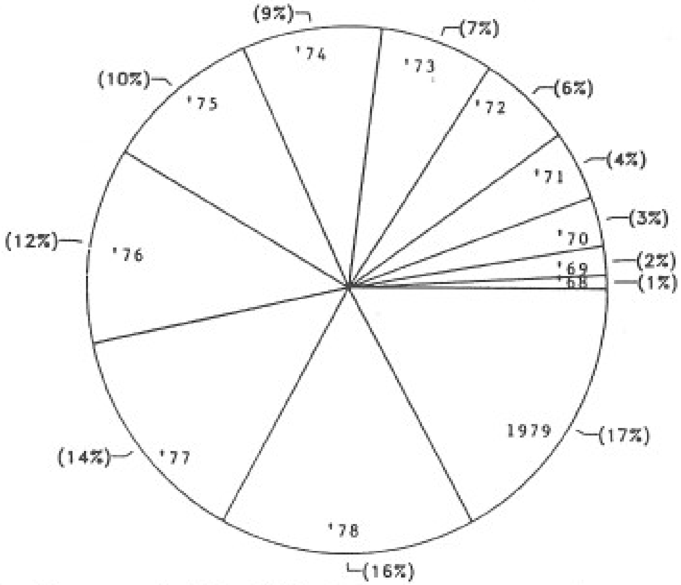


Fig. 2. Mean annual yields of 'Marrs' sweet orange expressed as a percentage of the cumulative yield over 12 years of production.

HAMLIN
PERCENTAGE DISTRIBUTION OF CUMULATIVE YIELD

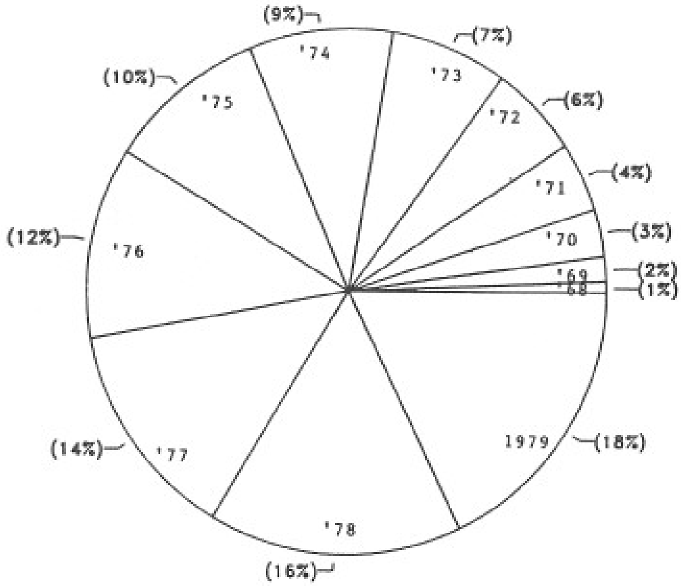


Fig. 3. Mean annual yields of 'Hamlin' sweet orange expressed as a percentage of the cumulative yield over 12 years of production.

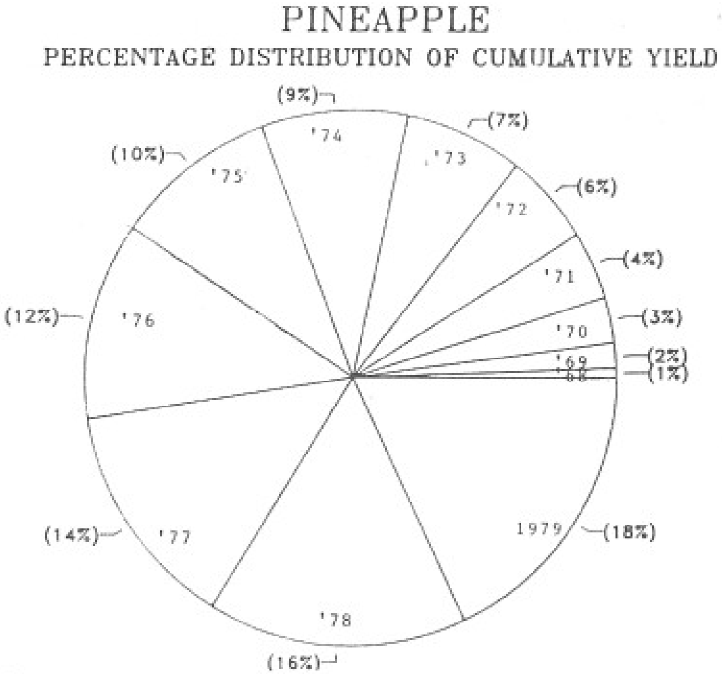


Fig. 4. Mean annual yields of 'Pineapple' sweet orange expressed as a percentage of the cumulative yield over 12 years of production.

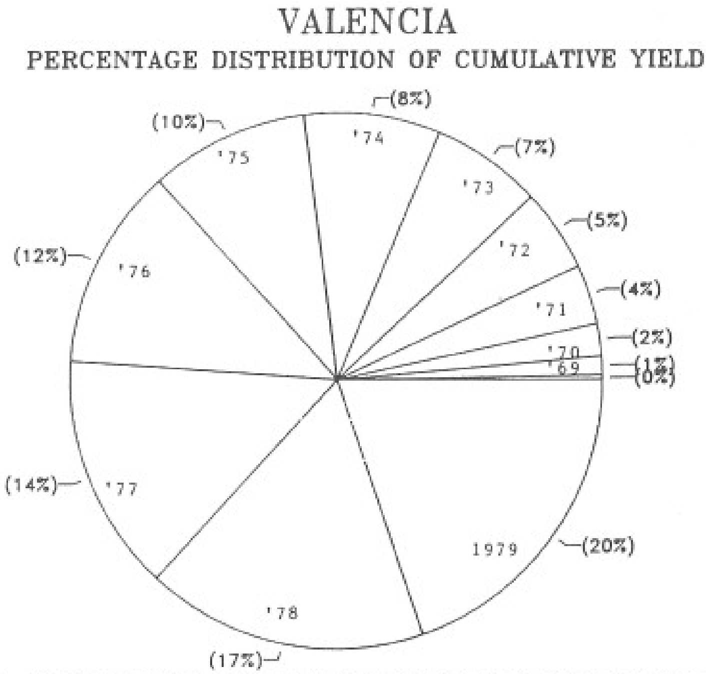


Fig. 5. Mean annual yields of 'Valencia' sweet orange expressed as a percentage of the cumulative yield over 12 years of production.

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Long-Term Production Performance Of Nucellar 'Valencia' Sweet Orange In Texas

R.E. Rouse, Assistant Professor
N.P. Maxwell, Associate Professor, Retired
Texas A&M University Research and Extension Center
2415 East Highway 83
Weslaco, TX 78596

Additional Index Words: *Citrus sinensis,* yield

ABSTRACT

Sixteen-year mean and cumulative yields are reported for nucellar 'Valencia' sweet orange (*Citrus sinensis* L. Osbeck) clones Olinda, Campbell, Cutter, Frost, one Texas Agricultural Experiment Station (TAES) selection and old-budline. Yields for individual years were consistently among the highest with Olinda and Campbell clones, and lowest with Frost and old-budline. Cumulative yield was highest with Olinda, although not significantly greater than Campbell. Tree canopy volumes were greatest for the TAES nucellar selection and smallest for old-budline, which was not significantly different from Frost or Olinda. Based on yield per unit of canopy, Olinda had the highest yield efficiency and lowest coefficient of variation among years. Fruit quality data (Brix, acid, Brix/acid ratio and percentage juice) showed no differences among clones.

The 'Valencia' orange has become the most widely grown sweet orange cultivar in the world because it is adapted to a wide range of climatic conditions (15). Despite this adaptability and fruit, tree characteristics are greatly influenced by climate (10,14,16). Numerous budlines have been selected, named, and propagated clonally wherever 'Valencia' is grown. Slight differences in tree growth and fruit characteristics have been observed among the selections, although most do not differ from the original. Trees from seedling sources are generally larger and their mean yield per tree is greater than trees from old-budline sources (12,13) that produce compact canopies having more fruit per unit tree volume (3).

Modern budwood selection programs use budwood sources free from virus infection. Most citrus viruses are not considered to be seed transmitted. Before the use of *in vitro* shoot-tip grafting (9,11), nucellar seedlings were the best method for propagating virus- and viroid-free budwood from old-budline selections of desirable cultivars. Poor and/or irregular production has been one juvenility characteristic of concern when using budwood from nucellar citrus clones. However, nucellar clones of citrus remain a viable source of virus-free propagation material. In the late 1950's, California had available several nucellar 'Valencia' selections that had been developed and grown for several years to lessen the problem of juvenility.

The citrus industry in Texas predominately uses an old-budline 'Valencia' growing in the Rio Grande Valley. This study was initiated to compare fruit yield and tree growth of the existing old-line clone being propagated in Texas with several clones of nucellar 'Valencia'.

MATERIALS AND METHODS

Trees of 'Valencia' orange were planted in March, 1961, at the Texas Agricultural Experiment Station, Weslaco, Texas. The test had 4 virus-free California nucellar clonal selections (Olinda, Campbell, Cutter and Frost), one virus-free Texas Agricultural Experiment Station (TAES) nucellar clone and one standard old-budline. Budwood sources were indexed for psorosis, exocortis and xyloporosis. All clones were virus- and viroid-free except the old-budline, which carried xyloporosis and a mild strain of exocortis viroid. Tristeza virus is not present in commercial orchards in Texas (4).

The clonal selections were T-budded to sour orange (*C. aurantium* L.) rootstock in a field nursery. Test trees were planted in Willacy fine sandy loam soil at 6.1×7.6m tree spacing. Experimental units consisted of 2-tree plots replicated 5 times in a randomized complete block design. Trees were frozen to the soil-banks in Jan. 1962, when temperatures of -8.9°(16°F). were experienced. Tree canopies reestablished during 1962, but were again damaged in Jan. 1963 by freezing temperatures of -5.0°(23°F). Hurricane Beulah passed directly through the Texas citrus area in Sept. 1967, affecting the fruit crop. Fruit was harvested in February of each year from 1967 to 1982 and individual tree yields recorded. Yield data are reported for crop years 1967-1982. Inclusion of the 1967 yield data did not significantly change the conclusions and citrus growers in Texas will continue to experience hurricanes, so these data are reported.

Tree height and diameters on a north-south and east-west orientation were measured in 1980-1982 to determine differences in tree canopy size. Canopy volumes were calculated by the formula $V = 0.5236d^2h$ (17), where V = tree canopy volume in m^3 d = canopy mean diameter from measurements of N-S and E-W directions, and h = tree height. Yield efficiency was calculated by determining the mean fruit yield per unit of canopy volume. Fruit quality, expressed as percentage and volume of juice per fruit, total soluble solids (Brix) and total acid was determined at harvest for the 6 'Valencia' selections as mature trees in years 1977-1979. Measurements of maturity characteristics were determined from a 60-fruit sample from each tree.

RESULTS AND DISCUSSION

Mean yields for the 6 'Valencia' clones in each of the 16 years are shown in Table 1. The Olinda and Campbell 'Valencia' clones consistently had greater mean yields in more years than other 'Valencia' clones. Campbell had significantly less yield than Olinda only in 1976. Yields increased for all clones until the 1983 freeze, at which time severe damage to scaffold limbs and trunks forced termination of the test. The first 6 years of reported production showed very few significant differences among selections. It was not until trees were about 10 years old (1972) that consistent statistical differences in yield were evident.

Table 1. Mean annual yield (kg/tree) of 6 'Valencia' orange clones in Texas.

