POSTER SESSION

EPOXY OILSEEDS

GENETIC DIVERSITY OF *VERNONIA GALAMENSIS* IN ETHIOPIA

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Vernonia galamensis is a new potential industrial oilseed crop that originated in Ethiopia. It has unique properties, which makes it economically and ecologically interesting. The status of germplasm collection and collection sites across the different ecological zones with detailed description and current research in Ethiopia are described. Data bases have been also developed for the accession and collection sites.

Studies on variability of characters in *V. galamensis* collections at three contrasting agroclimatic zones during the last four years showed a highly significant difference for days to emergence, plant height, stem diameter, number of primary and secondary branches, number of primary and secondary heads, leaf number per plant, days to heading, flowering, physiological maturity, seed yield per plant, seed yield per hectare, seed number per head, 1000 seed weight, and oil content. The existence of variability indicates the potential for an effective basis for selection and improvement within characters. The mean performance of the accessions for the same characters showed significant difference using Duncan's multiple range test. The agronomic practices developed through this research effort are given as recommendations for growing this crop under Ethiopian conditions.

Harvesting and processing of the seed are described and presented. The potential of the crop is discussed within the framework of the agricultural system in Ethiopia.

COMPARING CROPPING SYSTEMS FOR STOKES ASTER

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Stokes aster (*Stokesia laevis*) is a potential natural seed source of vernolic acid (12,13-epoxy-*cis*-9-octadecenoic acid) with several problems limiting its culture as a crop. Among these is the fact that Stokes aster does not produce seed in its first year of development. Our objective was to compare productivity of Stokes aster relay intercropped with soybean with spring and fall plantings of monocropped Stokes aster. This comparison was initiated in 1992 and was repeated over a three-year period.

Stokes aster growth under the soybean canopy was significantly less than that of spring monocropped plants. However, after the soybean canopy was removed at harvest, the relay intercropped Stokes aster recovered before reproductive bolting. This resulted in seed yields equivalent to spring monocropped Stokes aster. Seed yields from these small plots varied considerably, but averaged about 1,000 kg/ha. Planting in the fall of the same year

instead of the spring did not allow plants to achieve adequate size for a vernalization response and most plants did not produce flowers the following spring.

Regardless of cropping system, production longevity of this perennial was no more than three years after initial reproductive development. Weed encroachment, disease, and mound building by fire ants (*Solenopsis invicta*) caused loss of stand over time at our location.

RESPONSE OF *VERNONIA GALAMENSIS* GROWN IN THE GREENHOUSE TO FERTILIZATION

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Vernonia galamensis is a new oilseed crop. At present, no publications or recommendations are available regarding the nutrient and fertilization requirements for vernonia. To elucidate some of these requirements, experiments were conducted in the greenhouse with two varieties of *V. galamensis*, var. *ethiopica* and *petitiana.*

In the first experiment, the plants were grown in soil-less medium, irrigated, and fertilized daily with 7:3:7 Shefer liquid fertilizer at three levels: 0.5, 1.0, and 2.0 l/m^3. Plants in the control were fertilized every two weeks at a rate 36 times lower than the low treatment of 0.5 l/m^3. The following parameters were determined: time of flowering, shoot elongation, number of branches and capituli, seed yield, and oil and vernolic acid contents. It was found that, in all aspects of growth, the control plants of both varieties had suffered greatly. There were no differences in performance among the three fertilization treatments for the var. *petitiana*; however, the performance of var. *ethiopica* was optimal at 1.0 l/m^3 of fertilizer. The growth parameter most affected was production of primary branches that lead to production of more flower heads. Fertilization also had a positive effect on the level of oil and vernolic acid.

In the second experiment, plants of var. *ethiopica* were grown at five fertilization regimes varying in nitrogen and phosphorus: 7:3:7, 14:3:7, 3.5:3:7, 7:6:7, and 7:1.5:7 (1.0 l/m^3). It was observed that high nitrogen caused a slight but significant decrease in biomass and seed yields and stimulated plant senescence and drying. Plants grown under high phosphorus had slightly more biomass and seeds. Fertilization did not affect the time of flowering.

VARIABILITY IN OIL AND VERNOLIC ACID CONTENTS IN THE NEW *VERNONIA GALAMENSIS* COLLECTION FROM EAST AFRICA

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Establishment of a new industrial crop such as vernonia (*Vernonia galamensis*) could be an alternative to farmers who need a "high cash" crop as a primary source of income. This is crucial in states such as Virginia where farms consist of relatively small acreages and depend upon tobacco as their "cash" crop in prior years. Vernonia is an annual herb and native of East Africa. It grows in areas with as little as 200 mm of seasonal rainfall. Plantings in Eritrea, Kenya, and Zimbabwe confirmed that *V. galamensis* has an excellent seed retention compared with *V. althemantica*.

The progress in developing improved vernonia germplasm has increased the national and international interest in this plant as a good source of seed oil rich in vernolic acid. The existing *V. galamensis* germplasm collection at USDA/ARS is limited to 33 accessions. Additional accessions were collected from Eritrea through the support of USAID grant. The seeds of the newly collected accessions were multiplied and planted at two locations in Eritrea. In addition to the agronomic studies, seeds were analyzed for oil, vernolic acid, and lipase activity.

Significant variations in oil and vernolic acid contents among accessions were found. Oil ranged from 13.8 to 53.7% with a mean of 24%. Vernolic acid ranged from 40 to 75% with a mean of 62.4%. A positive and significant correlation (r = 0.28**) between oil content and vernolic acid was found. This indicates that breeding vernonia for higher oil content will increase vernolic acid content. Highly significant and negative correlations (r = -0.90, -0.82, -0.95, and -0.96) were found between vernolic acid and palmitic, stearic, oleic, and linoleic acid, respectively. Agronomic traits of the accessions and the breeding strategies will be discussed.

PLANTING DATE AND HERBICIDE EFFECTS ON GROWTH, SEED YIELD, AND OIL YIELD OF *EUPHORBIA LAGASCAE*

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Euphorbia lagascae seed contains high levels of vernolic acid, a C-18 epoxidized fatty acid with potential use by the paint and coating industries. Our interest in euphorbia is because of its drought tolerance and grows well in the warm, Mediterranean climate of southwest Oregon. Use of "non-shattering" mutants from Spain has allowed evaluation of agronomic requirements. Time of planting and weed control are two factors that are important in plant growth, yield potential, and the mechanics of harvesting.

Early spring planting dates have produced plants that are more mature and more amenable to swathing and subsequent windrow combining by early September than later spring planting dates. However, early spring planting has often been hampered by wet weather. Euphorbia seeds that shattered on the ground during harvest have shown the ability to germinate in the fall and survive through the winter, suggesting that fall planting may be possible. A planting date study began in 1997, with four fall planting dates and two spring dates. Planting in late August and early September resulted in large, vigorous plants by April, whereas plants seeded in late September and early October survived the winter, but the plants were much smaller and less vigorous by April. Early March and early April planting dates were also included in this study. If trends continue, an early fall planting would likely allow harvest in midsummer, reducing irrigation requirements as well as avoiding weather-related harvest problems in September and October. Also, plants that are well-established by early April can much more easily compete with the summer weeds that emerge then, possibly avoiding extensive cultivation and herbicide use. Detailed seed and oil yield results will be discussed further.

Concurrent experiments will evaluate the tolerance of euphorbia to various post-emergence herbicides. By building on prior experience with pre-emergence herbicides, these results will allow growers the means to minimize weed competition during the germination and seedling stages, prior to canopy closure when euphorbia becomes very competitive. Greenhouse testing to date suggests that euphorbia is tolerant to a number of compounds, but plant growth stage and herbicide rate are important in some cases. Detailed results from ongoing tolerance evaluations in the greenhouse and field will be discussed as well as yield comparisons in the field tests.

FATTY ACID ANALYSIS OF DEVELOPING SEEDS IN *VERNONIA GALAMENSIS*

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Our study was undertaken to describe changes in fatty acid composition and oil content that occur during seed development in *Vernonia galamensis*. A second objective was to determine the progression of lipase activity in seeds as they mature.

Vernonia was planted in April 1997 at the U.S. Water Conservation Laboratory in Phoenix, Arizona. Heads were harvested at 4-day intervals from 7 to 56 days after anther emergence. Three replications of seven vernonia accessions were collected on each harvest day. Seeds were stored at -80 ^{o}C until analyzed for oil content and oil composition (fatty acid distribution). Lipase activity was determined by measuring free fatty acids present in the seeds at the time of oil extraction. Oil constituents were first separated by solid phase extraction columns using a procedure developed for this study. The amount of oil was determined using gas chromatography. Free fatty acid distribution was determined using a colorimetric method.

The information from this study will help determine optimum harvest time for vernonia seeds. It will also be useful in our study of the heredity of these traits.

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FOOD

GARBANZO BEAN: A POTENTIALLY VIABLE CROP FOR SOUTHWESTERN COLORADO

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Garbanzo bean also known as chickpea (*Cicer arietinum*) is an important source of protein in human diets. It is grown in the U.S. almost exclusively in California and the Palouse region of eastern Washington, northern Idaho, and eastern Oregon. Garbanzo bean production was introduced to southwestern Colorado in the early 1980's, but was short-lived due to agronomic, processing, and marketing constraints. Renewed interest in garbanzo bean in recent years has been prompted by the release of more adapted varieties and the need for alternative crops in southwestern Colorado.

Agronomic research at the Southwestern Colorado Research Center in 1994-1997 shows a yield potential of 1,120 kg/ha (1,000 lb/a) under dryland conditions and more than 2,240 kg/ha (2,000 lb/a) under irrigation of several garbanzo bean varieties. In comparison, the county yield average of pinto bean variety (*Phaseolus vulgaris* L.) rarely exceeds 448 kg/ha (400 lb/a) under dryland conditions and 2,016 kg/ha (1,800 lb/a) under irrigation.

Garbanzo and dry beans can be grown using similar equipment and cultural practices. An advantage of garbanzo beans over commonly grown dry bean varieties is the possibility of direct combining. Furthermore, garbanzo bean appears to be more frost tolerant than pinto bean, thus allowing earlier planting. A study by Adobe Milling Inc. shows the potential for much higher economic returns by growing garbanzo beans instead of pinto bean.

The quality of garbanzo bean seeds produced in southwestern Colorado seems adequate for dry packing and/or canning. However, the uniformity of seed maturity has been a problem in wet years resulting in a high number of stained seeds. Research is underway to determine the influence of planting date on seed yield and quality of several garbanzo bean varieties.

EVALUATION OF CHICKPEA, FABA BEAN, LUPIN, MUNGBEAN, AND PIGEONPEA AS NEW CROPS FOR MID-ATLANTIC REGION OF USA

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Increasing world population and increasing emphasis on protection of the environment require development and production of legumes. These crops provide protein-rich food and feed, and reduce inorganic nitrogen fertilizer applications due to their ability to fix atmospheric nitrogen. The New Crops Program of Virginia State University, established in 1991, has evaluated a wide array of legume plants for production in Virginia and adjoining states. The potential legume crops identified were chickpea, faba bean, mungbean, and pigeonpea. Since 1997, the white lupin is also being evaluated as a winter grain legume.

Because the Virginian farms are close to the Washington, D.C. metropolitan area, where international community is familiar with these crops, these growers can capitalize on the demand for the mature and immature seeds of chickpea (*Cicer arietinum* L.), faba bean (*Vicia faba* L.), and pigeonpea (*Cajanus cajan* (L.), Millsp.).

Production of mungbean (*Vigna radiata* (L.) Wilczek) as a summer crop, following winter wheat, can reduce imports of 5-7 million kg of mungbean into the United States for sprout manufacturing and other food uses. Research conducted during 1993 and 1994 showed that the mungbean yield of approximately 2,700 kg/ha is possible when it is planted in May.

White lupin (*Lupinus albus* L.) is making a comeback in the southern United States due to its high potential in both conventional and sustainable production systems. It can fix 150 to 200 kg/ha nitrogen for use by a succeeding crop. The fiber-rich lupin flour is gaining attention as a food source for humans. The nutritionally-rich lupin flour with its high content of potassium, calcium, carotene, and protein can be used to enrich pastas, cake mixes, cereals, and other baked goods. Sweet lupin seeds lack trypsin inhibitors and can make a valuable contribution to dairy, beef, swine, sheep, and poultry rations because high temperature cooking to eliminate anti-nutritional factors is not needed.

Both *desi* and *kabuli* types of chickpea have shown promise under Virginia conditions. The mature seed yields of *desi* types (small-seeded) have ranged from 876 to 1,400 kg/ha and those of *kabuli* (large-seeded) types from 307 to 1,082 kg/ha when planted in March and harvested in July.

Selected pigeonpea genotypes have yielded more than 10,000 kg/ha of green immature beans and approximately 1,900 kg/ha of dry beans.

Currently, 390 genotypes of faba bean and 284 genotypes of lupin are being evaluated to identify desirable genotypes for development of cultivars adapted to the agro-climatic region of Virginia and adjoining states. Detailed results of research efforts with these crops will be presented.

BIOTIC AND ABIOTIC RELATIONSHIPS OF *AMARANTHUS HYBRIDUS* CULTIVATED IN MONOCULTURE SYSTEMS IN SOUTH AFRICA

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Amaranthus hybridus is a nutritious, fast growing vegetable crop, with the potential for increased use in the semi-arid regions of the world. A sustainable pest and disease management approach for the cultivation of *A. hybridus* in South Africa requires a thorough understanding of the abiotic and biotic factors that affect the crop. Fungal and insect relationships are especially relevant because they play important roles in the ecology of most cultivated plants.

Our main goal was to identify fungi and insects associated with *A. hybridus* cultivated in monoculture systems. Special attention was devoted to endophytic fungi associated with *A. hybridus*. True endophytic fungi live

entirely within living plant tissues, but do not elicit disease symptoms. They can act as bioregulators of plant health or provide protection from pathogenic fungi and phytophagous insects. Certain endophytic fungi (latent-infecting fungi) can cause disease symptoms when induced by adverse environmental conditions or host maturity.

The first objective of this study was to identify and quantify frequencies of endophytic fungi associated with *A. hybridus* and to determine the influence of soil amendments and irrigation on their occurrence. Five-month-old *A. hybridus* plants were sampled from four treatments comprising the addition of fertilizer or manure to irrigated soil; wood ash to non-irrigated soil; or control plots that were not amended nor irrigated. Ten leaves, 10 petioles, and 10 roots from each of five plants per treatment were surface sterilized to remove exterior micro-organisms. Small sections of tissue were placed on corn-meal agar and observed after five days incubation. Significant differences in recovery of fungi occurred among the four treatments ($P<0.001$ for all tissue types). The highest recovery was from the fertilized/irrigated treatment for all tissues (mean 97% for all tissue types). Differences in species composition also occurred among plant tissues ($P<0.001$) and among soil treatments ($P < 0.001$). The most common species isolated from leaves and petioles was *Alternaria alternata* (90% and 70% respectively, for all samples). Different fungal genera predominated in the roots. These observations suggest that both the abundance and species diversity of endophytic fungi in *A. hybridus* are influenced by site conditions.

The second objective was to identify fungi associated with tissue decay observed in larval galleries of the pigweed weevil (*Hypolixus haerens*), the main pest of *A. hybridus* in South Africa. Six-month-old *A. hybridus* stems were split and small samples of discolored tissue and associated larvae were aseptically placed on corn-meal agar in petri-plates and incubated for four to seven days. The most common species isolated from both discolored tissue and larvae was *Fusarium subglutinans* (50% and 36% of the samples respectively). Additional species isolated from stems included other *Fusarium* sp. (19%), *Phomopsis* sp. (11%), and *A. alternata* (10%). Additional species isolated from the larvae included other *Fusarium* spp. (40%), *Phomopsis* sp. (4%), and *A. alternata* (6%). Inoculation studies revealed that isolates of *F. sambucinum*, *F. oxysporum* and *F. subglutinans* can act as pathogens independent of the pigweed weevil. The potential for significant disease loss associated with this insect-fungal association warrants further investigation.

POTENTIAL PRODUCTIVITY OF TWO PHYSALIS SPECIES: TOMATILLOS *(Physalis ixocarpa*) AND GOLDENBERRY (CAPE GOOSEBERRY, *Physalis peruviana*)

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The aim of this investigation was to measure the effect of a summer sowing date on the potential productivity of tomatillos (*Physalis ixocarpa*) and cape goosberry (*Physalis peruviana* L.) (syn. *P. edulis*).

Plants were grown with seeds obtained from Mexico (*P. ixocarpa)* and from Colombia (*P. peruviana*). They vary considerably in their developmental, morphological and biochemical characteristics. The trial was conducted under field conditions at the Agronomy Facility, Buenos Aires University (34° 36' S and 58° 29' W). Seeds were planted in a greenhouse on 20 December 1996 and the seedlings transplanted to the field on 14 January 1997. A randomized complete design with four replications was used. Each replicate consisted of four 2 m rows, 50 cm apart with a plant separation of 50 cm. At the end of the growing season on 25 April 1997, observations were taken on the total number of nodes m^{-2}; number of nodes m^{-2} on the superior and inferior auxiliary branches, and total number of fertile nodes m^{-2} (a single fruit per fertile node), and on stem, leaf, root and fruit dry weight m^{-2}. The results were subjected to analysis of variance. Differences were considered at the (P = 0.05) significance level.

The dates of first flower opening by 50% and of first fruit harvest were on 4 February 1997 and on 24 March 1997 for *P. ixocarpa*; and, 20 February 1997 and 7 April 1997 for *P. peruviana*. The total number of nodes m^{-2} did not differ significantly between genotypes during the trial, but node patterns varied significantly between genotypes. The number of nodes m^{-2} on the superior auxiliary branches was highest on *P. ixocarpa* (258 vs.161) as was the number of fertile nodes m^{-2} (292 vs. 76). There were no differences on total biomass production m^{-2} between

genotypes, although there were differences on biomass partitioning. Leaf dry weight m^{-2} was lowest (248 vs. 760) and fruit dry weight m^{-2} was highest (1,221 vs. 37) on *P. ixocarpa*.

The average fresh weight per fruit was 22 g for *P. ixocarpa* and 4 g for *P. peruviana*. The lower leaf dry weight m^{-2} measured at final harvest on P. ixocarpa compared with *P. peruviana*, was the result of the differences in the demand of the reproductive sinks, and was responding to a shorter phenological pattern.

P. ixocarpa had the greater economic yield and lower leaf dry weight at final harvest than *P. peruviana*. This is related to the growing conditions. *P. ixocarpa* is a short season genotype, and with earlier planting dates we could expect more than one cycle of production. *P. peruviana* must be planted earlier if we expect to improved its economic yield.

GENETIC DIVERSITY OF THE GENUS *APIOS* (FABACEAE) AND ITS POTENTIAL AS A CROP IN THE NORTHEASTERN UNITED STATES

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Apios americana, also known as the groundnut or potato bean, has long been used as a food source by Native Americans perhaps as a cultivated plant. This member of the Fabaceae has a number of small tuberous rhizomes that are edible and may reach two inches in diameter in the wild. The potential as a modern crop has long been recognized.

In 1995 and 1996, an electrophoretic analysis was done to understand the evolution and origin of the triploid races of *A. americana* by comparing banding patterns of this cytotype with geographically associated diploids. The triploids are found in the northern part of the range and may be important in developing this species as a crop in the Northeast. Using this analysis, it became evident that diploid races had a great deal of variation within and among populations. In addition, two different genotypes were identified in the triploids. To test the possibility that either *A. priceana* or *A. fortunei* contributed a genome to the triploid, their isozymes were also investigated. It was shown that these species had unique alleles not found in either the diploid or triploid populations of *A. americana.* This reveals that these congeners may have unique characteristics that could be used to improve the common groundnut. The small sample of the threatened North American species A. *priceana* showed great uniformity in banding patterns. This may mean that it is self pollinating, which could allow useful varieties to be produced true to type from seed, which is important, because unlike *A. americana*, it is not easily asexually propagated.

Apios priceana may be useful in agriculture because of its single large tuber that may be easier to harvest than *A. americana*. In addition to using isozymes or DNA techniques to insure capture of a high level of diversity while domesticating *A. americana,* research involving trials and selection need to be done in several regions of the United States. Varieties from Louisiana State University were grown at the University of Vermont horticultural farm in the summer 1996. It quickly became evident that most of the LSU selections were not appropriate for cultivation in New England. A few improved varieties did succeed, but were the types that produced a large number of smaller tubers. More work and selection has to be done in each area to ensure that varieties will yield in different regions. In addition more research on *A. priceana* could be done. Nutritional analyses showed its tubers to be inferior to the common groundnut for human consumption. The members of the genus *Apios* have potential to be developed as agricultural crops. A deliberate and directed effort must be made to capture the genetic diversity of the wild populations while improving their production. A broader genetic base may allow plants to be grown in different climatic regions and reduce the chances of a pathogenic disaster.

FRUIT QUALITY AND WATER USE EFFICIENCY AS AFFECTED BY THE IRRIGATION METHOD

IN PEPPER (Capsicum annuum)

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The study was conducted to determine the effect of four irrigation methods combined with two soil moisture levels on water use efficiency (WUE), fruit quality, and plant growth of pepper in the Las Cruces region of southwestern New Mexico state. Drip, furrow, alternate furrows, and alternating-alternate furrow irrigation methods were evaluated. The soil moisture levels studied varied with the irrigation method (-0.025 and -0.035 MPa of soil matric potential in drip irrigation, and -0.045 and -0.055 MPa in the furrow treatments). Water was applied based on Penman's potential evapotranspiration (PET) equation and irrigation efficiencies of 90% for drip irrigation and 85% for furrow irrigation. Alternate treatments received the equivalent of 85% of the water applied to furrow irrigation.

Drip irrigation produced the highest yield (green and red) and the highest WUE for green pepper, whereas no significant differences occurred between the every furrow irrigation compared with the alternate treatments. Pod quality (weight, length, and width) was better under both drip and furrow irrigation in three of four parameters evaluated. Drip irrigation promoted the highest leaf area; however, there were no significant differences among the four irrigation methods for the leaf area index (LAI). Similarly, the LAI values obtained from the four irrigation methods were considered as good values because they oscillated between the optimum range (3-5).

Total aerial dry matter, plant height, and plant stem diameter reached the highest values under drip irrigation. The two soil moisture levels evaluated did not produce a significant effect on any of the parameters measured. Therefore, the irrigation timing for pepper under drip irrigation can be when the soil matric potential is at either -0.025 or -0.035 MPa; however, for furrow irrigation, it is recommended at -0.055 MPa. Additional research is needed in getting the optimum soil moisture level for applying irrigation in pepper.

The alternate furrow treatment produced similar effects on important parameters such as yield (green and red) and WUE, and required 15% less water compared with the traditional every furrow irrigation. Thus, alternate furrow irrigation may be as good as other irrigation methods to produce chile pepper in areas with scarce and/or expensive water.

CORN STOVER POTENTIAL: A SCENARIO THAT CAN RECAST THE CORN SWEETENER INDUSTRY

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Corn stover is by far the largest single available biomass not being used, representing more than 70% of the total waste, including municipal solids. An estimated 220 million dry tons remain each year as aboveground residue.

Conversion of corn stover to sugars has been stymied for years due to cost. Environmental benefits, wider adaptation of sustainable farming practices and the relentless improvements in biotechnology are expected to overcome the economic hurdle within the next five years and recast the corn sweetener industry.

A limited amount, less than 1%, is collected for industrial processing. Although some bales are made for bedding, their amount is a small, less than 10% of the total. And, after use, they are recycled back to the field. The 90%+ must be plowed under for planting to proceed on schedule, insuring the best yield, eliminating insects and disease harbored by the stover, and reducing the threat of alpha toxins in the corn.

Because of plowing, a carbon deficit occurs in the soil, losing more carbon than in the residue plowed under due

to the exposure of all the carbon sequestered in the soil to the atmosphere - contributing further to the greenhouse gas, CO_2.

Also, additional fertilizer is required for the stover. Its C/N ratio of 30:1 must be decreased to about 10:1, if no N is added. The cash crop harvest is significantly affected while the residue slowly decomposes. Again, much of the nitrogen is lost, when plowed, from the oxidation of the residue by the organisms when exposed to the atmosphere.

Innovative corn stover harvest, collection, and transportation practices have reduced the corn stover cost to $30 - $35 per dry ton delivered in western Iowa where 50,000 acres were collected in the 1997 crop year. Planned improvements in productivity and storage stability are expected to reduce costs to less than $30/ton.