Clone	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Olinda	57[z]a[y]	93a	48a	131a	111a	144a	129a	159a	125a	209a	185ab	172a	161a	152ab	214a	215abcd
Campbell	34 bc	92a	42a	118ab	100a	126ab	132a	146ab	108ab	178b	191a	165ab	148ab	160a	204ab	229ab
Cutter	36 cd	85ab	48a	129ab	110a	141a	123a	133b	107ab	170bc	180ab	156ab	153ab	133bc	203ab	202bcd
TAES	34 cd	70bc	48a	112ab	105a	137a	117a	133b	108ab	134d	179ab	168ab	155ab	148abc	207ab	235a
Old-line	50 ab	93a	60a	120ab	105a	109b	127a	130b	86b	151cd	173ab	139b	135b	147abc	185b	183d
Frost	29 d	68c	59a	99b	115a	129ab	115a	138b	106b	163b	156b	154ab	139ab	128c	183b	190cd

[z]Mean of five 2-tree replications.

[y]Mean separation within columns by Duncan' multiple range test at 5% level.

Table 2. Mean and cumulative yield, canopy volume, fruiting efficiency, coefficient of variation (CV) and tree survival of 6 'Valencia' clones in Texas.

	Yield (kg/tree)						Canopy volume (m^3)	Yield efficiency (kg fruit/m^3canopy)			Tree survival (%) after
	Means		Cumulative								
Clone	16-year	1980-82	total	1-5 yr.[z]	6-10 yr.	11-15 yr.	1980-82	1967-82	1980-82	CV	20 years
Olinda	144a[y]	194ab	2305a	440a	766a	884a	98.9bc	4.31	5.87	38.9	100
Campbell	136ab	198a	2182ab	395ab	690a	868ab	103.2bc	4.23	5.75	37.8	100
Cutter	132bc	180bc	2109bc	408ab	674ab	825bcd	105.8b	3.73	5.09	41.6	100
TAES	131bc	196ab	2090bc	369b	629ab	857abc	115.7a	3.73	5.10	40.8	100
Old-line	125c	171c	1993c	428ab	603b	779de	91.3c	4.15	5.07	44.7	100
Frost	123c	167c	1971c	370b	651ab	760e	98.8bc	3.71	5.64	41.9	100

[y] Mean separation within columns by Duncan's multiple range test at 5% level.

[z] Years are production years where year 1 is a the 5th year after planting, from bloom set on a 4-year-old tree.

Sixteen-season mean and cumulative yields were greatest for Olinda, although not significantly greater than Campbell (Table 2). Texas old-budline and Frost nucellar were among the lowest yielding trees. The mean yields for 1980-82, when trees were nearing 20 years old, showed TAES nucellars to have high productivity as mature trees. This was somewhat unexpected since this selection, although statistically equal to Olinda in all but 1968, 1974, and 1976, was not a leading producer in any of the first 10 years.

It can be seen in Table 1 that in the 15th and 16th year of production a substantial increase has occurred in all clones, which is assumed to be associated with tree age and maturity. Table 2 presents the first 15-production years in consecutive 5-year groupings of cumulative yields. Cumulative yields increased in all clones for each 5-year period. The greatest increase occurred between the first and second 5-year period. Olinda yields were outstanding in each 5-year period, although not significantly better than several other clones. To the Texas citrus grower, the Olinda yield of 440 kg/tree (970 lbs) during the first 5 production years represents a mean of 11.25 tons/acre/year in an orchard planted with 116 trees/acre (15 × 25 ft spacing). The same orchard would produce a mean of 19.6 tons/acre/year for production years 6-10 and a mean yield of 22.6 tons/acre/year during production years 11-15.

Tree canopy volume was greatest for the TAES nucellar selection and smallest for old-budline, which was not significantly smaller than Frost and Olinda. The high yields from the TAES nucellar selection as a mature tree are desirable but consideration must be given to the larger tree size. The moderate size and high yield of Olinda make it an efficient fruit producer. Statistically, Campbell also fits these criteria with numerically less yield from a slightly larger canopy. Olinda and Campbell were among the most efficient trees relative to yield when evaluated over the total 16 year study or over the last 3 years, representative of mature tree production.

The coefficient of variation (CV) in Table 2 is the clone standard deviation divided by the clone mean and the result multiplied by 100. This value gives a measure of the uniformity of the cultivar's yields between seasons. Consistent yields will result in a low coefficient regardless of the actual yield being high or low. A low CV combined with a high mean yield is most desirable. By this criterion, the most desirable clones in this test were Olinda and Campbell. The apparent advantage of Olinda is indicated by the steadily increasing curve of its cumulative yield after the 5th year of production (Fig. 1).

Tree survival was not a factor in this test, as all trees in this experiment survived until damaged by the freeze in December, 1983. No trees were suffering from foot rot, *Phytophthora parasitica*.

Analysis of juice quality (data not shown) for Brix, acid, Brix/acid ratio and percentage juice obtained in seasons 1977-1979 showed no differences among 'Valencia' selections tested. This could be expected because rootstock, site and cultural practices were the same. Although differences in fruit quality and yield have been reported when using different rootstocks (1,2,5,6), irrigation regimes (8,18), and weed control practices (7), differences were not observed in this study among trees growing on the same rootstock and receiving similar cultural management.

The cumulative yield data from all clones are combined in Fig. 2. The distribution of combined mean annual cumulative yield for all clones over the 16-year period shows that Percentage of cumulative total production increases each year with tree age (fig. 2). Among the 6 'Valencia' clones, no individual clones annual percentage

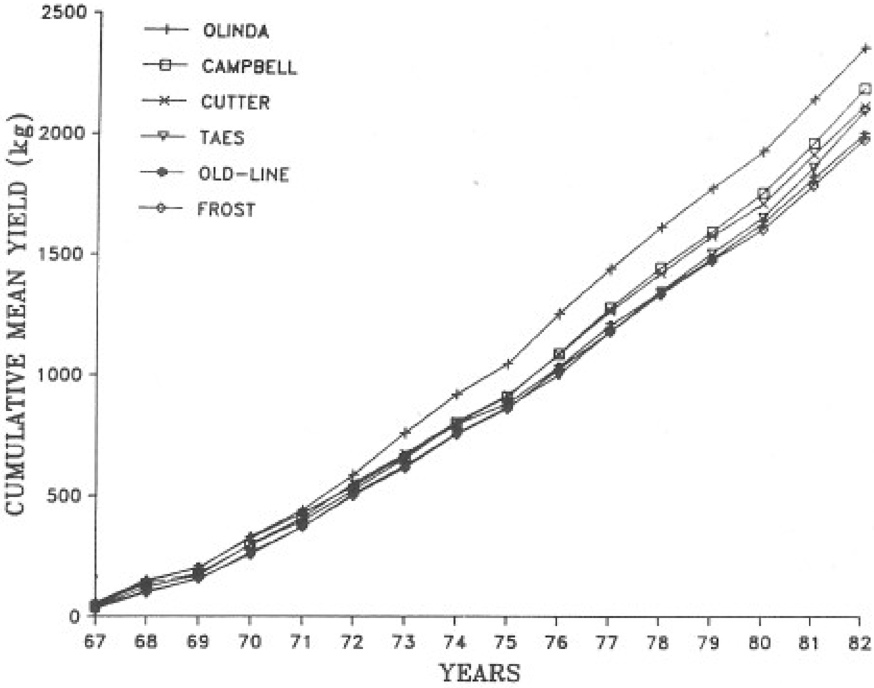

Fig. 1. Cumulative mean yields of 6 'Valencia' clones over 16 production years.

varied more than 1% from the mean in any year. When evaluating the 16 years of production from a 20-year-old tree, the first 6 years of production represent only 12% of the cumulative total production. Years 7 to 11 account for 32% of the cumulative total and 50% of the tree's production is realized in the last 4 years. Figure 2 illustrates why approximately 5 years are required after planting before meaningful yields are obtained, and 7-10 years before sufficient yields would allow returns to equal expenditures. It appears that as a general rule during the first 20 years of tree age, 'Valencia' orange yields increase at about 1% of the cumulative total each year after beginning production in the 4th year. These data bring into focus the realization that citrus production, in this case 'Valencia' oranges, is a long term venture.

The advantages to the grower of one 'Valencia' clone over another must be evaluated by considering factors of production in early years following planting, consistency during the expected life of the tree, total cumulative production, and canopy efficiency for maintaining yields while limiting tree size. Because fruit quality did not differ among the 'Valencia' clones, for maximum returns the grower interested in optimizing production should plant the most consistently productive clones in terms of yield and tree canopy efficiency. The Olinda and Campbell clones appear to be superior choices to accomplish this goal.

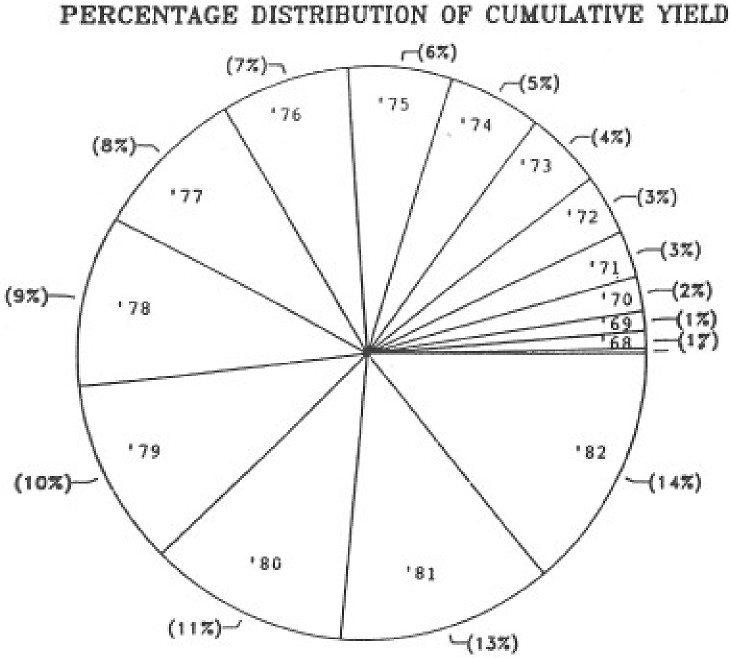

Fig. 2. Mean annual yield of 6 'Valencia' orange clones expressed as a percentage of the cumulative yield distributed over 16-years of production.

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Preemergence Weed Control with Prodiamine Herbicide in Young Citrus Orchards

Dariusz Swietlik, Assistant Professor
Texas A&I University Citrus Center
P.O. Box 1150
Weslaco, TX 78596

Additional Index Words: *diuron, grapefruit, orange, simazine, trifluralin*

ABSTRACT

Prodiamine [N^3, N^3-Di-n-propyl-2,4,dinitro-6-(trifluoromethyl)-m-phenylenediamine] is a new experimental herbicide for preemergence control of annual grasses and broadleaf weeds. Experiments conducted in young, non-bearing grapefruit ('Ruby Red' and 'Star Ruby') and orange ('Marrs') orchards indicated that a single treatment at 2-4 lb ai/acre can provide satisfactory weed control (>70%) for 8-9 months provided the material is thoroughly incorporated into the soil. In two experiments flood irrigation alone proved a satisfactory means of incorporating the chemical but in one experiment mechanical incorporation with a disc was necessary to obtain good weed control. Performance of prodiamine at 2 to 4 lb ai/acre was superior to diuron (Karmex) and simazine (Princep) used at the same rates. Prodiamine provided better control of grasses [browntop panicum (*Panicum fasciculatum* Sw.), and Texas panicum (*Panicum texanum* Buckl.)], selected broadleaf weeds [ridgeseed spurge (*Euphorbia glytosperma* Engelm.), Mexican vervain (*Verbena ciliata* Benth.)], and generally showed longer residual activity against all other weeds encountered in the experiments. No phytotoxicity was observed indicating that prodiamine at rates up to 4.0 lb ai/acre is safe to use around young grapefruit and orange trees grown on soils whose textures range from sandy clay to loamy sand.

A chemical weed control program for Texas citrus orchards calls for an early spring and late summer application of preemergence herbicides. Year-long favorable temperatures for weed growth, ample soil moisture from irrigation or occasional heavy rains, and the constant resupplying of weed seeds through irrigation ensure a heavy weed pressure in most orchards. As a consequence, sometimes a single preemergence herbicide application will not provide satisfactory weed control for a 6 month period (4). Moreover, the wide diversity of weed species precludes any single available herbicide controlling all weeds (3,4).