The sustainable amount that can be removed depends on soil, topography, crops, crop rotation, tillage practice, and environmental constraints. Just 1/3 of the total corn stover converted to glucose with improved cellulase enzyme systems currently being developed result in 64 billion lbs., more than twice the sweeteners shipped by the corn refiners in 1997, based on 38% cellulose in the stover.

Corn stover also contains 32% hemicellulose. When converted to C5 sugar that has less human food value, the most likely future use is a nutrient for fermentation processes, with the largest being alcohol. By converting 80% of the hemicellulose into alcohol, and employing any of at least three engineered organisms presently being developed, 3.6 billion gallons of ethanol can be produced, again 2X the 1.3 billion gallons produced annually. The targeted cost is less than $1/gal.

CAUSES AND FACTORS AFFECTING THE LOW GERMINATION OF *STEVIA*

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Stevia rebaudiana Bertoni is a new crop that is getting world attention for its medicinal use as a non-caloric natural sweetener. Commercial production is limited due to extremely poor field stand establishment. At present, commercial propagation is accomplished by stem cuttings. The objective of this research study was to determine the causes and factors for low germination of stevia.

Initially, stem cuttings from established potted *S. rebaudiana* "Chinese" genotype plants were rooted and transplanted into 24-cm plastic pots. At blooming time, the plants were conditioned to bumble bee (caged), hand, and wind pollination treatments. "SR8" genotype was used as a source of cross-pollination. Also, plants were hand-selfed and a control group was established. The experiment was carried out under greenhouse conditions. Seeds were harvested by hand and separated by color: black and tan. The germination test was conducted under a fluorescent light and dark treatments at 24°C. The number of blossoms produced per plant was recorded. Data were collected and analyzed with five replications for germination and seed weight.

Black seeds clearly and consistently exhibited better germination than the control treatment across all treatment methods. Results showed an average of 85% germination for a composite of three cross-pollinated methods under fluorescent light treatment, whereas the tan seeds under similar conditions had 7% germination. Seeds germinated under darkness resulted in 56% germination for all cross-pollinated methods for the first seven days of germination. However, an additional five days were needed to improve germination to 73%.

When pollination treatments were compared, the control group showed the lowest germination and the seeds were all tan colored. The data suggest that pollination treatment is needed. Furthermore, it is unclear whether cross-pollination is better than self-pollination. Black seeds weighed 300 mg/1,000 compared with 190 mg/1,000 for the tan seeds. The relationship between the number of blossoms per plant and the percent germinable black seeds demonstrates that the fewer the number of blossoms per plant, the higher the number of black seeds produced, and a higher germination rate. However, the data showed that the highest actual yield of germinable black seeds is produced by plants having a medium number of blossoms.

THE YAKON COMES BACK

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The yakon (*Smallanthus sonchifolius*, Heliantheae, Asteraceae) is an ancient Andean root tuber grown from southern Colombia to northwestern Argentina. Unlike other crops, yakon remained restricted to the Andes after the Spanish conquest. Subsequently and particularly in the last century, its overall importance as a crop has been reduced in this region and disappeared from several areas. However, the trend appears to be reversing in recent years. Yakon clones were introduced into New Zealand in the seventies, gaining a small market niche. It was introduced from New Zealand to Japan in 1985 and later to Korea with similar results. In 1993, a clone from Japan was introduced to Brazil and gained acceptance by the Japanese community of Sao Paulo. The first large-scale farm was established in Brazil obtaining yields exceeding 100 t FW/ha. As a result of the success abroad, renewed interest in yakon has developed as a crop in the Andean region.

The main storage sugars in yakon are oligofructans. Due to its low calories and high fiber, yakon is an excellent diet and diabetic food. Traditionally, the root tubers have been eaten raw as a "fruit", sharing places with cherimoyas, avocados, and apples in the Andean peasant markets. In the last years, several processed products have been developed: pickled tubers, sun-dried chips, syrup, and marmalade. More recently, anti-diabetic properties have been demonstrated in the leaves used in herbal teas.

This paper will focus on the historical development of the crop and its potential and limitations in modern agriculture, from low-input organic farming to large-scale conventional agriculture.

PLANT POPULATION INFLUENCE ON GRAIN YIELD AND AGRONOMIC TRAITS IN GRAIN AMARANTH

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One of the constraints for the commercial production of grain amaranth (*Amaranthus spp*.) in the United States is the lack of planting equipment able to accurately meter the unusually small seed. Currently, the lowest rate of seed that can be applied is about two million seeds ha^{-1}. To aid in developing adequate planting equipment for grain amaranth, identification of the plant population that maximizes yield is important. Field experiments were conducted in 1991 and 1992 in western Nebraska to evaluate the effect of plant population on grain yield and agronomic components of grain amaranth. The amaranth cultivar 'Plainsman' (*A. hypochondriacus* x *A. hybridus*) was grown at plant populations of 2,000,000 (control), 1,400,000, 700,000, 350,000, 170,000, 85,000, and 43,000 plants ha^{-1}.

Plant population showed no significant effect on grain yield. The study suggests that grain amaranth may compensate for variations in plant population by allocating more energy to reproductive structures in the plant, reducing the effects of solar radiation competition, and developing reproductive secondary branches. Because of its adaptability, amaranth could be planted over a wide range of plant populations with the advantage of lower populations limited to savings in seed cost.

VARIABILITY IN *AMARANTHUS* SPP. CULTIVAR 'PLAINSMAN'

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A great deal of variation in 'Plainsman' (*A. hypochondriacus x A. hybridus*) cultivar, one of the most widely grown grain amaranths in the United States, has been observed in the field. The complexity of its reproductive system along with the breeding strategy employed in its development provided grounds to suspect that residual genetic variance is still present in Plainsman. The well-known phenotypic plasticity observed in the amaranth species might be causing such variation.

To gain understanding on the variability within Plainsman, 140 selfed families from a random sample of this cultivar were evaluated at three different environments in western Nebraska during 1995. Overall, a small amount of genetic variances was observed. Plant height showed the relative largest variance followed by grain yield. No genetic variance was observed in 1,000-seed weight. Broad-sense heritability estimates indicated a similar pattern. Given the size of the estimates, a homozygous genetic structure appears to characterize Plainsman. In contrast, a large amount of plastic variances was observed for the traits studied. Plasticity estimates were by far larger than broad-sense heritability estimates. The study suggests that variation in Plainsman occur mostly by phenotypic plasticity rather than genetic variability.

APPLICATION OF RANDOM AMPLIFIED POLYMORPHIC DNA MARKERS FOR IDENTIFICATION OF MARULA (*Sclerocarya birrea subsp.caffra*) GENOTYPES

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Marula (Anacardiacea) is a large dioecious deciduous tree endemic to Southern Africa. The yellow, plum-sized fruits are consumed fresh or processed into liqueur and nectar. The kernel is a source of high quality edible oil. Marula trees exhibit a high degree of morphological and physiological variability. Seed propagated plants and selected grafted clones have been planted at different sites of the Israel Negev for development of marula as a fruit crop for arid areas.

In the present study, we examined whether marula can be distinguished by randomly amplified polymorphic DNA (RAPD) analysis. Twenty 10-bp random primers were chosen to amplify 24 DNA samples isolated from different trees. Fifteen primers gave 2-11 bands from all templates, and of these, four primers gave bands that were unique to a subset of the trees. A single primer gave at least one unique band in 13 of the 24 genotypes. A unique pattern of RAPD bands for each individual tree was obtained using four primers. Vegetatively propagated grafts maintained the RAPD pattern of the mother plant.

Our results show that a high degree of genetic variability is present in marula underlying their morphological and physiological diversity. The ease of RAPD analysis suggests that this technique will become the method of choice for studies of marula varieties and for registration of proprietary cultivars.

CHEMICAL COMPOSITION AND NOVEL FOOD USES OF YACON

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The asteraceous root crop yacon (*Smallanthus sonchifolius* (Poepp. & Endl.) H. Robinson) is a vegetatively propagated domesticates of Andean South America. As one of the "lost crops of the Incas," it is mostly grown in its native range for subsistence. The sweet and crisp yacon roots are eaten raw and function as "fruits" in traditional food systems. Although it is declining in importance and only sporadically cultivated in the Andes, yacon is becoming increasingly popular in Brazil, Japan, Korea, and New Zealand. Although the fresh roots have high water content (86-90%), dry matter root yields are high (10-12 t/ha in 7-10 months growth period).

We determined the approximate composition of 10 clones representing the geographic range of the species. Compositional diversity was found low with 86-91% of the root dry matter accounted for by carbohydrates, of which 50-70% was oligofructans with an average degree of polymerization of 4-5. The more important non-fructan carbohydrates present in the fresh root are fructose, sucrose and glucose. The starch-free yacon root contains only traces of lipids and 2-4% of raw protein in the dry matter. With 0.2-0.3% of potassium in the fresh roots, yacon is an excellent dietary source of this mineral.

In recent years, entrepreneurial farmers have seized upon market opportunities and developed several attractive products through processing yacon roots. They include air-dried chips, which are similar in texture and taste to apple chips and with a pleasant resinous aftertaste. The roots can also be processed successfully into pickles, candies, and syrups. Interestingly, yacon leaves are also marketed as medicinal tea with putative benefits to diabetics. The existence of such products provides pointers for future yacon product development. High content of sweetening, yet undigestible, fructans in the yacon root fully justify its reputation as a diet food.

LOW INPUT AGRICULTURAL SYSTEMS BASED ON CACTUS PEAR (*Opuntia* spp.) FOR SEMIARID ENVIRONMENTS

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The biological productivity of semiarid lands is typically restricted by the amount of rain. Agricultural systems throughout the world rely on C4 and C3 plants. In Central Mexico, corn and dry beans have been the cornerstones for centuries. However, CAM plants can provide an opportunity to improve the productivity in these regions, due to their higher water use efficiency. Cactus pear, a perennial crop for fruit and fodder production, can enhance sustainability in the long term; however, its adoption as a sole crop during its establishment years represents a significant financial drain for the typical farmer of these regions.

The feasibility of intercropping common annual crops and cactus pear was studied in a series of field experiments conducted in Central Mexico from 1988 to 1995. The northern part of Guanajuato Research Station is located at the southern tip of the Chihuahua-Sonoran desert, characterized for its limiting rainfall pattern, 548?112 mm a year, shallow soils, the traditional cultivation of corn and beans, and the intensive overgrazed natural pasture.

By using the empty spaces between rows of a newly planted cactus pear orchard, up to 677 kg ha^{-1} of barley plus 377 kg ha^{-1} of canola seed, or 817 kg ha^{-1} of dry beans, or 7.45 t ha^{-1} of foxtail millet hay were obtained. Based on the barley/canola association as an example, and combining the income obtained from both grains, an estimated 40% of the initial investment in the orchard establishment can be readily recovered without significantly harming cactus pear growth. Yields were obtained in 1990 when the rainfall received in the experimental site totaled 497.8 mm, of which 89.5% was recorded during the growing season. Water usage was optimized by the introduction of simple water harvesting techniques such as tied-ridges and microcatchments.

The area is also prone to water shortages for irrigation purposes, so that the irrigation schedule was designed to cover the most critical stages of the dry bean crop, a staple food among Mexicans. When limited irrigation was provided to the system (10 cm at planting and additional 10 cm at flower initiation), up to 1.28 t ha^{-1} of dry beans were obtained, and approximately 25% reduction of the same annual crop without the competition of the perennial

crop. Yields of the intercrop decreased in the second year due to the lower number of rows that could be planted and also from the greater competition of the cactus plant. The cactus pear started bearing fruit in the third year, gradually becoming the main asset. Some additional advantages of the system are: better use of fertilizers and more efficient weed control between the rows of the perennial crop.

Other systems to produce fruit and pasture and mature cactus pear pads for fodder and/or tender pads for human consumption are discussed. The water harvesting practices, the associated costs and benefits in the short and long terms, and the overall crop management are described.

EDAMAME: A VIABLE VEGETABLE SOYBEAN

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Edamame soybean (*Glycine max* L.) has been used as a snackfood and vegetable in Asian cultures. It has potential in health food markets because of its high fiber and protein and low fat content. Soybeans have also been associated with lowering risk of certain types of cancers. Colorado State University began experimenting with edamame in 1991.

Production practices were similar to conventional soybeans until harvest. Initial trials were based on planting rates of 78 kg/ha with both furrow and sprinkler irrigation depending upon location. Harvest was accomplished using hand-harvest of green mature bean pods. Salable bean pods at a minimum of 9% Brix and consisting of two or more beans per pod without surface flaws (spots, scratched or tears) were weighed and used as yield per ha. Seed harvest was accomplished using a Mitsubishi BH208 bean harvester. Cut plants were windrowed on canvas tarps until 14% moisture was obtained and were then combined using a modified Hege B125 with an internal belt threshing system to minimize damage. Direct combining studies at Rocky Ford indicated that it was not feasible under normal environmental conditions (RH 18%, daytime temp. of 28-32°C).

Replicated trials in Ft. Collins, Rocky Ford, and Fruita, Colorado show edamame to be a viable alternative crop to conventional crops grown in these communities. Yields of salable pods have ranged from 3,525 to 7,350 kg/ha. Surface or furrow irrigation was found to be critical in reducing bacterial spotting on fruit. Sprinkler irrigation reduced salable pod yields by as much as 40%. Yield loss from single bean pods ranged from 18% in Rocky Ford and Fruita to 27% in Ft. Collins due to climatic variation.

Dry seed yields ranged from 1,870 to 2,540 kg/ha at 12% moisture. Seed quality was affected by timing of harvest. Threshing protocol was limited to the belt threshing system because conventional raspbar threshing caused extensive germination loss. Germination of belt threshed seed ranged from 45 to 80%. Raspbar combined seed ranged from 10 to 28% germination.

SUPPORTING THE DEVELOPMENT OF A NEW FRUIT CROP: DISSEMINATION OF INFORMATION VIA THE INTERNET ON HORTICULTURAL RESEARCH AND GENETIC RESOURCES FOR PAWPAW (*ASIMINA TRILOBA)*

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Development of a new commercial crop requires, among other things, research on cultural methods, breeding programs, and evaluation of suitability of cultivars. Kentucky State University (KSU) has had a pawpaw research

program in place since 1990. The goal of the program is to develop pawpaw as a new commercial crop. Objectives include: 1) horticultural research for developing new or improved methods of propagation; 2) collection, evaluation, preservation, and dissemination of germplasm; and 3) dissemination of information on pawpaw to scientists, commercial growers and marketers, and to the general public.

To aid in the dissemination of information, a web site is being developed that includes information on current and past pawpaw research at KSU and information on the PawPaw Foundation. On this site, a selected bibliography of publications will include pawpaw and related species, recipes and nutritional information, a guide to buying and growing pawpaws, results from regional variety trials, the database for the National Clonal Germplasm Repository for *Asimina* spp. located at KSU, and links to other web sites with pawpaw information. The exponential growth of public access to the Internet at home, in business, and in public libraries should greatly facilitate the introduction of pawpaw as a new, potentially high-valued tree fruit crop in Kentucky and the United States.

PRUNING IN ROSEHIP PRODUCTION

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Different pruning treatments were conducted on a two-year-old rosehip orchard (*Rosa rubiginosa*) during 1997. Shrubs were pruned on 24 June and 5 August in the southern hemisphere (36° 03’ S, 72° 06’W, 144 m below sea level). The pruning treatments for the one-year-old wood were:

1. No pruning

2. Pruning leaving five primary cane

3. Same treatment as (2) and cutting the top 10 cm of the primary cane.

A randomized complete block design with five replications was used.

The number of the primocane developed during the summer was higher in the pruned than unpruned plants, but without effect on its height. Fruit production was higher in the plants without pruning (0.67 kg/plant for the first date and 0.43 kg/plant for the second), but the harvest speed was the lowest (3.1 kg/h vs. 4.6 kg/h) for the check treatment. Fruit flesh thickness was higher in the pruned plants without affecting other parameters of fruit size. However, fruit quality (dried pulp yield of 25.1 to 26.6%) and fruit weight (1.072 to 1.202 g) were not affected.

OCCURRENCE AND PROMINENCE OF INSECT GUILDS ON CULTIVATED TREE SPINACH (*Amaranthus hybridus*: AMARANTHACEAE) IN THE CENTRAL FREE STATE, SOUTH AFRICA

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In the 1995 - 1996 growth season, 89 species of insects were sampled in direct association with cultivated *Amaranthus hybridus* (Amaranthaceae) at Tempe Airport, Bloemfontein in the central Free State province. These species comprise five feeding guilds, *i.e.*, chewers, suckers, predators, parasites, and tourists. The stems, leaves, seeds, and pollen of the plant are severely attacked by several species, of which the most injurious proved to be the amaranth weevil, *Hypolixus haerens* (Coleoptera: Curculionidae). Both the larvae and adults of these weevils attack the crop, with the endophytic, stem-boring larvae causing the most damage. Dominance structures and

prominence values of all the amaranth insects were analyzed and three phytophages, *viz.Astylus atromaculatus* (Coleoptera: Melyridae), a *Lygus* sp. (Hemiptera: Lygaeidae), and an unidentified Coreidae (Hemiptera) species, and a predator *Hippodamia variegata* (Coleoptera: Coccinellidae) proved to dominate.

An intricate weevil species complex comprising four *Baris* spp., in addition to three *Lixin*i spp., a single *Ceutorhynchini* sp., and a single *Aponinae* sp., are associated with amaranths. Investigation into the feeding preferences of these species revealed supplementary information concerning weevil life-cycle traits that should have noteworthy implications for amaranth cultivation.

INCIDENCE, MOVEMENT AND SEASONAL DISTRIBUTION OF TERRESTRIAL ARTHROPODS IN A STAND OF CULTIVATED *AMARANTHUS HYBRIDUS* (AMARANTHACEAE)

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The diversity within and invasion tempo into a vegetable amaranth monoculture of ‘terrestrial’ insects and other arthropods was studied for a period of eight months (November 1995 - June 1996) by means of a pitfall trapping program at a site 20 km northeast of Bloemfontein in the central Free State province of South Africa. Analysis of trap material yielded a diversity of 221 species, of which Coleoptera formed the dominant order with 127 species. Feeding guilds were also analyzed so that predators, which, together with parasites, form the potential candidates for biologically curbing insect herbivore damage to the plants could be identified.

Correlation of species diversity within guilds showed that predators consisting of Dermaptera (*i.e.* Forficulidae), Coleoptera (*i.e*. Cicindelidae, Carabidae, Coccinellidae, Histeridae, Staphylinidae and Anthicidae), Hymenoptera (*i.e.* Formicidae), and Araneae constitute 96 species (43.4%) of the total recorded, whereas phytophages (*i.e.* Coleoptera, Isoptera, Orthoptera, Thysanaptera and Hemiptera) constitute 94 species (42.5%). An approximately 1:1 ratio, thus exists between these two guilds, reflecting aspects of insect guild structure on cultivated plants that need further investigation.

The study site is, amongst others, surrounded by patches of natural veld and fallowland and the invasion tempo from each of these areas into the monoculture was high (*i.e.* 102 spp. and 13,419 individuals; and 87 spp. and 511 individuals, respectively). This phenomenon leads to the notion that such undisturbed marginal areas could act as insect reservoir refuges during periods of unfavorable environmental conditions. In this study, such a scenario could explain the high predator incidence. This also ensures early predator availability in the following growth season, bypassing the time lapse involved in population buildup, which is unavoidable under conditions of standard cultivation practices.

ROSEMARY: DEVELOPING A NEW FIELD CROP

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Recently, a novel method for producing antioxidants from Rosemary (*Rosnox*) was developed in Israel by the Analit Extracts Company. The antioxidants are used for extending the shelf life of products that contain oils or fats (food and cosmetic products), for preventing oxidation through assimilation into the semipermeable wrapping, as an addition to health foods, etc. The advantages of these materials over other existing antioxidants in the market today are the fact that they are natural, no danger to humans, inexpensive, and with improved effectiveness. These materials produced from Rosemary leaves in such a manner are unique.

Rosemary, a perennial Labiate plant, is generally grown in Israel in small fields of up to half a hectare per farmer and is used only as fresh spice branches. Producing enough raw materials for obtaining the antioxidants requires development of a large-scale cultivation of Rosemary or to rely on imports.

To get the maximum amount of antioxidants, we must have maximum dry matter yield and high concentration of the active materials. Therefore, the first stage was to select a line that embodies the highest concentration of antioxidants, approximately three times that of the standard lines and of imported Rosemary. The second stage of the agricultural work tested the following:

What are the best harvest dates for achieving the maximum yield of active materials?

What is the effect of plant population and irrigation amounts on yield?

Does leaf age have any significance on the concentration of active materials?

Hand-harvesting at different dates, sun-drying and hand-separating of the leaves, confirmed that the active components increased relative to the amount of water applied. As the harvest date was delayed, the plants became woody and the leaf percent of total vegetative material decreased. There was no effect of plant population on yield or on active material concentration.

An additional examination included hand-harvest according to height: the upper half and the lower half the plants with the same irrigation and population. The highest concentration of active materials was in the higher and younger part of the plant. Thus, harvesting young, fresh plants will produce higher vegetative yield, higher concentration of active materials and greater total yield of active materials per field unit. Irrigation of Rosemary (500 mm/y plus rainfall) is necessary, in the geographic region where the trial was conducted. Harvest can be made in early spring and toward the end of the summer. Plant population should be approximately 50,000 plants per ha. Field cost can be reduced by direct planting of cuttings 10 to 15 cm long obtained from the top of the plant.

GERMPLASM COLLECTION AND EVALUATION OF MACABO COCOYAM (*Xanthosoma sagittifolium* (L.) Schott)

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For many years, the production of macabo cocoyams (*Xanthosoma sagittifolium.* (L.) Schott) declined significantly in Cameroon and other macabo producing countries due largely to a root rot disease caused by *Pythium myriotylum.* This plant species is known to be an important food crop for more than 400 million people worldwide, especially in the tropics and subtropics. Between 1986 and 1994, the United States Agency for International Development (USAID) and the Government of the Republic of Cameroon (GRC) funded a Root and Tubers Research Project (ROTREP) in Cameroon. The main objective of the projects was to develop tolerant/resistant varieties with acceptable agronomic and sociological characteristics. Assemblage of cocoyam germplasm from different agroecological zones of Cameroon was a major part of the breeding program. Additional accessions were collected from other locations including Gabon, Ghana, and Puerto Rico.

Initial collections resulted in the identification of three types of cocoyams, "Yellow," "White,"and "Red." A fourth type "Jinika" was identified in later collections. All assembled genetic materials were then evaluated for growth and yield characteristics, overall yield, composition, and most important, their reaction to root rot disease in the field. Studies were also conducted on several aspects of the floral biology of the species and subsequently, the hybridization success among the different types of cocoyams was determined.

A total of 236 accessions were collected. As would be expected, significant differences were found among

accessions for petiole length; leaf, petiole and tuber protein content; tuber dry matter content, marketable cormel weight, seed size and 100-seed weight, and reaction to the root rot disease. Hybridization resulted in the production of 10,132 seeds from the "white" x "white" and "white" x "red" crosses. However, virtually no viable seeds were produced from the "white" x "yellow" or "red" x "yellow" crosses. These results indicate that there may be different ploidy levels for the various types of cocoyams with resultant gynodioecy and incipient speciation in the center of diversity for this species. We also found that a fungicide, Ridomil plus 72, was very effective in controlling the disease, but its cost may be prohibitive for the small-scale farmer. Therefore, a combination of cultural management and fungicidal application should enhance local production until tolerant/resistant cultivars are developed and released by the cocoyam breeders.

EVALUATION OF GERMPLASM AND IMPROVED CROP MANAGEMENT FOR TROPICAL LEAF VEGETABLES IN THE VIRGIN ISLANDS

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The increased consumption of new and exotic vegetables of tropical origin associated with the growing ethnic population in the U.S. has stimulated great interest for research among groups in the agricultural and scientific community. Tropical exotic and specialty green leafy vegetables are one major group of horticultural crops given attention in the past national symposia on new crops. These crops are mainly grown and consumed in the tropics providing most of the nutrients, particularly minerals and vitamins to the population. During the past five to eight years, the U.S. imported significant amounts of tropical green leafy vegetables and this trend will likely continue. Some of these crops can be grown in the U.S., but factors such as scarcity of seeds and planting materials coupled with inadequate information on cultural management practices, limit the production of these crops. The U.S. Virgin Islands has an ideal climate for growing tropical green leafy vegetables and production of these crops offers alternative marketing opportunities for the sluggish economy. Alternative crops, tropical and specialty greens will have good market potential to meet increasing demands in the U.S. Local growers will have better market advantage in producing these crops over common vegetables such as tomatoes, lettuce and cucumber because growers cannot compete for lower market price of these vegetables coming from the mainland U.S.