Clearly, more effective materials are needed. Prodiamine [N^3, N^3,-Di-n-propyl-2,4,-dinitro-6-(trifluoromethyl)-m-phenylenediamine, Sandoz Crop Protection Co., Chicago, IL 60611] is a new experimental herbicide developed for preemergence control of annual grasses and broadleaf weeds with a potential for use in fruit crops (1,2). The chemical has been reported to control weeds as they germinate by inhibiting seedling root and shoot growth (1).

The purpose of this study was to compare the efficacy of prodiamine and some standard herbicides [diuron(Karmex), simazine (Princep), trifluralin (Treflan)] for weed control in citrus orchards and to assess its safety for use around newly-planted trees in the lower Rio Grande Valley of Texas.

MATERIALS AND METHODS

Experiments were conducted on the research farms of Texas A&I University Citrus Center in Weslaco and Mission, Texas.

Experiment 1. The experiment was established in a 'Ruby Red' (*Citrus paradisi*, Macf.) grapefruit orchard on sour orange (*C. aurantium*, L.) rootstock 4 weeks after planting the trees. Soil texture in the top 12 inches varied from sandy clay loam to sandy clay. Organic matter ranged from 0.8 to 1.0% and pH was approximately 8.0. Prodiamine at 0.5, 2.0, and 4.0 lb ai/acre and diuron at 2.0 lb ai/acre were applied in July, 1985, several days after field discing. Treatments were arranged in a completely randomized block design with 3 replications. Two and 7 days following treatment, all plots received 5-inch flood irrigations applied over the whole surface of orchard. The 1st irrigation was applied to incorporate the herbicides into the soil; the 2nd one was a routinely scheduled irrigation of the orchard the experimental plots were part of. Within 13 weeks after treatment, diuron lost control of most weeds and was reapplied at 4.0 lb ai/acre.

A tractor-mounted sprayer equipped with 8006-E flat nozzles and operating at 25 psi at a spray volume of 50 gal/acre was used to apply the chemicals. During spraying, liquid in the tank was continuously agitated. Diuron was formulated as 80% wettable powder whereas prodiamine was a 42% flowable concentrate.

Experiment 2. The experiment was established in a 'Star Ruby' grapefruit orchard on sour orange rootstock, 3 weeks after planting the trees. Soil texture in the top 12 inches was sandy loam to loamy sand; organic matter varied from 0.5 to 1.0%, and pH was approximately 8.0. In December, 1985, prodiamine at 1.6 and 3.2 lb ai/acre and trifluralin at 1.6 and 8.0 lb ai/acre were applied to a round basin (12 sq. ft in area) under the trees. Required amount of each material was diluted in 2 gal of water and applied using a sprinkler can. Treatments were arranged in a completely randomized block design with 6 replications. Immediately after the herbicide applications, the trees were irrigated with 25 gal of water per basin which is roughly equivalent to 4-inch irrigation. Trifluralin used in this experiment was formulated as 48% emulsifiable concentrate and prodiamine as indicated above.

Experiment 3. The experiment was established in a 'Marrs' orange (*C. sinensis*, Osbeck) orchard on sour orange rootstock, 5 weeks after planting the trees. Soil characteristics and the techniques of herbicide application were similar to those described for Experiment 1. Prodiamine at 1.0, 2.0, and 4.0 lb ai/acre, diuron and simazine at 2.0 and 4.0 lb ai/acre were applied to bare ground in March, 1986. Treatments were arranged in a completely randomized block design with 3 replications. One day after treatment, 8-ft wide strips of soil straddling the tree rows were flood irrigated with 5 inches of water.

Simazine used in this experiment was 80% wettable powder formulation; formulations of diuron and prodiamine were as described for Experiment 1.

Weed Control Measurements. Weeds in Experiment 1 consisted of broadleaf species; both grasses and broadleaf weeds were encountered in Experiments 2 and 3. At various time intervals after treatment, the proportion of soil surface covered by grasses, major broadleaf species, and those occurring in small numbers designated "other broadleaf weeds" were estimated visually by 2 observers. Subsequently, the percent control of various weeds was calculated using the untreated weedy check as the standard basis for

Table 1. The effect of prodiamine and diuron herbicides on weed control in a young 'Ruby Red' grapefruit orchard.

	% Weed control[z]				
Treatment (lb a.i./acre)	Prostrate pigweed	Ridgeseed spurge	Common purslane	Mexican vervain	Other broadleaf weeds
	6 weeks after treatment (August, 1985)[y]				
Check - untreated[x]	0b	0b	0a	--	--
Diuron - 2.0	89a	6b	0a	--	--
Prodiamine - 0.5	98a	93a	0a	--	--
Prodiamine - 2.0	98a	100a	17a	--	--
Prodiamine - 4.0	100a	100a	30a	--	--
	13 weeks after treatment (November, 1985)				
Check - untreated[w]	0c	0b	--	--	0c
Diuron - 2.0	65b	3b	--	--	0c
Prodiamine - 0.5	88ab	15b	--	--	43b
Prodiamine - 2.0	94a	73a	--	--	74a
Prodiamine - 4.0	96a	84a	--	--	92a
	33 weeks after treatment (March, 1986)				
Check - untreated[v]	--	0b	--	0c	0c
Diuron - 2.0 + 4.0	--	97a	--	34b	93a
Prodiamine - 0.5	--	9b	--	20bc	17b
Prodiamine - 2.0	--	91a	--	87a	80a
Prodiamine - 4.0	--	97a	--	96a	100a

[z]Mean separation in columns within dates according to Duncan's Multiple Range Test at 5% level.

[y]After the 1st and 2nd rating, all weeds were killed with glyphosate at 2 lb a.i./acre and paraquat at 0.25 a.i./acre, respectively.

[x]100% ground covered by weeds. Prostrate pigweed 66%; common purslane 24%; and ridgeseed spurge 9%.

[w]100% ground covered by weeds. Prostrate pigweed 64%; ridgeseed spurge 22%; other broadleaf weeds [common purslane, horse purslane, henbit] – 14%.

[v]100% ground covered by weeds. Mexican vervain 65%; ridgeseed spurge 20%; other broadleaf weeds [horseweed, virginia pepperweed, London rocket, annual sowthistle] – 7%.

comparison. In Experiment 2, only total weed control was evaluated but weed species found were recorded.

Unless otherwise indicated, after each weed rating, existing weeds in the check and treated plots were killed with postemergence, non-residual herbicides such as glyphosate (Roundup) or paraquat (Paraquat) applied at 2.0 and 0.25 lb ai/acre, respectively. This enabled us to follow the residual activity of the preemergence herbicides against weeds germinating at progressively longer time intervals after treatment. Results were evaluated satistically using analysis of variance; means were separated with Duncan's Multiple Range Test.

RESULTS

Experiment 1. Prodiamine at 0.5, 2, and 4 lb ai/acre provided satisfactory (>70%) control of prostrate pigweed (*Amaranthus blitoides* Wats.) and ridgeseed spurge (*Euphorbia glyptosperma* Engelm.) within the first 6 weeks after treatment (Table 1). Diuron at 2 lb ai/acre controlled prostrate pigweed as effectively as prodiamine but it was inferior to prodiamine in controlling ridgeseed spurge. Both materials did not control common purslane (*Portulaca oleracea* L.) which heavily infested the experimental field earlier that year. Plants not completely destroyed by discing prior to herbicides application produced new sprouts from various vegetative parts. Observations indicated that this was the predominant source of common purslane reinfestation.

At the 2nd weed rating (13 weeks after treatment, Table 1), prodiamine at 2 and 4 lb ai/acre provided satisfactory control of all weeds but the 0.5 lb ai/acre rate was only effective against prostrate pigweed. Diuron gave poor control of weeds.

Diuron was reapplied at 4 lb ai/acre shortly after the 2nd weed rating. Winter months slowed the growth of weeds and it was not before the 33rd week of the experiment that the 3rd weed rating was taken. Up to that time, prodiamine at 2 and 4 lb ai/acre and diuron at 2 + 4 lb ai/acre provided satisfactory control of ridgeseed spurge and the "other broadleaf weeds" i.e. horseweed (*Conyza canadensis* L.), virginia pepperweed (*Lepidium virginicum* L.), London rocket (*Sisymbrium irio* L.), annual sowthistle (*Sonchus oleraceus* L.) (Table 1). Only prodiamine at 2 and 4 lb ai/acre produced satisfactory control of Mexican vervain (*Verbena ciliata* Benth.), but at 0.5 lb ai/acre did not provide satisfactory control of any weed species.

Weeds were allowed to grow undisturbed after the 3rd rating. One month later (April 1986, 37 weeks after treatment) a 4th rating was taken. Only total weed control was recorded because high weed density made it impossible to evaluate each individual species. The percent of total weed control in the check and in treatments with diuron at 2 + 4, prodiamine at 0.5, 2, and 4 lb ai/acre were 0c, 10c, 7c, 24b, and 76% a, respectively. No phytotoxicity symptoms were observed on any trees.

Experiment 2. Total weed control was measured without evaluating individual weed species. During the 13 weeks following herbicide application weed growth was slow. Under these conditions, trifluralin and prodiamine provided excellent weed control regardless of the rate (Table 2).

Twenty-six weeks after treatment, weed pressure was high, but the weed control by both materials was still good (Table 2). Though the treatment averages varied somewhat, the differences were statistically nonsignificant. No treatment produced phytotoxicity symptoms on trees.

Table 2. Weed control with prodiamine and trifluralin herbicides around tank-watered young 'Star Ruby' grapefruit trees.

Treatment (lb. a.i./acre)	% Weed control[z] 13 weeks after treatment (March, 1986)	26 weeks after treatment (May, 1986)
Check - untreated[y]	0c	0b
Trifluralin - 1.6	94b	88a
Trifluralin - 8.0	97ab	92a
Prodiamine - 1.6	100a	91a
Prodiamine - 3.2	99a	99a

[z]Mean separation in columns according to Duncan's Multiple Range Test at 5% level.

[y]13 weeks after treatment - 24% of ground covered by weeds (Palmer amaranth, golden corydalis, Texas panicum, common lambsquarters).

26 weeks after treatment - 92% of ground covered by weeds (Texas panicum, Palmer amaranth, sunflower).

Experiment 3. During the first 7 weeks after treatment, most of the herbicide treatments satisfactorily controlled grasses [browntop panicum (*Panicum texanum* Buckl.], Palmer amaranth (*Amaranthus palmeri* Wats.), ridgeseed spurge and the "other broadleaf weeds," i.e. ragweed parthenium (*Parthenium hysterophorus* L.), common purslane, puncturevine (*Tribulus terrestris* L.), annual sowthistle, and London rocket (Table 3). Diuron and simazine at 2 lb ai/acre were ineffective against grasses and prodiamine at 1 lb ai/acre gave unsatisfactory control of the "other broadleaf species".

More than 5 inches of rain, within 5 weeks preceding the 2nd weed rating, caused heavy weed germination especially Palmer amaranth which became the dominant weed. Only diuron at 4 lb ai/acre provided satisfactory control of that weed (Table 2). Prodiamine at all rates controlled grasses and at 2 and 4 lb ai/acre its control of ridgeseed spurge was superior to that of diuron at 2 and 4 and simazine at 2 lb ai/acre. Diuron at 2 and 4, simazine at 4, and prodiamine at 2 and 4 lb ai/acre provided good control of the "other broadleaf weeds".

After the 2nd rating, weeds were killed with discing. The 3rd weed rating, 23 weeks after treatment, indicated that prodiamine was the only material still effective against all weed species present. It provided very good control of grasses, Palmer amaranth, ridgeseed spurge (except at 1 lb ai/acre), and common purslane. Diuron and simazine were ineffective. No phytotoxicity symptoms were detected on the trees in any treatment.

Table 3. Weed control with prodiamine, diuron and simazine herbicides in a young 'Marrs' orange orchard.

Treatment (lb a.i./acre)	% Weed control[z] Grasses	Palmer amaranth	Ridgeseed spurge	Common purslane	Other broadleaf weeds
	7 weeks after treatment (May, 1986)[y]				
Check - untreated[x]	0b	0b	0c	--	0d
Diuron - 2.0	15b	98a	72b	--	93ab
Diuron - 4.0	94a	100a	99a	--	100a
Simazine - 2.0	4b	81a	74b	--	78bc
Simazine - 4.0	85a	99a	100a	--	100a
Prodiamine - 1.0	86a	86a	93a	--	69c
Prodiamine - 2.0	98a	100a	99a	--	99a
Prodiamine - 4.0	96a	91a	94a	--	93ab
	15 weeks after treatment (July, 1986)				
Check - untreated[w]	0b	0b	0d	--	0c
Diuron - 2.0	0b	29b	5d	--	86a
Diuron - 4.0	0b	82a	38bcd	--	100a
Simazine - 2.0	0b	13b	11cd	--	48b
Simazine - 4.0	0b	18b	51abc	--	86a
Prodiamine - 1.0	75a	15b	61ab	--	27bc
Prodiamine - 2.0	79a	26b	73ab	--	84a
Prodiamine - 4.0	90a	14b	83a	--	83a
	23 weeks after treatment (September, 1986)				
Check - untreated[v]	0c	0c	0b	0d	--
Diuron - 2.0	0c	0c	5b	63c	--
Diuron - 4.0	0c	24b	0b	65c	--
Simazine - 2.0	0c	7bc	16b	74bc	--
Simazine - 4.0	4c	9bc	12b	70c	--
Prodiamine - 1.0	89b	92a	32b	89ab	--
Prodiamine - 2.0	100a	99a	100a	100a	--
Prodiamine - 4.0	100a	96a	98a	100a	--

[z]Mean separation in columns within dates according to Duncan's Multiple Range Test at 5% level.

[y]All weeds were killed after the 1st and 2nd rating with glyphosate at 2 lb a.i./acre and mechanical discing, respectively.

[x]66% of ground covered by weeds. Grasses (browntop panicum, Texas panicum) - 39%; Palmer amaranth - 11%; ridgeseed spurge - 9%; "other broadleaf weeds" (ragweed parthenium, common purslane, annual sowthistle, puncturevine, London rocket) - 7%.

[w]90% of ground covered by weeds. Grasses (browntop panicum, Texas panicum) - 22%; Palmer amaranth - 41%; ridgeseed spurge - 19%; other broadleaf weeds (common purslane, ragweed parthenium, puncturevine) - 7%.

[v]100% of ground covered by weeds. Grasses (browntop panicum) - 9%; Palmer amaranth -70%; ridgeseed spurge - 5%; common purslane - 16%.

DISCUSSION

Prodiamine proved an effective preemergency herbicide for controlling grasses and a wide range of broadleaf weeds. Results of Experiment 1 indicated that a single treatment at 2-4 lb ai/acre can provide satisfactory weed control for 8-9 months. However, such long term weed control was not observed in all experiments. Under high pressure from Palmer amaranth in Experiment 3, prodiamine failed to control that weed 15 weeks after treatment. A subsequent soil discing, however, recurred the effectiveness of prodiamine on Palmer amaranth and improved its control of most other weeds. This suggests that mechanical incorporation may be required to fully realize the benefits from prodiamine application. Contrary to Experiment 3, however, irrigation alone proved a satisfactory means of incorporating the chemical in Experiments 1 and 2.

Some of the variations in responses were probably caused by post-treatment irrigation practices. In Experiment 1 and 3 application of herbicides was immediately followed by a 5-inch flood irrigation. In Experiment 1, however, an additional irrigation was applied 7 days later while the soil was still wet. Water infiltration into a wet soil is slow. Consequently, the prolonged saturation conditions at the soil surface could facilitate chemical dissolution and diffusion into deeper soil layers. In Experiment 2, trees required frequent waterings because water was applied to limited soil surface area under each tree. This may be expected to facilitate herbicide movement into the soil. This view is supported by the excellent weed control from trifluralin which normally requires mechanical incorporation to be effective.

The performance of prodiamine in Experiment 1 and 3 was superior to diuron and simazine in control of grasses, selected broadleaf weeds (ridgeseed spurge, Mexican vervain), and it generally had a longer residual activity. In Experiment 2, prodiamine performed as well as trifluralin for the 6 month period following treatment, however, maximal duration of weed control by both materials was not established since no observations were conducted beyond 6 months.

Neither diuron nor prodiamine provided control of a common purslane infestation 6 weeks after treatment in Experiment 1. But the infestation consisted of plants which originated from the vegetative parts of plants that were not totally destroyed by discing prior to the treatment application. Since prodiamine and diuron are only effective against seedling weeds, control of such an infestation should not be expected.

No phytotoxicity was observed on young grapefruit and orange trees indicating that prodiamine was quite safe for young citrus grown on soils whose texture ranged from sandy clay to loamy sand. Moreover, no phytotoxicity was recorded on 'Star Ruby' grapefruit which is more sensitive than other cultivars to some soil-active herbicides (R. Hensz, Texas A&I University Citrus Center - personal communication).

Results of the present studies indicate that prodiamine is a promising material for preemergence weed control in Texas citrus orchards. However, more research is needed to clarify the effect of mechanical incorporation and various irrigation regimes on the efficacy of this material.

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Screening and Establishment of Forage Legumes in South Texas

C.L. Gonzalez
USDA, ARS, SPA, STARL
Conservation & Production Systems Research
Weslaco, TX 78596

ABSTRACT

Dolichos lablab and other tropical beans are well established as forages in Australia, Brazil, Sudan, and elsewhere, but the possible use of such legumes in the United States has received little attention. Several lines of tropical beans were evaluated from 1977 to 1981 for forage potential in south Texas, both under dryland and irrigated conditions. Nine cultivars of *Dolichos* were successfully grown in south Texas. Dry matter forage production was equal to or better than most forage grasses grown in south Texas. Crude protein and phosphorus levels were at an acceptable level to meet nutritional requirements for both dry and lactating cows. In all trials tested, beef cattle and calves grazed these legumes readily and good regrowth took place after being grazed by animals. *Dolichos* appears to have good potential as forage for cattle in south Texas.

In recent years, increased attention has been focused on the use of legumes in forage livestock production enterprises. The skyrocketing prices of N fertilizers and a possible supply shortage have increased the need of forage legumes as a source of both high-quality forage and cheap biological nitrogen. South Texas has marginal land unsuitable for new crop production which could be utilized for pasture and/or hay. A forage legume species with a wide range of genetic diversity within species could provide the genetic potential for establishment and adaptation to south Texas.

Generally, forage legumes provide (1) a high-quality forage in terms of protein and energy, (2) higher dry matter production than grasses, (3) a lengthened grazing period, (4) improved animal performance, and (5) nutrient recycling in the soil-plant-animal ecosystem which can improve soil nitrogen fertility.

This study was conducted to screen introduced tropical legumes showing potential in south Texas in terms of forage yield, seed production, protein content, phosphorous content, and livestock preferences.

MATERIALS AND METHODS

The agronomic trials were conducted on or near the USDA farm located about 8 km north of Weslaco, Texas and the grazing trials both at Weslaco and Starr County, Texas. The soil in Weslaco is classified as Hidalgo sandy clay loam (*Typic calciustolls*) which is alkaline, has a pH of 7.8, and is high in available K. The associated soils in Starr County are McAllen and Brennan sandy loams. These soils have a noncalcareous fine sandy loam surface layer and a sandy clay loam subsoil. The Brennan series is a member of the fine-loamy, mixed, hyperthermic family of Aridic Haplustalfs; the McAllen series belong to the hyperthermic family of Aridic Ustochrepts. Nitrogen (112 kg/ha) and P (56 kg/ha) were applied prior to planting each year.

Agronomic evaluations were first made in 1977 and further screening in 1978 and 1979. Grazing observations were made in 1980 and 1981. Legumes seeded originally in 1977 included 22 plant introductions (P.I.) of *Dolichos lablab*, 5 P.I. of Tepary beans and one cultivar each of chinese and pigeon peas (Table 1). About 50 grams of seed were hand seeded in a single 6m row plot, 1m wide beds, on April 13, 1977. Irrigation water was applied as needed and plots maintained weed free. Data acquired in 1977 concerned phenological and morphological characteristics. All plots that produced seed were hand harvested.

In 1978, 12 P.I. of *Dolichos lablab*, one P.I. of tepary beans, and one cultivar each of pigeon and chinese peas were selected and seeded (22.4 kg/ha) in a replicated study (Table 1). The experimental design was a randomized complete block with three replications. Prefar herbicide (1.7 kg/ha) was applied and incorporated 5cm deep into the soil 4 days prior to planting. Plots consisted of 4 rows, 13m long, 1m wide and were seeded April 3, using conventional equipment. All plots were flood irrigated following planting and throughout the year as needed.

A 3m section of row was harvested each time for forage from each plot on 4 selected dates and one 13m row was used to harvest seed. Harvest dates were May 27, June 19, July 24, and Sept. 14, which were 49, 76, 111, and 164 days from planting, respectively. Plant regrowth was harvested 2 times (June 27 and Aug. 17) from all plots that were initially harvested on May 27, and one time (Aug. 31), from all plots that were initially harvested on June 19. Regrowth was not sufficient to merit harvest after the July 24 and Sept. 14 harvest dates.

Samples for forage (whole plants) analysis were collected from every harvest. Plant material was analyzed for N and P. Percent N was determined by Kjeldahl method (Peech et. al, 1947). Nitrogen levels were multiplied by 6.25 and expressed as percent crude protein. Phosphorous was determined by the rapid digestion method (Bolin and Stramberg, 1944).

In 1979, 9 P.I. of *Dolichos lablab* were selected from 1978 performance test and seeded in a replicated study (Table 1). Experimental plot design and data collection methods were the same as in 1978. Planting date was March 16. No regrowth forage yield was evaluated in 1979.

In 1980 and 1981, the same 9 cultivars planted in 1979 were used in cattle grazing observation trials. These trials were evaluated both under irrigation conditions in Weslaco, Texas and dryland conditions in La Reforma, Starr County, Texas. These trials were designed to provide information that would aid in establishing legumes and animal preference. Trials were planted both in fall and spring. Grazing began at first bloom or when enough forage warranted grazing. This usually was about 60 to 80 days after planting, and consisted of areas 8 to 20 ha in size. Beef cattle (cow-calf pairs) were used for grazing. Number of cattle varied but were carefully managed to prevent overgrazing.

After the animals grazed most of the leaves in the *Dolichos* plants, plots were closed to allow regrowth. Areas were grazed several times throughout the year as regrowth warranted. Grazing intervals were 30 to 45 days depending on rainfall. Dryland sites received 41.8 and 26.0 cm of rain in 1980 and 1981, respectively.

Harvest data were analyzed using analysis of variance method (Steele and Torric, 1980) and means were analyzed using Duncan's multiple range test.

RESULTS AND DISCUSSION

General Observations-1977 and 1978

There was considerable variation in stand, vigor, blooming habits, forage, and seed production among warm season tropical legumes (Table 1). Stands of most cultivars remained in good condition early in the growing season, however, about 4-6 weeks after emergence, those cultivars with a vigor numerical rating of 3 or less began to show abnormal growth and highly chlorotic symptoms and produced few or no blooms. The annual cultivars grew faster, produced forage and seed earlier. If the annuals are permitted to produce a seed crop, the abundant seed crop which had shattered to the ground would result in a fair volunteer stand and would produce another harvest. Fourteen of the 29 cultivars planted were eliminated in 1977 as potential forage producers for south Texas.

All fifteen cultivars (13 perennials and 2 annuals) planted in 1978 germinated fast and produced acceptable stands. Numerical ratings for vigor and seed production ranged from 7.0 to 7.5 and 4.0 to 10.0, respectively. Six cultivars bloomed in the fall and 9 bloomed in the spring.