Research and development efforts on crop management and production practices for tropical leaf vegetables have been small. The objectives of this study are to: 1) collect and evaluate germplasm of minor tropical green leafy vegetables; 2) evaluate response of germplasm to growing environment; 3) develop sustainable crop management practices and cropping systems for improving yields and market potential; and 4) maintain germplasm collection of promising species for future research.

Over the past two years, close to 80 species and cultivars were collected and some have been field evaluated for growth, response to environment, and productivity. In 1996-97, 54 species and cultivars consisting of *Amaranthus sp., Celosia argentia, Basella sp., Corchorus sp., Ipomoea sp.* and *Brassica sp.* (Chinese cabbage and mustard) were field evaluated in replicated and non-replicated trials. Data were collected on leaf area index (LAI), plant height or vine length, fresh leaf and dry matter yields, flowering, pest and disease damage, and seed production. Most cultivars in the *Amaranth* group have poor plant vigor and were susceptible to damage by cutworms and leaf rollers (*Pyralidae sp.)*. Seed head formation was apparent in *Amaranth sp., Celosia sp.,* and *Basella sp.,* but not in the *Brassicae sp.* (Pakchoi, mustard and collard). The *Brassicae sp.* was more productive than others yielding more than 4,000 g m^{-2} of edible leaves, which is equivalent to 100-200 g m^{-2} d^{-1} of edible yield. High yields of this species are attributed to higher LAI, early and more frequent harvests compared with other species.

The trials indicate that under Virgin Islands conditions, the *Brassicae sp.* including the Oriental greens show potentials for adaptability and higher productivity. Crop management trials including plant spacing and fertilizer application are in progress to improve the yield of traditional species such as the local *Amaranth, Basella* sp., *Corchorus* sp., *Celosia* sp., and *Ipomoea* sp.

THE PAWPAW REGIONAL VARIETY TRIAL: BACKGROUND, RATIONALE, AND EARLY DATA

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In 1993, The PawPaw Foundation (PPF) and Kentucky State University (KSU) embarked on a joint venture to evaluate many commercially available named pawpaw [*Asimina triloba* (L.) Dunal] cultivars and PPF's advanced selections within and outside its native range.

Orchards for the Regional Variety Trial (RVT), consisting of 300 trees each, will be planted in 18 different locations from Fall 1995 through Spring of 1999. At each RVT site, eight replicate trees of each of the 28 grafted scion varieties will be tested in a randomized complete block design. Named varieties secured for testing include Middletown, Mitchell, NC-1, Overleese, PA-Golden, Sunflower, Taylor, Taytwo, Wells, and Wilson. The other 18 clones to be evaluated originated in PPF orchards at the University of Maryland Experiment Stations at Wye, MD, and Keedysville, MD. Seedling trees from local native sources were planted around the perimeter as a buffer against edge effects and to allow comparisons with local germplasm.

Identical orchards of the RVT are located in the following states: AR, IN, IA, KY (2 sites), LA, MD, MI, NE, NY, NC, OH, OR, SC, and TN (2 sites), the Chinese Academy of Forestry, Beijing, China, and the Chinese Academy of Sciences, Wuhan, Hubei, PRC. An orchard of nonidentical design is located in Tallahassee, Florida. Variables being studied in the trial include climate, culture, pests, growth, flowering, yield, and fruit characteristics.

Trees will be evaluated for several years for yield, year-to-year consistency, regional suitability, etc. At the end of the trial period, regional recommendations will be made. First-year field data will be presented and discussed.

POTENTIAL NEW CUCURBIT CROPS FROM NAMIBIA

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In Namibia, there are interesting wild members of the *Cucurbitaceae* that deserve special recognition for the contributions they might make to watermelon breeding. *Citrullus ecirrhosus* is an arid-zone loving perennial plant. It has recurved leaves along the margins that appear ribbed from above. The leaves have stomata on the top and bottom. The fruits are exploited by the bushmen for their seeds.

Citrullus lanatus is the other species. The wild members of this species have leaves with the top surface exposed. They inhabit slightly wetter areas of the dunes compared with the previous species. The fruit is greenish inside and has oil and protein rich seeds, which are also consumed by the bushmen. The flesh of both species is inedible due to the presence of cucurbitacins. These are very bitter and poisonous. The first species would seem to be suitable for providing drought tolerance. The wild *Citrullus lanatus* appears useful for providing green flesh to the cultivars. In Namibia, some natives cultivate watermelons, which have green parts on the edible flesh. Remarkably, the green fleshed character has not yet appeared in western or eastern cultivars.

Finally, efforts should be made to create exports based on *Acanthosicyos horridus*, a cucurbit that grows and contributes to the seawards dunes in Namibia. The fruit is bitter when young, but lose their bitterness when mature. At that time, the white fruit flesh changes into a mandarin-colored flesh, sweet, aromatic, and a food-reserve-rich flesh with highly nutritious oily seeds. The bushmen process both the flesh and the seeds. Opportunities exist for its use in ice cream manufacture, chocolate fillings, rice pudding, freeze-dried chocolate,

and cake flavorings. The seeds make excellent pumpkin or watermelon seed substitutes. They are thicker than these competitors and have a fine flavor.

PRODUCTION POTENTIAL OF POINTED GOURD IN TEMPERATE CLIMATES

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Pointed gourd (*Trichosanthes dioica* Roxb) is a tropical vegetable crop widely cultivated in the eastern part of India. It is commonly known in India by the name parwal. The plant is a creeping vine producing dioecious flowers and 5-16 cm long pepo fruits. It is a semi-perennial with a useful fruiting life of several years. The crop is usually propagated by vine cuttings or root-suckers. Its seed is not suited for propagation because of poor germination and difficulty in identifying the gender of vines before flowering. There is a niche market for the pointed gourd in the United States among immigrants from the Indian subcontinent. Because this vegetable is reputed to lower blood sugar, it may also attract buyers who need to lower their blood sugar. However, pointed gourds are currently not grown in the United States. Limited quantities are occasionally imported from the Caribbean and sold for premium in the metropolitan speciality vegetable markets. A need exists to develop an indigenous source. Pointed gourd may not be suited for production on large acreage because of the labor needed to pick the small-size fruits. However, small farms and part-time growers located close to metropolitan cities may find it economically rewarding to produce this crop.

This study was initiated during 1995 to determine the potential of producing pointed gourd in the temperate North American climate. Vines for establishing the study were procured from the Narendra Deva University of Agriculture and Technology, Faizabad, India with the help of the National Germplasm Resources Laboratory, Beltsville, Maryland. Vine cuttings were planted in pots in a greenhouse in September 1994 and kept under mist until roots formed. Plants were transferred to the field in April 1995. Field planting consisted of five female and one male row each 12 m long. Intra-row and inter-row spacings were 1.5 m and 1.8 m, respectively. Vines were trained on 3 m high fence-wire trellises. During the fall, vines were cut to ground level and covered with pine-straw for the winter. Data on winter survival rate, fruit number, and fresh and dry fruit weight were collected.

Findings during 1996 and 1997 are reported. The winter plant survival was 100%. Harvesting lasted for 15 and 17 weeks during 1996 and 1997, respectively. In 1996, the total number of fruits per plant, fresh fruit weight per plant, and total dry fruit weight per plant were 190, 5.0 kg, and 0.46 kg, respectively; and for 1997, 254, 6.5 kg, and 0.65kg. When the weight of fresh fruits per plant was converted to yield on a land area basis, it was similar or better than yields reported in the literature. Therefore, these results suggest that pointed gourd can be produced successfully in the southeastern United States.

FUNGI ASSOCIATED WITH DISEASED PISTACHIO TREES IN SOUTH AFRICA

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The cultivation of pistachio nuts in South Africa is a relatively new enterprise with vast economic potential. However, it is inevitable that pistachio cultivation will be faced with numerous disease problems in time. Many of the disease causing microorganisms of cultivated pistachio in other parts of the world will inevitably make their presence felt in South Africa as will new pathogens never recorded. The need to establishing a disease management program for this crop is clearly evident. The present investigation was undertaken to characterize the fungal microflora associated with diseased pistachio trees over six years.

In the spring of 1992, dieback of three-year-old *Pistacia vera* grafted onto *P. atlantica* rootstocks was first

observed in trial plantings in the district of Prieska, Northern Cape. Dying trees (foliage appearing chlorotic and wilted) were scattered throughout the plantings. Examination of these trees revealed cankers on the lower stems in the vicinity of the graft. A study was undertaken to characterize the fungi present and to test their virulence to three important *Pistacia* species.

Isolations from margins of diseased tissue onto malt-extract agar consistently yielded black fungal colonies and pycnidia bearing mature conidia. These were identified as the *Sphaeropsis* anamorph of *Botryosphaeria obtusa*. Branches, 5 mm in diameter, of *P. atlantica, P. vera*, and *P. integerrima* developed mean cambial lesions of 53, 51, and 15 mm, respectively, 14 days after artificial inoculation with mycelium of *B. obtusa*. Wounding of branches prior to inoculation resulted in larger cambial lesions ($P < 0.05$). As far as we could determine, there were no previous published reports of *B. obtusa* associated with disease of cultivated pistachio trees.

In the past five years, one- and two-year-old rootstocks of *P. atlantica* and *P. intergerrima* were frequently observed with cankers on the lower stem during the spring months. Diseased trees were examined in the laboratory for potentially pathogenic fungi. Of the cankers examined during this period, the most common fungi isolated were *B. obtusa* (55%), five *Fusarium* species (25%), *Fusicoccumaesculi* (anamorph of *Botryosphaeria dothidea*) (10%), *Cytospora* sp. (5%), and other fungi (5%). Other fungi included *Alternaria alternata*, *Phoma* sp., and *Chaetomium* sp. In inoculations conducted in the glasshouse, only *F. aesculi* proved to be pathogenic to *P. atlantica*. Mean lesion lengths of 40.6 mm were measured eight weeks after stem inoculations of potted plants that had a mean stem diameter of 6.7 mm. The consistent occurrence of *B. obtusa* and *B. dothidea* with diseased pistachio trees justifies establishing an intensive disease management program for pistachios in South Africa.

IDENTIFICATION OF THE KEY AROMA COMPOUNDS IN DRIED FRUITS OF *XYLOPIA AETHIOPICA* USING AROMA EXTRACT DILUTION ANALYSIS

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To determine the key aroma compounds of the dried fruits of *Xylopia aethiopica*, high resolution gas chromatography/olfactometry (HRGC/O) was applied to the aroma concentrate obtained by high vacuum distillation of an ether extract of the fruit material. Twenty-eight odor-active compounds were detected at the sniffing port and fully identified by using reference odorants. They were then ranked based on their flavor contribution by means of aroma extract dilution analysis (AEDA), a technique combining instrumental-chemical analysis and sensorial evaluation.

According to their high flavor dilution factors, 19 of the 28 volatiles were elucidated with the highest aroma activity. Linalool (flowery), trans-b-ocimene (flowery), a-farnesene (sweet, flowery), b-pinene (terpeny), vaniline (vanilla-like), and 3-ethylphenol (smoky, phenolic) were unequivocally identified as the character impact odorants by HRGC/mass spectroscopy and by comparison of the chromatographic, spectroscopic as well as sensory data with those of the synthetic reference compounds. Implications of these novel findings in food, medicinal, and perfumery applications are discussed.

USES AND CULTIVATION OF "YACON"(*POLYMNIASONCHIFOLIA* POEP ENDL.) IN BRAZIL

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Yacon is a species of Asteraceae family originating in the Andean areas of Colombia, Ecuador, Peru, Bolivia and northwest Argentina at altitudes between 2,000 and 3,100 m. It is also known as "aricoma" or "jicama" in Peru

and Ecuador, and "yacon strawberry" in United States. The species was introduced in Brazil about 1991 in Capão Bonito, State of São Paulo by Japanese immigrants who used the leaves and tuberous roots for treating diabetes and to lower blood cholesterol.

The perennial plant has a complex root system consisting of three parts: the tubers are rich in fructans and nondigestible fibers and can create a new plant; the absorbing and structural roots; and, the tuberous roots that are rich in fructans, succulent, translucent, with tasty juices. They grow up to 2 kg and are favorite for consumption. They contain high amounts of fruto-oligosaccharides with potential application for pharmaceuticals, diet products, and fructose syrup in the food industry. The University has done economic and agronomic studies on the yacon in Brazil.

ENZYMATIC PRELIMINARY STUDY FROM DEVELOPING AMARANTH (*A. Hypochondriacus* X *A. hybridus* CV. PLAINSMAN) SEEDS

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Amaranth is a pseudocereal with very interesting nutritional properties. Enzymatic pattern of amaranth has not been described and this study proposes to use it as a method to determine physiological maturity.

Several enzymes were extracted from amaranth seeds harvested between 5 and 75 days after anthesis (DAA) and separated by polyacrylamide gel electrophoresis (PAGE). Field design was a randomized complete block with four replicates. Peroxidase and a-esterase isozymes were detected during the grain filling period.

Both electrophoresis patterns showed that some bands between 27 and 32 DAA disappeared and others of lower mobility were detected. Such changes in peroxidase and a-esterase isozymic patterns coincide with the seed physiological maturity as previously determined through its moisture analysis.

NEW VALUE-ADDED PRODUCTS FROM THE ACKEE PLANT

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Ackee *(Blighia sapida* Konig.: Sapindaceae) is a fruit that forms part of the main dish in many Jamaican households. The fruit is exported as a processed food from Jamaica to countries such as Canada and the United Kingdom. During processing, large quantities of unutilized parts of the fruit are accumulated. This poses some financial losses and disposal problems.

Scientific investigations of the unutilized portions of the fruit and the leaves of the ackee plant have lead to the development of three value-added products. A specially formulated soap, a biopesticide, and a biofertilizer are products made from the unutilized parts of the ackee plant.

INVESTIGATING FEASIBILITY OF GROWING PHALSA (*Grewia asiatica* L.)IN TEMPERATE CLIMATE OF MIDDLE GEORGIA

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The phalsa (*Grewia asiatica* L., family *Tiliaceae*) is an exotic plant classified as a bush fruit. It is native to the south Asian region. Phalsa plants grow to be straggling tall shrubs with rough stem bark, alternate broad heart-shaped thick leaves, small yellow flowers, round small fruit drupes like blueberry, and purple or red in color when ripe. The ripe fruits are eaten fresh, in desserts, or processed into several refreshing and outstanding fruit and soft drinks mostly enjoyed during the hot summer months. Phalsa has short shelf life and, thus it is suitable only for the local market. The consumption of fresh phalsa fruit has cooling, astringent, and stomach effects. It has higher vitamin C content than the major fruits and has a pleasing flavor along with an acidic taste.

The unripe phalsa fruit, which alleviates inflammation, is advised for use in several health-related problems including respiratory, cardiac and blood disorders, and for fever reduction. Phalsa bark is used for a demulcent, febrifuge, and treatment for diarrhea. The root bark is used to treat rheumatism. Leaves are applied on the skin for controlling eruption and rash. The ether extract of phalsa leaves possesses antibacterial activities against *E. coli* and *Staphylococcus aureus*. The mucilaginous extract of phalsa bark is commonly used in north Indian sugar factories for clarification of sugarcane juice. The phalsa wood is elastic and strong and has many uses. The bark yields a fiber good for rope making.

Phalsa thrives well under many soil types and climatic conditions, but needs protection from frost. The deciduous plant loses its leaves slowly in areas with mild winters. It is readily propagated by hardwood cuttings and layering; however, seed propagation is preferable because the seedlings can produce a crop of fully-formed fruits in 12 to 15 months. The plant needs severe annual pruning. Because of its gradual and steady fruit ripening, it requires frequent pickings. Due to its stress tolerance and hardy nature, phalsa appears to endure neglect better than other hardy fruits.

At the Fort Valley State University Agricultural Experiment Station, we have been studying the feasibility of growing phalsa since 1994. Phalsa seeds obtained from India through the USDA Plant Introduction, and hardwood cuttings received from the USDA-ARS, Miami, Florida were established in the field plots in a cold protected house. Both the seedlings of Indian phalsa and the rooted cuttings of genotype from Miami have profusely flowered and fruited during the 1996 and 1997 summer seasons indicating a good production potential. We have observed phalsa bushes for plant establishment, plant growth and development, fruiting characteristics, and biotic and abiotic stresses. Efforts are also underway to use plant biotechnology to enhance cold hardiness of phalsa plants through *in vitro* regeneration and genetic transformation to generate uniform plants. We hope to see the successful and profitable growing of phalsa in middle Georgia to extend its benefits to the consumers and fruit growers.

EVALUATION OF *CITRULLUS COLOCYNTHIS*, A DESERT PLANT NATIVE IN ISRAEL AS A POTENTIAL SOURCE OF EDIBLE OIL

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Citrullus colocynthis (wild gourd) is a desert plant of the Cucurbitaceae naturally adapted to the arid environments. It was known in biblical times as a source of seed oil and its fruits were used as an efficient laxative.

Accessions were collected in Israel and evaluated as a potential oilseed crop adapted to arid zones. It was found that its oil composition is similar to safflower oil, with a total of 80-85% unsaturated fatty acids. A yield potential of 250-400 l ha^{-1} of oil was calculated. The best yield was obtained during the first four weeks of the 10-week maturation period. Yield potential should be estimated under desert conditions to evaluate the plant's economic future as a crop suitable for an arid environment.

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GENERAL CROPS

VERY OLD CROPS IN A VERY NEW MARKET: USING A SYSTEMS APPROACH TO INTRODUCE A NEW CROP

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The ethnic mix in the state of Massachusetts has changed considerably since the Pilgrims landed at Plymouth Rock in 1620. At different times, large populations of Irish, Italian, and Polish immigrants moved into the state. New immigrant populations of Puerto Ricans, Dominicans, and other Latinos now comprise 5% of Massachusetts. With the change in population mix, the demand for non-traditional food crops occurs at Farmers' Markets. The crops requested include calabaza (*Cucurbita moschata* (Duchesne) Poir), recao (*Eryngium foetidum* L.), rosita (*Solanum melongena* L.), and batata blanca (*Ipomea batatas*). Recao is more commonly known as spiny or Mexican coriander, rosita is a pink-fleshed eggplant, and batata blanca is a red-skinned, white- fleshed sweet potato. These crops have been grown and used in Puerto Rico since before the days of Columbus, but are new to the northeastern United States.

Two of these crops, calabaza and recao, were selected for a systems approach to introducing a new crop to the state. Several questions needed to be answered. Is the growing season long enough? What pests and diseases will attack the crops in a new environment and how will those problems be controlled? How should the crop be marketed? How do you let the Latinos know that the crops are now available at the market? How do you get non-Latinos to try the new crop? Are the varieties chosen appealing to the consumer? Do the crops have a nutritional or medicinal market? Are there opportunities for value-added products using these crops? Is there a wholesale outlet? Is there a competitive market outside the state?

The crops were grown in research plots and at 15 farms throughout the state. Various growing techniques were used to extend the growing season for recao and calabaza. The plots were scouted weekly by a professional Integrated Pest Management scout for incidence of diseases and insects. Batata blanca, rosita, and various beans were given to interested growers, but were not part of the research program to determine the appropriate cultural practices. Information about the crops was sent to growers through biweekly pest messages and personal contacts. Two extension field days were held at farms to exhibit the new crops and discuss cultural practices.

Once the crops were harvested, the Expanded Food and Nutrition Education Program (EFNEP) provided cooking demonstrations at three selected farmers' markets. Latino community groups advertised the "arrival" of the crops through various means. EFNEP workers and personnel from Tufts University surveyed consumers concerning the quality and flavor of the new crops; how/why they came to the farmer's market; and what they purchased while they were there. Three other farmers' markets had the crops, but no additional demonstrations or advertisements about the new crops were done.

NEW CROP TRIALS IN THE PATAGONIA REGION OF ARGENTINA

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This project began in September 1996 to evaluate the potential of several new crops in the Patagonia region of Argentina. Two locations were chosen for the plots. One is near Hilaro Acasubi in the southernmost part of the province of Buenos Aires, and the other near Choele Choel in central Rio Negro province.

The plots were sown by hand with no fertilizer or herbicides used. The spring seeding took place in November 1996 and 1997, and consisted of replicated plots of several potential crops: 8 varieties of crambe, 8 varieties of amaranthus, 7 varieties of quinoa, 2 varieties of milkweed, and one each of evening primrose, cuphea, chia, and grindelia.

The fall planting, which took place in February 1997 in Choele Choel, and March in Hilaro Acasubi, also was sown in replicated plots. The crops sown were: 4 varieties of lesquerella, 2 varieties of milkweed, and one variety each of kamut, meadowfoam, evening primrose, euphorbia lagascae, and grindelia. In addition, transplants of guayule, evening primrose, and grindilia were set out in March and April.

Results to date are encouraging. Yields of up to 2,400 kg/ha for crambe, 3,500 kg/ha for quinoa, 1,800 kg/ha for amaranthus, 4,150 kg/ha for evening primrose, 812 kg/ha for euphobia lagascae, and 288 kg/ha for meadowfoam have been measured.

The success realized during the first spring planting led to planting of a total of 27 ha of quinoa at two sites, to better evaluate the commercial potential of this crop in the region. Additional semi-commercial trials will be established in the fall.

PYRETHRUM: AN INSECTICIDE CROP FOR THE DESERT SOUTHWEST

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Among the botanically produced chemicals, pyrethrins, the six insecticidal esters synthesized by the pyrethrum plant [*Tanacetum cinerariifolium* (Trev.) Schultz-Bip.] rank as one of the most valuable plant-derived products. Pyrethrins are widely utilized as an insecticide in food production and in human and animal habitations because of its very low mammalian toxicity and the lack of residue problems. World production of pyrethrins has fluctuated greatly in recent years. The introduction of domestic production base for pyrethrins should help stabilize world supply, and facilitate broader uses of pyrethrin-based insecticides than are now possible.

A long-term breeding program in Arizona has resulted in the development of stress tolerant pyrethrin strains that produce economic levels of pyrethrins. Results of research leading to the successful mechanized planting, cultivation, harvest, and drying techniques are presented. Commercial pyrethrum production fields now have been established at several Arizona locations.

NEW FORAGE, GRAIN, AND ENERGY CROPS FOR THE HUMID LOWER SOUTH, USA

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The humid lower south (HLS) with its predominately subtropical climate with high rainfall and long warm

growing season offers opportunities for developing new crops of tropical origin. The rhizoma perennial peanut (*Arachis glabrata*) (RPP) is an excellent forage legume crop for pasture, silage, and hay for all classes of livestock. Two cultivars, 'Arbrook' and 'Florigraze' have been released for forage use. The perennial peanuts were propagated by rhizomes and now grown on about 8,000 ha in HLS with about 90% of this being 'Florigraze'. The RPP is very persistent and some plantings are over 20 years old. Hay yields of established RPP have ranged from 3.2 to 7 Mg ha^{-1} y^{-1} with 4 to 5 Mg ha^{-1} y^{-1} most common. The protein content of the hay ranged from 12 to 19% with 15 to 17% most common. The forage quality of RPP compares very favorably with alfalfa with the RPP having slightly lower protein, but higher energy content. The RPP with colorful yellow flowers has potential as an ornamental ground cover. Two introductions, PI 262839 and PI 262840, are being increased for release as ornamentals.

Pigeonpea (*Cajanus cajan*) genotypes have been developed for grain adapted to HLS growing conditions. Seed yields vary greatly with time-of-planting, location, and season from 1,000 to over 3,000 kg ha^{-1}. Two experimental pigeonpeas, FL 76WW and FL 99WW are being increased for release as cultivars.

The tall C_4 grasses, sugarcane and energycane (*saccharum* sp.), elephantgrass (*Pennisetum purpurem*), and erianthus (*Erianthus arundenaceum*) have dry biomass yields of 20 to 60 Mg ha^{-1} y^{-1}. These grasses are propagated by stem or root cuttings. The intermediate grass switchgrass (*Panicum virgatum*), is seeded, sustainable and gives dry biomass production up to 22 Mg ha^{-1} y^{-1}. A tall castor (*Ricinus communis*) produced oven-dry stem yields of 40 Mg ha^{-1} y^{-1}. Leucaena (*Leucaena* sp.) genotypes have persisted at Gainesville, FL for 20 years and the best genotypes have given annual dry biomass yields of 18 to 30 Mg ha^{-1} y^{-1}. Leucaena requires well-drained soils and likes soils with a high pH. It can be grown for annual biomass production or where winters are warm enough as a short rotation woody crop. Short rotation woody plantings can be made of *Eucalyptus* in peninsular Florida, and cottonwood (*Populus* sp.) and slash pine (*Pinuselliotti*) in the upper portion of HLS. These bioenergy crops are backstopped by wood residues from natural hardwood and pine forests. The crops gives the HLS great potential for bioenergy industrial development.