Forage production (kg/ha) between cultivars was extremely variable (Table 2). Forage production for the 2 annual cultivars (Tepary bean and chinese peas) was significantly higher the first harvest, 49 days after planting, than some *Dolichos* but reached peak production 77 days after planting. Teparies produced a seed crop 60 days from planting. Similar results have been reported (Rachie and Roberts, 1974). Tepary bean (P.I. 239056) finished growing 164 days from planting and chinese peas decreased in production to 2785 kg/ha. Late forage production for chinese peas was mostly attributed to new seedlings that had reestablished from seed previously produced.

Forage production for most *Dolichos lablab* was low 49 days from planting, but many of the cultivars produced around 4,000 kg/ha of forage 77 days after planting. The highest producer at 164 days after planting was Pigeon Peas (12174 kg/ha).

Two *Dolichos lablab* cultivars (P.I. #338341 and 284802) peaked early, 112 days from planting and produced 6685 and 6330 kg/ha of forage. Production for these 2 cultivars decreased 164 days from planting, due to shedding of leaves. Seven of the 11 *Dolichos lablab* cultivars produced more than 10,000 kg/ha forage in 164 days. All cultivars produced yields higher than those reported in the midsouth (Fribourg et al., 1984). Many grasses under irrigation or dryland produced less than 10,000 kg/ha forage in 164 days (Kretschmer et al., 1973; Woodward, 1979; Wiedenfield et al., 1982).

Crude Protein (CP)

Mean CP percentages of all cultivars were higher in younger plants (49 days) as compared to 164 days (Table 3). There were no significant differences among the younger plants; however, as the plants grew older (112 days) significant differences were evident. Similar results have been reported in other tropical legumes (Siewerdt and Holt, 1975).

For every harvest, all cultivars resulted in higher CP than that reported for any of the better forage producing grasses (Kratschmer, 1973; Siewerdt and Holt, 1974; Woodward 1979; Holt and Conrad, 1981; Everitt and Alaniz, 1982). The National Research Council (NRC, 1984) recommended 9.2 and 5.9% CP for lactating and dry cows, respectively.

All cultivars met CP requirements for both lactating and dry cows. When cattle, consume this forage, protein need not be supplemented during the growing season which in south Texas is over 300 days (U.S. Dep. Commerce, 1970).

Table 1. [1]Warm season legumes planted for forage selections and seed increase purposes.

Entries	Origin	P.I. No.	Stand	Vigor	Seed Production	Remarks	Longevity
Dolichos	Australia	388003	4[2]	3.0[2]	3.0[2]	Spring Bloom	Perennial
Lablab	″	388006**	7	7.0	3.5	Fall Bloom	″
″	″	387994*	6	7.5	8.0	Fall Bloom	″
″	″	388000	4	2.5	2.0	Spring Bloom	″
″	″	388019**	8	8.5	9.0	Spring Bloom	″
″	″	388002**	5	8.0	5.0	Fall Bloom	″
″	India	288466	4	3.0	4.5	Fall Bloom	″
″	″	180438	1	7.0	0	No Bloom	″
″	″	164302*	7	8.0	5.5	Fall Bloom	″
″	″	212998**	5	8.5	6.0	Fall Bloom	″
″	″	164772	4	3.5	2.5	No Bloom	″
″	″	212996	3	4.0	3.0	Fall Bloom	″
″	″	288467**	7	7.0	4.0	Spring Bloom	″
″	USSR	345607**	7	7.5	9.0	Spring Bloom	″
″	Zambia	338341**	8	8.5	10.0	Spring Bloom	″
″	China	284802**	9	9.5	10.0	Spring Bloom	″
″	Malaya	284801*	6	7.0	5.0	Fall Bloom	″
″	Pakistan	219696**	4	8.0	7.0	Spring Bloom	″
″	Egypt	195851	3	4.0	4.5	No Bloom	″
″	Afghan	267705	1	2.0	0	No Bloom	″
″	Peru	215753	1	2.0	0	No Bloom	″
″	Kenya	280861	2	6.0	3.5	No Bloom	″
Tepary	Mexico	319551	3	6.0	7.5	Spring Bloom	Annual
Bean	″	200749	3	6.5	6.0	Spring Bloom	″
″	Arizona	321637	2	6.0	6.0	Spring Bloom	″
″	″	321638	2	5.5	6.5	Spring Bloom	″
″	Morocco	239056*	9	8.5	7.0	Spring Bloom	″
Pigeon Peas	Norman Var.	-	8	9.0	10.0	Spring Bloom	Perennial
Chinese Peas	China*	-	10	9.5	10.0	Spring Bloom	Annual

[1]Planting date 4/13/77 - all lines were planted.

[2]On scale 1 to 10, 10 is best, 0 is poorest. Ratings are averages for 10 plants.

*Planting date 4/3/78 - These lines used in 1978, but not 1979.

**Planting date 3/16/79 - These lines used in 1978 and 1979.

Table 2. Forage Production (kg/ha) of warm season legumes planted April 3, 1978.[1]

Entries	Origin	P.I. No.	Days from planting			
			49 days	77 days	112 days	164 days
Dolichos	Pakistan	219696	460 bcd[2]	2863 bc	5238 b	8045 ab
lablab	Australia	388006	547 abcd	3365 ab	6523 a	10447 a
"	Australia	387994	516 abcd	2750 abc	4798 b	10973 a
"	Australia	388019	836 ab	3092 ab	2999 d	3250 c
"	Australia	388002	303 cd	3638 a	5525 ab	10258 ab
"	India	164302	615 abc	4083 a	6683 a	11575 a
"	India	212998	793 ab	3866 a	6607 a	10283 a
"	India	288467	693 abc	4125 a	7438 a	10993 a
"	USSR	345607	710 abc	3680 a	3079 d	4230 c
"	Zambia	338341	650 abc	4014 a	6685 a	4733 bc
"	China	284802	736 abc	3496 ab	6330 ab	3964 c
"	Malaya	284801	367 bcd	2225 bc	4388 bc	10461 a
Tepary Bean	Morocco	239056	966 a	4052 a	4488 bc	-
Pigeon Peas	Norman Var.	-	155 d	1713 c	5274 b	12174 a
Chinese Peas	China	-	961 a	3444 ab	3957 c	2785 c

[1] Whole plant - ovendry basis.

[2] Values in columns followed by the same letter do not differ significantly at the .05 probability level according to Duncan's multiple range test.

Table 3. Crude protein (%) of warm season legumes planted April 3, 1978.[1]

Entries	Origin	P.I. No.	Days from planting: 49 days	77 days	112 days	164 days
Dolichos	Pakistan	219696				
Lablab	Australia	388006	20.7 a[2]	20.4 a	17.6 abc	18.3 abc
"	Australia	387994	22.2 a	19.1 a	15.4 bcd	17.8 bc
"	Australia	388019	18.7 a	17.3 a	14.3 cd	15.5 cd
"	Australia	388002	22.6 a	17.2 a	15.6 bcd	18.3 abc
"	India	164302	23.1 a	18.7 a	19.0 ab	20.7 ab
"	India	212998	22.7 a	21.6 a	20.9 a	22.4 a
"	India	288467	20.1 a	21.4 a	17.4 abc	19.3 abc
"	USSR	345607	18.5 a	16.9 a	14.3 cd	16.9 bc
"	Zambia	338341	23.0 a	22.7 a	13.9 cd	19.1 abc
"	China	284802	22.6 a	18.9 a	14.5 cd	19.5 abc
"	Malaya	284801	22.4 a	21.2 a	15.6 bcd	18.3 abc
Tepary Bean	Morocco	239056	18.9 a	19.3 a	15.6 bcd	-
Pigeon Peas	Norman Var.	-	20.1 a	22.4 a	17.2 abc	12.6 d
Chinese Peas	China	-	19.5 a	18.1 a	11.8 d	17.7 abc

[1] Whole plant - ovendry basis.

[2] Values in columns followed by the same letter do not differ significantly at the .05 probability level according to Duncan's multiple range test.

Phosphorous (P)

Phosphorous content of most cultivars studied were generally lower in younger plants than older plants (Table 4). Plants 49 days old averaged about 0.36% P as compared to 0.47% for 164-day old plants. Among the cultivars studied, Pigeon Peas had the lowest and *Dolichos lablab* from India (P.I. 212998) had the highest P level at 164 days. Mean P levels of most cultivars at 49-days were above the levels of 0.18 and 0.39% considered adequate for dry and lactating cows, respectively (NRC, 1984). All cultivars 164-days with the exception of Pigeon Peas, met requirements of both dry and lactating cows.

1978 Regrowth

The regrowth performance of all *Dolichos lablabs* (Table 5) indicated that all the cultivars would grow back after one harvest, and produce an acceptable forage yield in a short period of time (30 days). Almost half of the cultivars produced more than 1000 kg/ha after the first regrowth following the May harvest. Forage production decreased on the 1st regrowth of the June harvest, indicating that regrowth is better when plants are harvested at younger stage. Second regrowth on the May harvested plants was less vegetative, poorer quality, and yielded less. Tepary bean, an annual, behaved like a perennial and produced good regrowth when first harvested at a young stage of growth (45 days from planting). Some of the forage harvested as regrowth were seedlings from volunteer plants. Crude protein and phosphorus content were in the same range as 1st harvest and was considered adequate for dry and lactating cows.

1979

Nine perennial cultivars were used in 1979. Planting was 2 weeks earlier than 1978 and plots were harvested 5 times throughout the year. The latest harvest was 248 days after planting. Only two cultivars, Pakistan (P.I. 219696) and Australia (P.I. 388002) showed a large increase in production by extending harvest to 248 days (Table 6). Most production of the cultivars peaked in 112 to 156 days. Significant difference in forage production occurred in 3 harvest dates, 112, 156, and 248 days from planting. Forage production showed a decrease at 181 days which reflects no growth and leaf shedding during hot summer days. By late fall, 248 days from planting, yield increased in most cultivars, indicating more growth during the earlier days of fall.

Crude Protein (CP)

Mean CP percentages of all cultivars were significantly different only at 112 days (Table 7). Crude protein was slightly higher in younger plants (75 to 112 days from planting). As in 1978, all cultivars resulted in higher CP than any of the better forage producing grasses, and satisfied the 9.2 and 5.9% CP requirement for lactating and dry cows, respectively.

Phosphorous (P)

Mean P content of most cultivars in 1979 were generally lower than those of 1978 (Table 8). This indicates that *Dolichos* depletes the soil of P at a fast rate. P concentration was fairly constant throughout the year and not significantly different among cultivars and harvest dates. All cultivars contained more than 0.18% which is considered adequate for dry cows. *Dolichos* plants older than 112 days were lower than 0.39% P the level considered adequate for lactating cows.

Cattle Performance

During first day of grazing, cattle fed mostly on grassy species along fence lines and alley ways, but by the second and third day, animals started to graze *Dolichos*.

Table 4. Phosphorous (%) of warm season legumes planted April 3, 1978.[1]

			Days from planting			
Entries	Origin	P.I. No.	49 days	77 days	112 days	164 days
Dolichos	Pakistan	219696				
Lablab	Australia	388006	.35 a[2]	.44 a	.37 a	.58 ab
"	Australia	387994	.34 a	.42 a	.40 a	.46 abc
"	Australia	388019	.37 a	.39 a	.48 a	.40 bcd
"	Australia	388002	.33 a	.34 a	.35 a	.53 abc
"	India	164302	.38 a	.54 a	.40 a	.45 abcd
"	India	212998	.38 a	.47 a	.46 a	.62 a
"	India	288467	.37 a	.50 a	.38 a	.43 abcd
"	USSR	345607	.38 a	.42 a	.41 a	.38 cd
"	Zambia	338341	.40 a	.42 a	.32 a	.55 abc
"	China	284802	.34 a	.49 a	.47 a	.50 abc
"	Malaya	284801	.39 a	.52 a	.41 a	.48 abc
Tepary Bean	Morocco	239056	.33 a	.31 a	.42 a	-
Pigeon Peas	Norman Var.	-	.37 a	.38 a	.26 a	.27 d
Chinese Peas	China	-	.34 a	.34 a	.29 a	.47 abc

[1] Forage - ovendry basis.

[2] Values in columns followed by the same letter do not differ significantly at the .05 probability level according to Duncan's multiple range test.