THE EFFECT OF RADIATION AVAILABILITY ON GROWTH OF *PROSOPIS* (MIMOSACEAE) SEEDLINGS

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Mesquite (*Prosopis* spp.) has a great potential as a multipurpose tree for agroforestry because it provides a wide variety of natural products. In Argentina, there are 29 species of *Prosopis* (algarrobo), six with potential for commercial cultivation, but information is lacking on several aspects of their propagation.

The objective of this study was to assess the effect of radiation on potential assimilation (Ap), the rate of leaf appearance (Lr), plant height (H), and biomass partition 60 days after seed germination. A factorial experiment with four species (*P. alba*, *P. chilensis*, *P. flexuosa*, and *P. glandulosa*) and three radiation levels (full-sun, 50% full-sun, and 20% full-sun) was established in a greenhouse (3 blocks and 10 reps/block).

Lr was not significantly affected by radiation ($P < 0.01$) although it was species dependant. *P. flexuosa* showed the highest Lr and *P. alba* the lowest (4.8 and 6.7 days/leaf, respectively, $P < 0.01$). Ap (recorded under full sun conditions) was not affected by radiation level or species. All the species (except for *Prosopis alba*) showed a similar response to decrease light availability significantly reducing above and below ground and total biomass ($P < 0.01$). *P. alba* leaf biomass was more stable to reductions in radiation than the other species. Species differed both in H and total biomass accumulated ($P < 0.01$). *P. chilensis* accumulated more leaf and stem biomass than the other three species. This resulted in significantly higher total biomass because root biomass did not differ among species. Overall, the shoot/root ratio was significantly higher for *P. chilensis* and *P. flexuosa* (large trees) than for *P. glandulosa* (shrub) and *P. alba* (tree) (2.6 and 2.3 vs. 1.8 and 1.4 respectively; $P < 0.01$). These ratios respond to plant architecture except for *P. alba*, that being a tree showed the lowest ratio. These results can be used to improve the production of *Prosopis* transplants in nurseries.

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GERMPLASM RESOURCE

EXPLOITATION OF INDIGENOUS PLANT GENETIC RESOURCES—ILLICIT OR LEGAL? A SOUTH AFRICAN PERSPECTIVE

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South Africa is considered to be a "hotspot" for biodiversity. Its flowering plants, in particular, are known worldwide, but large quantities of plants are also utilized in the traditional medicinal industry. An estimated 60% of South African people rely on this type of healing. The country is relatively poor in indigenous nutritive plants. There are some traditional edible varieties, but indigenous food comprises about 5% of the food intake of South Africans. Approximately 63% of the inhabitants of the country consume indigenous food as a small proportion of their diet. This includes foliage and tubers of *Amaranthus, Plectranthus* and *Solenostemon* species. In certain rural areas, these plants form the bulk of their diet.

Economic exploitation of 22,000 species of indigenous SA plants has only occurred on a limited scale in South Africa. The trade in traditional plants for cultural and medicinal uses has developed into a relatively large local informal industry due to urbanization. However, except for *Protea*, *Aspalathus* (rooibos), and *Cyclopia* (honeybush) tea, *Agathosma* (buchu), and the *Aloe* industry, no other successful export industries have been established. Foreign countries have in the past profited financially by exploiting South African plants with floricultural potential. Examples of these are freesias, gladioli, and gerbera.

The country today realizes the value of the large variety of plant genetic material and actual attempts have been made to protect and develop these natural resources for the inhabitants. The problem is to prohibit illicit exploitation of plant material, as well as other prejudicial actions. At present there is no official legislation, but a proposed law known as the "Protection of Indigenous Knowledge Act" is being prepared to advance the promotion and protection of indigenous knowledge. In the proposed act, reference is made to the illicit use and exploitation of indigenous food and medicinal plants, but floricultural products are apparently excluded. However, the act, for example, does not prohibit the exploitation of medicinal plants. On the contrary, the act attempts to promote and develop the use of indigenous medicinal plants. The primary aim is to ensure that the lawful owner is recognized in the development.

The proposed legislation will contribute to documenting indigenous knowledge. The act makes provision for cultures and customs related to food, production of traditional medicine from herbs or other sources, and fermentation techniques to be documented without giving away ownership. This aspect is invaluable in ensuring that the cultural heritage is conserved for generations to come.

Communities fear the illicit use and exploitation of indigenous knowledge by outsiders, resulting in most knowledge and especially indigenous medicinal plant knowledge being kept secret. The proposed act will allay fears because the law will now protect the individuals and communities. Protocol and guidance are available to assist communities in negotiations on use of indigenous knowledge. These developments will enhance the maintenance and availability of indigenous knowledge and will contribute to R & D, contributing to the African Renaissance, not only in South Africa, but the whole of Africa.

THE DYNAMIC ROLE OF NEW CROPS IN THE AGRICULTURAL ECONOMY - IS THE SUCCESS OF NEW CROPS PREDICTABLE?

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Emphasizing the value of new and lesser-known crops leads to two diametrically opposed reactions. Either we preach to the converted, and receive an enthusiastic response, or we are met with indifference. These responses are part of the system mechanics and interactions that lead to a dynamic flow of germplasm up and down the scale of economic importance over the years.

The present study attempts to quantify and model the dynamics of economic crops using New Zealand as a laboratory. New Zealand is a valuable case history for crop dynamics as it has a relatively short but well documented history of crop introductions and is well known for its development of some high value new crops. The paper presents the New Zealand case history, and suggests that the dynamics of crop boom and bust is predictable within the probabilistic framework of the particle attraction model of complexity. In this study, new crops include the completely unknown and never cultivated, as well as the species known in one area but developed in a new area or for a new use, and the minor crops, which are around but do not participate in the mainstream economy. Crop statistics can be compartmentalized into functional groups (e.g. timber, field crops, fruit) and each is shown to follow similar patterns of abundance distribution as the whole. The following numbers represent a grouping of all species-based statistics, which excludes areas sown in mixed pastures. Data on mixed pastures are not identified to species and are not amenable to this analysis.

In New Zealand, the ten highest ranking species, in terms of land covered in 1990, were radiata pine, barley, lucerne, Douglas fir, ponderosa pine, turnips, wheat, brassicas, peas and oats. Each of these species covered 1% or more of the cultivated land area. Only four of these (oats, wheat, turnips, barley) were important crops in 1891 (covering more than 1% and included in the top ten species). Of the next ten, each covering areas of 0.1% or more in 1990, five were covering 0.1% or more in 1891.

Out of the 20 major economic species of New Zealand today that account for more than 98% of the planted area, 11 had to be developed from "new" crops. They include the largest export earners renowned as examples of new crop development such as radiata pine and kiwi fruit, practically unknown in 1891. Conversely, of the 20 most important crops in 1891, eight are now minor crops. The turnover of the most abundant species is 3-33% per decade. Roughly one new species needs to be ready to become a "major" species every decade. Many more become economically important, although without reaching the top 20. This dynamic flow has been maintained in the past thanks to an open-ended reservoir of new "redundant" germplasm, which is thus more important than is implicitly assumed by public policy. This reservoir is made up of the global biodiversity. Indications are that with some variations in details, such dynamics occur around the world.

CONSERVING THE WILD RELATIVES OF CULTIVATED PLANTS NATIVE TO EUROPE

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Following a Colloquy on the "Conservation of the Wild Progenitors of Cultivated Plants" in 1989, the Council of Europe convened a Group of Experts to address the problems involved in conserving the wild relatives of native European cultivated plants.

One of the outputs of this Group was *A Catalogue of the Wild Relatives of Cultivated Plants Native to Europe* (Heywood & Zohary, 1995) that provides an initial survey of the wild genetic resources of European cultivated

plants. The catalog enumerates species and subspecies belonging to the following main groups of cultivated plants grown in Europe and also has their wild relatives on this continent.

In addition, the Group of Experts organized a series of three workshops whose aim was to combine the skills of conservation biologists, crop plant evolutionists, population biologists, biochemists, cytogeneticists, and molecular biologists, with those of conservationists, managers of protected areas, and gene bank managers and apply it to the surveying, conservation and management of the genetic diversity of the wild gene pools of the cultivated plants of Europe. The proceedings of the workshops were combined in a single volume: B. Valdés, V.H. Heywood, F. Raimondo, and D. Zohary (eds.), *Conservation of the Wild Relatives of European Cultivated Plants*. Bocconea 7. Palermo, 1997.

The Group of Experts is now associated with the DIVERSITAS program of biodiversity science as a European node of the Program Theme 'Conservation of the Genetic Diversity of Wild Species, Especially Those Used in Human Activities' (Convenor V.H.Heywood). It is planning to:

- build on the existing catalog by commissioning in-depth studies of the species concerned on a country-by-country basis
- extend the catalog to cover the whole of the Mediterranean Region
- prepare a set of guidelines for the conservation and sustainable use of European wild relatives.

THE MEDUSA NETWORK: IDENTIFICATION, CONSERVATION, AND SUSTAINABLE USE OF WILD PLANTS OF THE MEDITERRANEAN REGION

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A network on the 'Identification, Conservation and Use of Wild Plants in the Mediterranean Region', called MEDUSA, was formally established during the workshop on 'Identification of Wild Food and Non-food Plants of the Mediterranean Region' held on 28-29 June 1996 at the Mediterranean Agronomic Institute of Chania (MAICh). This network is currently (1995-1997 and 1997-1999) supported financially by the Directorate General I of the European Union, CIHEAM, and MAICh.

The objectives of the Network are:

- The identification of native and naturalized plants of the Mediterranean Region, according to use categories such as food, food additives, animal food, bee plants, invertebrate foods, materials, fuels, social uses, vertebrate poisons, non-vertebrate poisons, medicines, perfumery and cosmetics, environmental uses, and gene sources.
- The creation of a Regional Information System that will include: scientific plant name and authority, vernacular names, plant description, chemical data, distribution, habitat description, uses, conservation status, present and past ways of trading, marketing and dispensing, and indigenous knowledge (ethnobiology and ethnopharmacology), including references to literature sources.
- Preliminary evaluation of the conservation status and potential utilization in agriculture of these plants as alternative minor crops.

The network includes members who are representatives of International Organizations (CIHEAM-MAICh, IUBS ICMAP, FAO, IPGRI, LEAD) and form the Steering Committee, and representatives of Institutions from countries of the Mediterranean basin, acting as the Focal Point Coordinators. It is envisioned that the Network will include eventually members from all the Mediterranean countries, from relevant National Institutions, and from other International Organizations. Publications include a Newsletter and Workshop Proceedings.

NEWCROP: AN INFORMATION-RICH, WEB-BASED CROP RESOURCE

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NewCROP (New Crops Resource On-line Program) is a web-based internet resource emphasizing new and specialty crops developed by the Purdue University Center for New Crops and Plant Products to deliver instant topical information on crop plants. The home page address is "http://www.hort.purdue.edu/newcrop."

Linkage to crops is achieved by using a comprehensive index of plants listed by common and scientific names (CropINDEX) or via a search engine (CropSEARCH). The information on crops is based on FactSHEETS (in depth information prepared by crop experts), various crop monographs, published papers from the proceedings of the three previous national new crop symposia, and outside links to relevant sources. Herbs, spices, aromatic, and medicinal plants can be also searched separately (MedAroCROP).

Other useful databases include CropIMPORT-EXPORT (information on importation permits, phytosanitary certificates, quarantine, and inspection information), FarmMARKET (a listing of US farmers' markets), FamineFOODS (information on 1,250 species consumed in times of food scarcity), CropREFERENCE (crop bibliographies), CropEXPERT (directories of crops researchers and experts), and CropEVENTS (announcements of crop events and new crop newsletters and activities). An electronic bulletin board (NewCROP LISTSERV) is maintained for posting queries and messages to subscribers. The server is linked to other related websites and serves as a worldwide crop information network. Plans are underway to develop a location specific retrieval system to identify current and alternative crops. NewCROP currently serves more than 80,000 inquires (page hits) per month. Papers that will be delivered at the present symposium will be added to the web-site as soon as they become available.

NEW-CROPS STRATEGIC DEVELOPMENT ENTITY NEEDED[1]

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New-crops are not a panacea, but they have made major contributions to society. Farmers have needed profitable new-crop alternatives to surplus crops throughout U.S. peacetime history. Lack of options has had enormous economic, environmental, social, and political costs. Why have efforts during the past century failed to meet this need?