Table 5. Forage production (regrowth Kg/ha) of warm season legumes planted April 3, 1978.[1]

Entries	Origin	P.I. No.	1st harvest[2] 1st regrowth 6/27	1st harvest[2] 2nd regrowth 8/17	2nd harvest[3] 1st regrowth 8/3
Dolichos	Australia	388006	1252	42	360
Lablab	"	387994	1100	21	525
"	"	388019	1287	712	701
"	"	388002	814	45	145
"	India	164302	952	194	731
"	"	212998	818	47	231
"	"	288467	646	24	318
"	USSR	345607	966	557	944
"	Zambia	338341	1221	101	1360
"	China	284802	567	49	359
"	Malaya	284801	506	24	186
Tepary Bean	Morocco	239056	1035	633	210

[1] Forage - ovendry basis.

[2] 1st harvest date - 5/27
1st regrowth date - 6/27
2nd regrowth date - 8/17

[3] 2nd harvest date - 6/19
1st regrowth harvest - 8/3

Table 6. Forage production (kg/ha) of warm season legumes planted March 16, 1979.[1]

			Days from planting				
Entries	Origin	P.I. No.	75	112	156	181	248
Dolichos	Pakistan	219696	2041 a[2]	5543 ab	5770 abc	4441 a	10253 abc
Lablab	Australia	388006	2434 a	5543 ab	4519 bc	5486 a	7658 abc
"	Australia	388019	2193 a	2291 c	2104 d	3808 a	3926 d
"	Australia	388002	2303 a	8916 a	6513 ab	6377 a	11568 a
"	India	212998	1434 a	7339 ab	4558 bc	6680 a	6182 bcd
"	India	288467	1923 a	5942 abc	7343 a	5856 a	5648 cd
"	USSR	345607	2528 a	3542 bc	3343 cd	3354 a	5338 cd
"	Zambia	338341	2199 a	5524 abc	3733 cd	5460 a	6710 bcd
"	China	284802	2713 a	6012 abc	4321 bcd	5297 a	8115 abcd

[1]Forage - ovendry basis.

[2]Values in columns followed by the same letter do not differ significantly at the .05 probability level according to Duncan's multiple range test.

Table 7. Crude protein (%) of warm season legumes planted March 16, 1979.[1]

			Days from planting				
Entries	Origin	P.I. No.	75	112	156	181	248
Dolichos	Pakistan	219696	21.0a[2]	23.8abc	19.5a	21.6a	19.6a
Lablab	Australia	388006	23.7a	22.9ab	15.4a	17.4a	15.8a
"	Australia	388019	19.7a	16.3c	15.0a	17.9a	16.4a
"	Australia	388002	22.4a	19.6a	16.6a	21.4a	16.7a
"	India	212998	23.9a	21.5ab	16.4a	22.9a	17.8a
"	India	288467	24.4a	23.8abc	17.9a	17.5a	15.5a
"	USSR	345607	21.7a	17.6bc	17.1a	17.3a	16.2a
"	Zambia	338341	23.9a	23.4abc	17.7a	18.4a	17.6a
"	China	284802	20.5a	19.6a	18.5a	18.4a	17.0a

[1] Forage - ovendry basis.

[2] Values in columns followed by the same letter do not differ significantly at the .05 probability level according to Duncan's multiple range test.

Table 8. Phosphorous (%) of warm season legumes planted March 16, 1979.[1]

			Days from planting				
Entries	Origin	P.I. No.	75	112	156	181	248
Dolichos	Pakistan	219696	.44 a[2]	.46 a	.34 a	.42 a	.35 a
Lablab	Australia	388006	.40 a	.48 a	.33 a	.41 a	.30 a
″	Australia	388019	.46 a	.45 a	.30 a	.42 a	.33 a
″	Australia	388002	.45 a	.39 a	.31 a	.45 a	.34 a
″	India	212998	.50 a	.49 a	.31 a	.49 a	.32 a
″	India	288467	.45 a	.53 a	.34 a	.46 a	.34 a
″	USSR	345607	.43 a	.49 a	.28 a	.34 a	.36 a
″	Zambia	338341	.40 a	.45 a	.31 a	.42 a	.32 a
″	China	284802	.40 a	.48 a	.31 a	.35 a	.32 a

[1] Forage - ovendry basis.

[2] Values in columns followed by the same letter do not differ significantly at the .05 probability level according to Duncan's multiple range test.

Odor was strong in the full bloom stage of plant growth, but slightly less in the regrowth stage; however, the odor from *Dolichos* did not seem to bother any of the animals. Once cattle started to graze *Dolichos* they preferred it as compared to any other species of forage available (Fig. 1). These grazing patterns are similar to those reported in Australia (Cassidy, 1975; Montgomery and Allen, 1977; in Brazil, Favoretto and Costa, 1978; and others, Van Schaiks P., 1978; Hendrickson and Munson, 1980), but contrary to the results from other grazing trials in Georgia reported by Fribourg et al., 1984. The cultivar used in Georgia was obtained from a cross between cultivar Rongai and an early maturing bean from India and it is possible that this cultivar is less acceptable to cattle than are the genotypes successfully grazed in Australia or other parts of the world. A different climatic regime may have altered growth or maturity rate, so that acceptability by cattle was affected.

Cattle eagerly grazed leaves, flowers, young pods, and tender young stems of *Dolichos*. The coarse stems were not eaten, which is advantageous for new regrowth. After the animals were removed from the pasture and the gates of the grazing pasture were closed, most of the animals walked around the enclosed pasture trying to break in. In all trials in different areas, the same was observed of the different grazing animals.

Dolichos, high in protein and phosphorous, offer a very good quality of forage for cattle. Since these legumes have at least twice the protein of most grasses, animals were observed to gain weight faster and remained in better shape throughout the year. *Dolichos*, besides being rich in protein, are also a good source of iron (155 mg per 100g dry wt.) (Plenumum Press, 1981).

CONCLUSIONS

These results indicate that some cultivars of the tropical legumes, *"Dolichos lablab* beans," can be successfully grown in south Texas, under both irrigated and dryland conditions. Dryland conditions would probably require annual precipitation of at least 50 cm. Rainfall records at the site indicate that for 10 of the last 15 years, precipitation has exceeded 50 cm. The levels of CP and P at any age are higher than those found in tropical or native grasses. Adapted quality legumes such as *Dolichos lablab* could make a significant contribution to pasture production in the extreme southern United States. *Dolichos lablab* could also serve as an efficient source of soil N which could eliminate or reduce the need for supplement N.

Dolichos lablab lacks sufficient cold hardiness for consistent survival, but in subtropical south Texas they survived winters with low temperatures of $-12\,^{\circ}C$, and a good regrowth stand resulted the following spring. Voluntary seedlings from seed that remained in the ground was also a good source of some plants in the stand.

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Fig. 1. Dolichos beans make a good high quality forage and are acceptable to cattle.

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Water From the Rio Grande: The Only Game In Town

John Hinojosa IV, Rio Grande Watermaster

The Rio Grande River has changed its course many times over the years. However, one thing that has not changed is that this river continues to be the major source of water for the Rio Grande Valley. One might say that the Rio Grande River is the only game in town.

Water use along the Rio Grande below Amistad Reservoir for municipal, domestic, industrial, livestock, agricultural, and mining purposes totals approximately 1.2 million acre-feet per annum. The total U.S. share in Amistad and Falcon Reservoirs when full is 3,464,900 acre-feet, 57.4% of the total storage. Mexico is entitled to the remaining storage in the reservoirs.

Even with all of this water, the Rio Grande continues to be impacted by rapid growth and the related demands for water. There are currently more than 500,000 residents in the Rio Grande Valley, with published projections as high as 1 million people by the year 2000. While the Valley population may double, the water supply will not. Therefore, it is quite evident that there is a strong need for conservation by municipal as well as agricultural users. The water supply for the Rio Grande Valley must not be taken for granted.

The Rio Grande Watermaster is responsible for administering the water rights, allocating these rights, monitoring diversions from the Rio Grande, and controlling the releases from Amistad and Falcon Reservoirs. Anzalduas Diversion Dam is used as a regulatory structure to improve delivery efficiency. The current Watermaster Operation was implemented in 1971 as a result of a lengthy lawsuit. Millions of dollars were spent during the fifteen year litigation period 1956 to 1971, after which the courts ended their judicial watermaster function on May 31, 1971. On June 1, 1971 the Texas Water Rights Commission accepted and assumed the Watermaster functions and trust from the court. The acceptance was made under the provisions of the Water Rights Adjudication Act of 1967. Since that time, the agency has undergone name changes and is now known as the Texas Water Commission.

The ownership of water in the Rio Grande between Mexico and the United States is determined by the International Boundary and Water Commission (IB&WC) in accordance with the Treaty of 1944 between the United States and Mexico. Once the IB&WC determines the water ownership for each country, it is then the Rio Grande Watermaster's responsibility to allocate the U.S. (Texas) share to Texas users.

Water rights holders along the Rio Grande must obtain authorization from the Rio Grande Watermaster prior to diverting any water from the river. The demand is tabulated and releases scheduled so as to meet the demand with minimal waste released to the Gulf of Mexico. There is a seven-day lag time for water released from Falcon Reservoir to reach the city of Brownsville. Every water right has an account with an annual authorization. Much like a bank, when one withdraws from his account, his balance decreases. When the system (Falcon and Amistad Reservoirs) receives inflow (new water), these new waters are then allocated to each water right holder on a pro-rata basis.

The Rio Grande Watermaster Operation is unique for several reasons. First, the Rio Grande is the only River in the State of Texas which has the water adjudication process finalized from Fort Quitman to the Gulf of Mexico, approximately 1173 river miles. Additionally, the Rio Grande is the only waterway in Texas which also serves as an international boundary. For these reasons, the river will always be unique and important to Texas. It is important to recognize this river for its value and strive to utilize its water as efficiently as possible through the development and implementation of conservation programs.

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SANCTUARY IN YOUR YARD: Some Unusual Native Plants For Use in South Texas Landscapes

John E. Fucik[1] and James H. Everitt[2]

ABSTRACT

The landscaping potential of 7 uncommon native plants, including 3 trees, 3 shrubs and a cactus, are described. Suggestions and precautions on using and possible sources of these plants are included.

In visiting an arboretum, one is impressed with the wide variety and arrangement of plants being grown. Natural, semi-formal, and display plantings may be combined with highly stylized Japanese or rock garden landscapes to provide panoramas of plants to attract and interest everyone. The established arboretum is a series of mini-landscapes where trees, shrubs and herbaceous plants are selected and grouped to meet ecological, educational and aesthetic needs.

With the proper choice of plants, site and care, any yard could become a miniature arboretum. Furthermore, in almost any region the dedicated horticulturist and nature lover has the opportunity and challenge to preserve rare or endangered native plants. The key word is "dedicated;" without devoting sufficient time and effort to meeting the plants' needs, one may hasten, rather than slow, the species' extinction.(7) Two keys to success are duplicating the plants' native habitats, and using the right propagation and transplanting techniques.(10) Though it may require special care, growing stock from seed or cuttings is the surest, easiest and only unobjectionable way to obtain plants.(1,4,6)

Generally, removing plants from public or private land without prior permission is illegal(7). Also, unless the transplanting is properly timed and executed, the plant stands little chance of surviving.

The ultimate satisfaction of having plants around the home, whether they are native or exotic, rare or common, should go beyond their mere survival and development into healthy specimens. A plant's purpose is to add function, unity, interest and beauty to the landscape(5). We have kept this in mind in describing the following plants nominated for sanctuary in your yard and garden. The cultural and landscaping suggestions included are those intended to gain the appreciation of both plant and plantsman.

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[1]Professor, Texas A&I University Citrus Center, Weslaco, TX 78596

[2]Range Scientist, U.S.D.A. Agricultural Research Service, Weslaco, TX

THREE HARDY TREES WITH HIGH LANDSCAPE POTENTIAL[3]

SABAL PALM, Texas palmetto. *Sabal texana* (Cook) Becc., Palm family (Palmae) (Fig. 1). This evergreen tree grows to 48 ft. and forms a dense, rounded crown of lustrous, blue-green, fan-like leaves. Greenish-white flowers that are borne on a drooping, branched spadix in March or April produce dull black berries in late summer. Since transplanting is difficult, it is best propagated from seeds. The sabal palm grows slowly and may take from 20 to 35 years to reach its maximum height. The tree's natural habitat is the alluvial soils along the Rio Grande River and resaca banks in Cameron County, but it is now restricted to only a few small groves. This palm has been grown on a variety of sites as far north as Victoria, Texas, and is very cold hardy and adaptable to most of the soils and sites of South Texas. It will grow in partial shade or full sun.

In the tropical, desert or general landscape, the sabal is preferable to the Washington palm where a smaller, better proportioned tree is desired. An additional advantage is that the leaf petioles of the sabal palm do not have the hooked thorns characteristic of Washington palms.

MOUNTAIN TORCHWOOD, Mexican amyris. *Amyris madrensis* Wats. Rue family (Rutaceae) (Fig. 2). The slender, irregularly spaced, spineless branches of this shrub or small tree 5 to 15 ft. tall, are tipped with glossy green pinnately compound clusters of leaves which create an open but arresting canopy. The panicles of tiny white flowers in spring yield clusters of small, black, berrylike fruit in the fall. Like many other rue family members, leaves and twigs of mountain torchwood give off a strong citrus scent when bruised. Unlike most citrus, Mexican amyris shows considerable cold tolerance. While found on sandy loam and alluvial soils, this shrub would likely adapt to the South Texas and Gulf Coast area providing the soils were not saline, it was watered well and was grown under some shade. It can easily be started from seeds and transplanted.

Torchwood, so named because its wood ignites easily, would add considerable interest to a contemporary or oriental landscape especially where limited space suggests a fine textured, slow growing specimen. Set in a bed of contrasting colored or textured ground cover like monkey grass, spider plants, or variegated English ivy, mountain torchwood should make a unique addition to any landscape.

TENAZA, mimosa-bush. *Pithecellobium pallens* (Benth.) Standl. Bean family (Fabaceae) (Fig. 3). In its natural habitat this spiny evergreen forms a small tree or large shrub whose slender branches have an irregular but spreading growth habit. The fern-like leaves are 5 to 6 inches long, medium green and pinnately compound. The creamy white, globose, mimosa-like flowers are produced after heavy summer rains. Flowering may occur two to three times a season. The fruit is a flat, strap-shaped, brown pod containing 5 to 12 dark brown seeds. Under normal yard care, tenaza may grow to a small tree of 16 to 20 ft. in height.

Although found in nature on alluvial sites, tenaza will grow on a wide variety of soils and is hardy as far north as Sinton (San Patricio County). Used as a tall shrub or small tree, the mimosa-bush provides filtered shade for other landscape plants, with the added bonus of having fragrant flowers which are also known to be good sources of nectar for bees.

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[3]Plant descriptions are based on references 2,9 and the authors' observations.

Fig. 1. SABAL PALM is an excellent choice where a slow-growing, well proportioned, hardy fan palm can be used in the landscape.

Fig. 2. Like other members of the rue family, MOUNTAIN TORCHWOOD'S shiny, pinnately compound leaves emit a strong citrus odor when crushed.

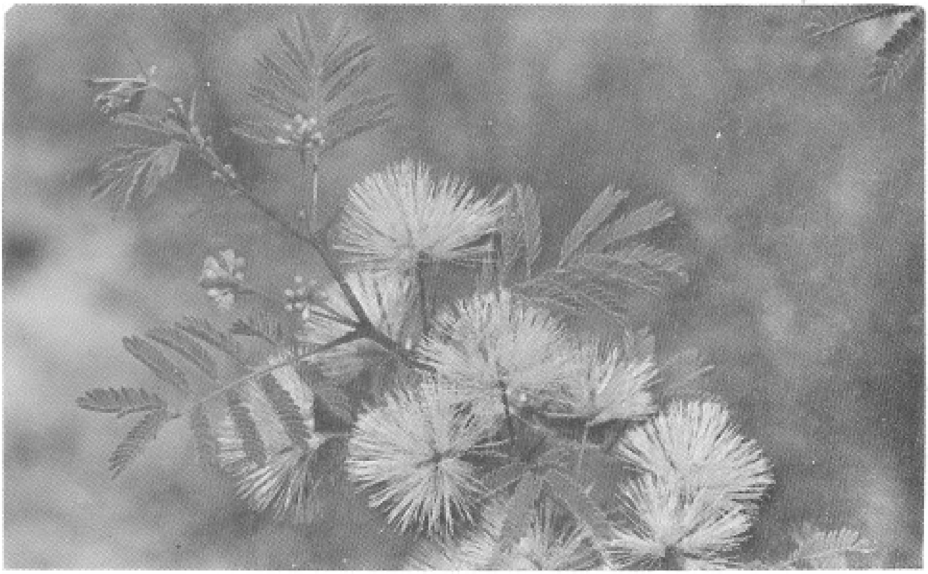

Fig. 3. The fine-textured foliage and showy mimosa-like flowers of TENAZA make a striking addition to a natural setting.

UNCOMMON SHRUBS DESERVING INTEREST

SCARLET HIBISCUS, Mountain rose-mallow. *Hisbiscus cardiophyllus* Gray. Mallow family (Malvaceae) (Fig. 4). This diminutive, woody-based perennial, whose large deciduous, heart-shaped leaves and stem are covered with a dense pubescence, seldom exceeds 2 ft. in height. Belying its small size, the shrub produces 1 to 2 inch diameter showy scarlet flowers throughout the year. The color and size of the blooms, though typical of hibiscus, certainly justify the plant's Mexican name, *tulipan del monte*--"tulip of the mountain." Since it grows naturally on gravelly hillsides and caliche ridges, the scarlet hibiscus does best on well-drained, loamy soils in either full sun or partial shade but is adapted to the area south of a line from Del Rio east through San Antonio. Though difficult to start from seeds, plants are easily obtained by rooting softwood cuttings (4).

An attractive, low-growing shrub like the scarlet hibiscus can find use in a wide variety of landscape designs and functions. Singly or in groups they'd add continuous color to the perennial border of a naturalistic setting. They would be especially valuable for fronting taller shrubs or lining informal walkways where space is limited. And how fitting an addition to the courtyard or entry garden of a Spanish or ranch style home.

SOUTHWEST BERNARDIA. *Bernardia myricaefolia* (Scheele) Wats., Spurge family (Euphorbiaceae) (Fig. 5). Bernardia's dense branches, covered with oblong to elliptic, 1 to 2 inch long leaves borne singly or sometimes in clusters, make a very compact, round-topped, symmetrical shrub 3 to 5 ft. tall. Neither the small inconspicuous flowers nor the three-lobed green fruit are of horticultural interest. Found most abundantly on gravelly hillsides and caliche ridges, it is particularly drought resistant and can take full sun or partial shade. Since it can be found around New Braunfels (Comal County), this shrub could probably be grown in protected sites throughout much of the state except the most northern and western areas. Bernardia could be quite useful as a natural hedge or background for lower growing plants. In an extensive naturalistic planting where water and care may be limited, bernardia should prove especially valuable.

TWO CANDIDATES FOR THE CACTUS GARDEN

CANDELILLA, wax euphorbia. *Euphorbia antisyphilitica* Zucc., Spurge family (Euphorbiaceae) (Fig. 6). Even in a plant family noted for its variety, the candelilla with its erect, rod-like, dark green leafless stems is an oddity and conversation piece. On the tips of the 3 to 3½ ft. stems, small white or pinkish flowers are produced following rains the year round. Adding to the curiosity is the pinkish-green to ultimately brown fruit, a three-lobed capsule which hangs like a pendant from the naked shoot tips. Candelilla prefers a well-drained sandy loam soil in full sun. In South Texas, massive bulldozing and clearing native brushlands for pasture have threatened this unusual shrub with extinction(3). However, candelilla would likely do well throughout all of South Texas and west to the Big Bend National Park.

Like the following native, candelilla can be treated as a succulent in the cactus garden or desert landscape. Its visually arresting characteristics are complemented by equally interesting lore. In Mexico, the branches were boiled for a good commercial grade of wax, hence its Spanish name--"little candle." Medicinally, the juice has been used as a purgative and for treating venereal diseases.

STAR CACTUS, sea urchin cactus. *Echinocactus asterias* Zucc. Cactus family (Cactaceae) (Fig. 7). This small, grayish-green spineless cactus is a true rarity in a family famous for its bizarre and unusual members. Star cactus looks like a green sand dollar, is only 6 inches in diameter, and bears beautiful yellow flowers throughout the growing season. Though very rare in the U.S., the star cactus is somewhat more common in Mexico where the combined pressures of cactus collectors and habitat destruction have been less intense. Since it is commonly cultivated, plants of this species may best be obtained from reliable cactus dealers. Like other cacti, star cactus needs a very well-drained sandy soil but grows best in light shade. In a typical protected cactus garden site, this native should do quite well in most areas south of San Antonio.

For that dry site in the rock garden or raised border, single or grouped specimens of the star cactus would add a splash of yellow color with minimum care. For more open, naturalistic sites featuring drought tolerant natives, this diminutive plant can easily fit into almost any compatible site.

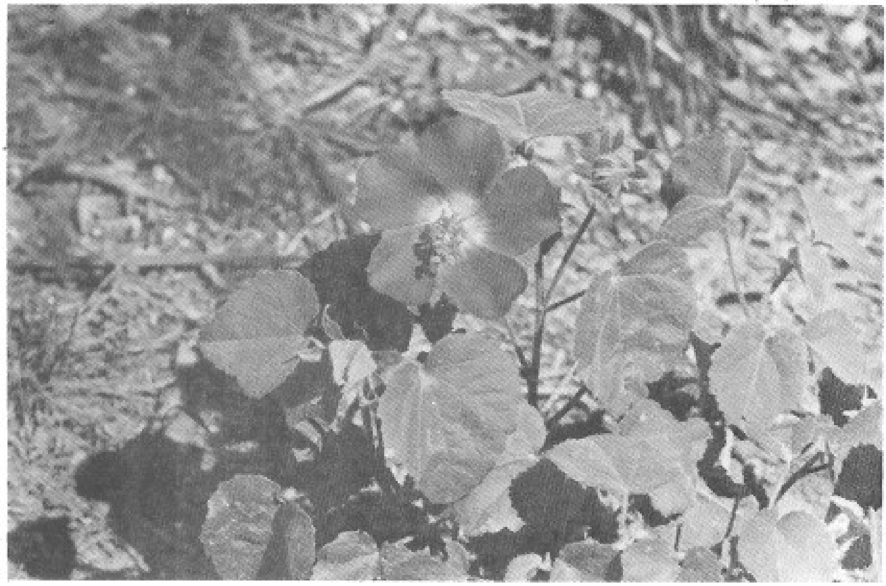

Fig. 4 The SCARLET HIBISCUS, a diminutive semi-shrub, bears showy red flowers throughout most of the year.

Fig. 5 SOUTHWEST BERNARDIA'S small leaves and compact, symmetrical shape make it equally at home in the tailored formal garden or adding textural interest to the naturalistic landscape.

Fig. 6 CANDELILLA, or wax euphorbia, is a cluster of leafless stems covered with a heavy, commercially valuable wax.

Fig. 7 For a small, everblooming addition to the cactus bed, STAR CACTUS makes a very prim and unusual candidate.

FINDING AND PLANTING OUR NATIVES

With the appreciation of native plants increasing and the advantages of using them in landscaping, more nurseries and garden centers now regularly stock native plants, including some of the species described here. For the location of nurseries handling native plants check the Texas Department of Agriculture's native plant directory(8). Another good source of information and some plants is the Valley Nature Center, 301 S. Border Ave., Weslaco, Texas 78596. See the native plant collection at Lone Star Nurseries, Rt. 9, Box 220, San Antonio, Texas, and visit Green Horizons, 500 Thompson Dr., Kerrville, Texas for unusual wild flowers and herbaceous natives.

Since many of our native plant species are rare or near extinction in the U.S., we strongly discourage seeking them out and transplanting them from the wild. Even where legal permission is obtained, the probability of a wilding transplanting successfully from its native habitat is very slim. To increase interest in native plants among local nurseries, the Native Plant Project, P.O. Box 1433, Edinburg, Texas 78540, is assembling data on how to propagate and increase native plants with exceptional ornamental promise. The Native Plant Project, affiliated with the Texas Native Plant Society, is dedicated to the preservation, utilization and appreciation of the Valley's wealth of indigenous plantlife. If the group is successful, the plants described above and many others of equal beauty, curiosity and appeal will be available to add to the pleasure and interest of our landscapes.

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Artist's Airbrush Inoculation as a Tool for Screening Cowpea for Reaction to Virus[1]

S.K. O'Hair[2], Research Assistant, J.C. Miller, Jr., Professor
Department of Horticultural Sciences
and R.W. Toler, Professor, Department of Plant Pathology
and Mircrobiology
Texas A&M University
College Station, TX 77843-2133

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ABSTRACT

The efficacy of the artist's airbrush in transmitting the cowpea strain of southern bean mosaic virus (SBMV-CS) to cowpea was evaluated in greenhouse and field studies. Results indicated that, with proper physical criteria, the artist's airbrush can provide 100% infection in susceptible cultivars. Conditions for optimum infection and disease expression included: An orifice to leaf distance of 10cm, pressure of 3.5 kg/cm^2, inoculum dilution of 1:2(w:v) and 1.0% carborundum. Flow rates of 2, 6, and 10ml per minute gave similar results. The most important variables for maximizing symptom severity were the air pressure followed by % abrasive and inoculum dilution, respectively. Major differences in disease severity were visible among treatments two weeks after inoculation. Through field testing it was shown that the artist's airbrush inoculation technique was 100% effective in transmitting SBMV-CS, CMV-CS, and TMV-CS to susceptible cowpea cultivars.

INTRODUCTION

Standard mechanical virus inoculation in cowpea (*Vigna unguiculata* (L.) Walp.) is labor intensive (1, 3). The artist's airbrush inoculation technique has been shown to be efficient in transmitting viruses to other crops when large plant populations are to be screened (4, 5). Physical criteria for using the artist's airbrush included: orifice to leaf distance, air pressure, abrasive concentration, flow rate and tissue dilution. The objective of this study was to evaluate the relative importance of these variables and to evaluate the efficacy of the artist's airbrush inoculation technique in transmitting the cowpea strains of southern bean mosaic (SBMV-CS), cucumber mosaic (CMV-CS) and tobacco mosaic (TMV-CS) viruses to cowpea.

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Texas Agricultural Experiment Station Technical Article 15479.

[2]Current address of senior author: University of Florida Agricultural Research and Education Center, Homestead, FL 33031.

MATERIALS AND METHODS

All viruses were maintained in California Blackeye No. 5 cowpea, which was also used in all inoculation studies as the source of inoculum and the treatment cultivar in the greenhouse. Virus purity was maintained by passing each through its specific host (3). Inoculum was prepared by macerating leaves from 21-day-old infected plants with chilled 0.1M phosphate buffer, pH 7.2. Various ratios of leaf tissue to buffer were used. The homogenate was filtered through cheesecloth and an abrasive (carborundum, 600-mesh) was added.

Physical Criteria for Maximizing Disease Severity. Seeds were planted in 1-liter pots. When the primary leaves were fully expanded, each plant was inoculated with a 1-2 sec spray of SBMV-CS. The experimental design was a central composite rotatable design in 5 x-variables (2^5 factorial, with a mid-point treatment) (2). The highest and lowest possible values that should have given infection were selected for each treatment to provide an estimate of the slope for each treatment increment. The mid-point treatment determined linearity. The factorial treatments were replicated three times and included 10 and 20cm orifice to leaf distance, 1:2 and 1:10 tissue to buffer ratio (w:v), 2.1 and 3.5 kg/cm^2 air pressure, 0 and 1% abrasive concentration (w:v) and 2 and 10 ml/minute flow rate. The mid-point treatment included 14 plants with 15cm orifice to leaf distance, 1:5 tissue dilution, 2.8 kg/cm^2 air pressure, 0.5% abrasive concentration and 6 ml/minute flow rate. Control plants were inoculated with buffer plus 1% abrasive. Inoculated plants were maintained in a greenhouse and disease severity was assessed for all plants 14 days after inoculation. The visual rating was: 1 = no symptoms; 2 = slight mosaic in newly formed leaves; 3 = mosaic plus leaf distortion; 4 = mottle, mosaic, leaf distortion and reduced growth; 5 = very severe symptoms.

To identify the optimum tissue and abrasive concentrations, a second greenhouse experiment was established. Inoculation with SBMV-CS took place when the primary leaves were fully expanded. The experimental design was a 2^2 factorial with a mid-point treatment. The factorial treatments were replicated 17 times and included 0 and 1% abrasive and 1:2 and 1:50 tissue dilution. The mid-point treatment included 14 plants and inoculation with 0.5% abrasive concentration and 1:25 tissue dilution. The orifice to leaf distance, air pressure and flow rate were maintained at 10cm, 3.5 kg/cm^2 and 6 ml/minute, respectively. Disease severity was assessed 14 days after inoculation. Least squares multiple linear regression analysis was used to identify the best treatment combination in both experiments. Treatment values were coded (the upper and lower levels were $+1$ and -1, respectively), resulting in a simple orthogonal form.

Field Testing. SBMV-CS, CMV-CS, and TMV-CS were selected for use on: California Blackeye No. 5, Mississippi Silver, Clay and Knuckle Purple Hull. Seeds were planted in 7 × 0.1m plots. Aldicarb 4.5 kg/ha was applied to control aphids. Seedlings were thinned to 15cm and inoculated with virus treatments when the primary leaves were fully expanded. The viruses (main plots) and cultivars (sub-plots) were studied in a split plot arrangement of treatments with 3 replications. Inoculum of each virus was prepared using 0.5% abrasive, and 1:25 tissue dilution. Orifice to leaf distance and air pressure were the same as described in the greenhouse experiments. Buffer was used as a control treatment. Readings were taken at 21 days after treatment and symptomless plants were indexed onto indicator plants to verify virus presence (3).

RESULTS AND DISCUSSION

Vein clearing appeared one week after inoculation with SBMV-CS in the first greenhouse experiment. At the end of the second week, 47% of the variability in visual ratings of disease severity was explained by the treatments. The reaction to virus infection was most severe in plants inoculated with the following parameters: 10cm orifice to leaf distance, 3.5 kg/cm^2 air pressure, 1:2 tissue dilution and 1.0% abrasive (Fig.1). Other treatment combinations gave less than optimal symptom severity. Air pressure, the most important variable, and abrasive concentration and tissue dilution were all significant in explaining differences in symptom severity (Table 1). Within the range tested, the flow rate and orifice to leaf distance did not significantly affect disease severity. Since air pressure was positively correlated with increased symptom severity, and air pressure greater than 3.5 kg/cm^2 resulted in extensive leaf damage, all further testing was done at 3.5 kg/cm^2. The second most important variable was abrasive concentration which was positively correlated with increased symptom severity.

The optimum tissue dilution and abrasive concentration were determined in the second greenhouse experiment. Optimum severity was observed in plants inoculated with 1:2 tissue dilution and 1.0% abrasive concentration, as well as with 1:25 tissue dilution and 0.5% abrasive concentration (Fig. 2). Again, abrasive concentration was more important than tissue dilution (Table 1). When tissue dilution was 1:50 with no abrasive, infection took place; however, the disease severity was sub-optimal.

In the field trial, 100% virus infection was achieved in all cultivar-virus combinations (Table 2). Mean inoculation time was 10 sec/m of row. Through this study, it was shown that the artist's airbrush can be utilized for efficiently infecting cowpeas with either a rod-shaped virus or an isometric virus.

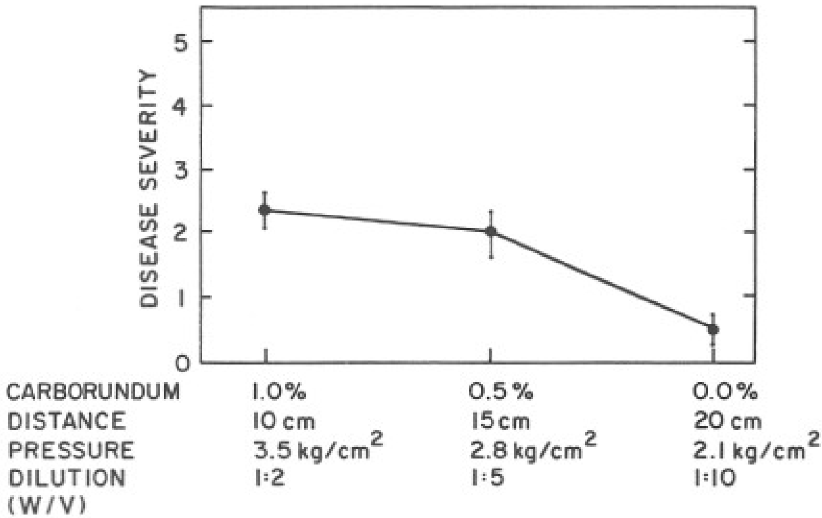

Fig. 1. Mean disease severity levels from selected treatment combinations, following artificial inoculation with the artist's airbrush, Greenhouse Experiment 1. Vertical bars represent + SE.

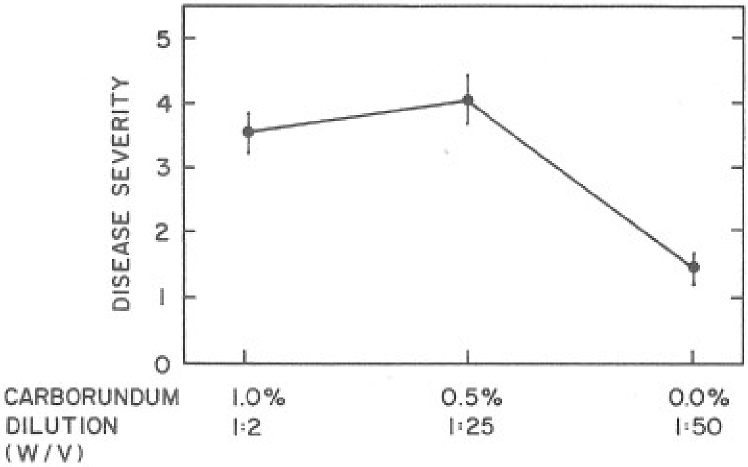

Fig. 2. Mean disease severity levels from selected treatment combinations, following artificial inoculation with the artist's airbrush, Greenhouse Experiment 2. Vertical bars represent + SE.

Table 1. Physical criteria, regression coefficients and levels of significance for optimizing virus severity in California Blackeye No. 5 cowpea following inoculation in the greenhouse.

Experiment 1		Experiment 2	
Variable	Coefficient	Variable	Coefficient
Air Pressure	+0.18***[a]	Carborundum	+1.34**
Carborundum	+0.06**	Dilution	−0.40*
Dilution	−0.04*		

[a]F test significant at 5% (*) level, 1% (**) level or 0.1% (***) level.

Table 2. Cultivars evaluated for artist's airbrush inoculation with 3 viruses and the subsequent % viral infection.

Cultivar	Virus Infection			
	Control	SBMV-CS	CMV-CS	TMV-CS
California Blackeye No. 5	0[a]	100	100	100
Clay	0	100[b]	-	-
Knuckle Purple Hull	0	100	100	100
Mississippi Silver	0	100	100	100

[a] % infected based on visual observations and indexing of symptomless plants onto indicator plants.

[b] local lesions produced on cotyledonary leaves.

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ON THE COVER

Tenaza, *Mimosa pallens*, is a native evergreen shrub which lends itself to landscaping in South Texas. See "Sanctuary in Your Yard: Some Unusual Native Plants for Use in South Texas Landscapes" in this issue.