New-crops development is long-term and high-risk; and, the benefits often accrue to persons other than those making the initial investments. Thus, it lacks attraction for private investment. Because new-crops development benefits the nation in general, public resources are appropriate for its support. However, public resources commonly are allocated to special interest areas that have forceful representation -- and new crops development is not one of those areas.

Therefore, Congress needs incentive to legislate and fund new-crops R&D. Changes in farm programs made in the 1996 Farm Bill -- because of budget deficit pressures -- will increase farmer susceptibility to crop market prices. More than four million U.S. farmers (>70% of the total number), plus their families, have been displaced from the land since 1935. This is substantially because of insufficient economic opportunities, i.e., the lack of sufficiently profitable alternatives to the few major crops commonly produced in surplus. Economic costs and lost opportunities from not having developed profitable new crop options for farmers have been estimated to total as much as $932 billion, in 1995 dollars, for the brief period between 1978 and 1994.

Barriers to policy development include: a) the nature of the policy development process, b) agrarian myths, c)

special interests that compete with public interests for resources, and d) organizational cultures in the public-funded research communities.

Society is insisting that the agricultural research system become more responsive to its broader needs as contrasted with the narrower, more traditional focus on the ideology of production agriculture. Therefore, in the public interest, it is recommended that the United States Congress:

1. Make new crops development a national priority to improve U.S. farmers' sustainability and to enhance rural development.
2. Use legislative language that is new crops-development-specific to: (a) distinguish its intent from work on new uses of existing commodities, (b) to assure intended results, and (c) to guard against resource redirection or diversion - as has happened repeatedly in the past.
3. Create or modify an organizational entity - such as the proposed Thomas Jefferson Institute for Crop Diversification - to ensure the focused capability, responsibility, and accountability to: (a) respond to the unique needs, opportunities, and challenges of new crops development, and (b) compete with powerful established interest groups for public resources.

[1]Adapted (with RIRDC permission) from: Jolliff, G. 1997. "Policy consideration in new crops development," Proc. First Australian New Crops Conf. Rural Industries Research and Development Corporation (RIRDC).

CHALLENGES AND STRATEGIES IN PROMOTING CONSERVATION AND USE OF UNDERUTILIZED AND NEGLECTED SPECIES

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There is increasing interest in neglected and underutilized crop species (NUS) throughout the world, reflecting a growing trend within agriculture to identify and develop new crops for export and domestic markets. The FAO's Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture, which was adopted in 1996 by approximately 150 countries, identified the improved conservation and use of NUS as devoted one of its 20 main activities. Interest in NUS stems from a variety of factors, including their contribution to agricultural diversification and, better use of land, their economic potentials and the opportunities they provide for diet diversification. NUS are being often presented as new species although they have usually been used by local populations in traditional ways for many centuries. Their novelty, thus is not related to their introduction to new areas, but rather to the ways in which old and new uses are being readdressed to meet today's needs.

IPGRI has been concerned in improving the conservation and use of NUS, and has spearheaded, over the last few years, specific activities at national and international levels for the better conservation and use of these species. Collaborative works on a number of NUS-oriented Networks have been supported together along with the production of a series of monographs on selected NUS.

IPGRI's strategy for meeting the challenges of NUS promotion is based on the premise that the deployment of plant genetic diversity in agriculture will lead to more balanced and sustainable patterns of development. Because NUS may never command a large percentage of national resources and are often characterized by local specificity, they require a different approach from that used for other crops. Key elements of the IPGRI's strategy for NUS conservation consists in enhancing conservation by identifying specific indicators to measures threats of genetic erosion, promoting the interest of national programs and other agencies, and facilitating exchange of information and collaboration among interested parties. IPGRI is particularly concerned in developing general tools and methods for promoting conservation and use of NUS, which can be adapted to different contexts and enable national programs and local institutions to use them for those species to which they give priority.

AGROFORESTRY: A NEW CROP OPTION FOR MARGINAL FOOTHILLS OF THE PACIFIC NORTHWEST

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Thousands of acres of marginal foothill land in Oregon and other portions of the Pacific Northwest have few cropping options. Poor soils, steepness, and other problems have limited use to either grazing or timber production. Often, these sites are not considered optimum for these enterprises. Historically, these areas have been over-cut and over-grazed—not managed for sustainability.

For about eight years, the owner of Rising Oak Ranch has cooperated with the Extension Agriculture and Forestry faculty in creating an applied research and demonstration area to investigate a system that could provide sustainable and profitable use for the foothills—agroforestry. Rising Oak Ranch is located on the north side of Peterson Butte near Lebanon, Oregon.

Agroforestry is the planned combination of trees with one or more crops. Trees can generate large incomes, but take a long time to grow. Many landowners are, therefore, reluctant to plant woodlands. Combining trees with a crop that produces an annual income buys time for the landowner during the years when the trees are growing to marketable size. A landowner can provide an annual income, add value to their land through establishing timber, and can have larger profits as timber is harvested.

Silvopastoral agroforestry combines forage and livestock production with timber production. Agroforests may be established as new plantings or in older woodlands that are pruned and thinned to accept planted forages. Agroforestry represents a sustainable system to produce meat, wool, and timber.

To date, applied research at Rising Oak Ranch is examining the performance of three tree species in grid and cluster plantings; forage yields in new agroforests; and forage varieties appropriate for established agroforests. Tours of the site offer landowners a true "feel" for the potential for agroforestry on their land. Approximately 175 landowners have adopted this system during the past eight years. The projects at Rising Oak Ranch are demonstrating that the marginal foothill lands of the Pacific Northwest can provide a profitable and sustainable system.

EUPHORBIA TIRUCALLI, AN UNKNOWN PLANT WITH HIGH POTENTIAL IN ARID AND SEMIARID, AND MARGINAL ZONES

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During the eighties, the quest for alternative and renewable energy resources led us to investigate the potential of *Euphorbia tirucalli* to grow and perform in marginal, and arid to semiarid environments. This Euphorbiaceae member that has its center of origin in Eastern Africa is rich in latex, which contains hydrocarbons that form an almost a direct source of gasoil for engines and energy. The plant, however, is also a rich source of biomass that can be converted into methane.

The plant's ecophysiological traits and salinity/drought tolerance were tested in the field (Kenya) and the laboratory (Belgium). Research concentrated on gas exchanges (CO_2 and H_2O) and osmotic agents involved in plant water potential relations. It was found that *E. tirucalli* is an almost unique plant in that it combines succulent

CAM stems and C3 leaves, which explains its high Water Use Efficiency and Relative Growth Rates. This latter factor makes it an ideal candidate for biomass production in marginal areas, i.e., low fertility, high aridity, and low input agriculture, as research showed that the plant does not need additional fertilizers to grow well.

USING A GEOGRAPHIC INFORMATION SYSTEM TO IDENTIFY AREAS FOR ALTERNATIVE CROPS IN THE BIGHORN BASIN, NORTHWESTERN WYOMING

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The Bighorn Basin in northwestern Wyoming is an important agricultural region that relies heavily upon irrigated crop production. To promote expansion of economic prospects within the Bighorn Basin, the feasibility of growing alternative crops was explored. Currently, the dominant crops in this region are sugar beet, alfalfa, and edible beans. Diversification of agricultural cropping systems both within the Bighorn Basin and Wyoming is important for enhancing the state's economy. Some potential alternative crops investigated in this project include safflower, grapes, canola, Kentucky bluegrass, and faba beans.

A Geographic Information System (GIS) is an automated system used to display, analyze, manipulate and construct digital data. GIS can be used to combine spatial data to identify areas with unique combinations of characteristics for enhanced land use. The objective of this project was to compile environmental parameters into a GIS (ARC/INFO) database. First, a soil series data layer was developed for the study area. A predictive model of soil occurrence was described through the evaluation of a detailed soil survey for part of the study area. The model, which was based on surficial and bedrock geology, was used to predict soils for the entire study area. The soil map was then ground-truthed and adjusted to improve the accuracy of the soils data layer. Second, monthly mean and minimum summer temperatures, precipitation, growing degree days, frost free season, and number of days exceeding 32°C were obtained from 18 weather centers in and around the Bighorn Basin, where 30-year averages have been collected by the National Climate Data Center. The point data from the weather stations were extrapolated using geostatistics to develop continuous climate data coverages for the study area.

A literature search was done to identify growth parameters required for implementing the use of alternative crops. Areas suitable for the production of new crops were delineated through the combination of crop growth parameters and environmental conditions of the study area. Maps depicting areas where new crops could be cultivated will be displayed. In addition, the Land Evaluation and Site Assessment (LESA) system developed by the Natural Resource Conservation Service for rating agricultural land suitability was implemented in this study to demonstrate its applicability in the Bighorn Basin. A parcel of land was selected to illustrate the use of the LESA rating system for lands now in agricultural production in the study area.

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GUAYULE

A SIMPLIFIED PROCEDURE FOR GUAYULE MICROPROPAGATION

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Evaluation of the performance or yield of a particular line or cultivar often requires large numbers of genetically identical plants. Although guayule (*Parthenium argentatum*) is a prolific seed producer, its apomictic nature, and problems associated with direct seeding, present obstacles for producing and evaluating large numbers of plants. Micropropagation through tissue culture offers an alternative method for production of clonal material from improved or genetically engineered plants. Procedures for micropropagation of guayule through *in vitro* multiplication of shoots followed by rooting and subsequent acclimation of plantlets have been reported by Trautmann and Visser (1990) and also by Pan *et al.* (1996). We report modifications to these methods, which improve shoot proliferation and simplify the protocols for both rooting and acclimation of plantlets to greenhouse conditions.

Shoot cultures of guayule line N6-5 and the hybrid line AZ101 were established as described by Pan *et al.* (1996) and were maintained on a modified shoot multiplication medium (MS + 3% sucrose + 1 mg/l BA + 25 mg/l NAA) that reduced anatomical abnormalities. Rooting was induced by a single overnight treatment with 1/2X MS medium containing 100 mg/l of the auxin IBA. After the auxin treatment, shoots were inserted into cellulose plugs in sterile ventilated trays containing 1/2X MS medium without growth regulators. The use of cellulose plugs instead of agar-solidified medium for rooting eliminated the need to extract rooted plantlets from culture tubes and remove the agar from the roots before potting. With this method, root formation occurred on 70-100% of the shoots within 10 -20 days. Similar percentages were attained by Pan *et al.* (1996) only by strict adherence to the complicated anatomical criteria required to select and excise shoots capable of root formation. After three weeks, the rooted plantlets were transferred directly into pots containing a cactus-mix potting medium and placed in the greenhouse. Acclimation was achieved by covering the plants with a clear plastic tent for two days, followed by daily watering for one week and three times a week thereafter. Our method considerably shortened the acclimation process, presumably due to a combination of lowered humidity levels in the ventilated rooting trays and minimal disturbance of the established root system during potting.

LATEX QUANTIFICATION IN GUAYULE SHRUB AND HOMOGENATE

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Commercial development of hypoallergenic latex from *Parthenium argentatum* (Gray) for the manufacture of latex medical and household goods, is hampered by the lack of specific knowledge on the best lines, agronomic practices, and storage conditions for the generation of maximal latex yield. These factors all depend upon reliable plant latex content analysis. The objective of this study was to develop a rapid latex quantification procedure for shrub and shrub homogenates, and to confirm its accuracy with tissue balance analysis. The reproducibility of two variations of this basic method was determined by analysis of identical homogenates by researchers in Albany and Phoenix. Also, we describe a latex extraction process that parallels the proposed commercial extraction process, and discuss possible evaluation protocols for alternative methods.

Our results show that both quantification method variations produced comparable results at the two laboratories. However, one variation is faster and less variable than the other, but requires a bucket microfuge rotor. The faster method also can be used on smaller samples than the other, and should prove useful for screening young plants or parts of the guayule shrub. We also show how an adaptation of this method can be used to quantify latex in materials with unusually low latex contents. For both variations of the method, centrifuge heads with large numbers of sample holders increase the speed of analysis where multiple plant materials are involved.

The latex content of homogenates produced by two different extraction techniques was also compared, using both variations of the latex quantification method. In one technique, guayule branches were cut into 1-cm length,

placed into extraction buffer within 5 min, and then homogenized using a Waring blender. In the second technique, similar branches were cut, and stored overnight at 4 ?C. These were ground in an Oster blender for latex extraction. The Waring blender homogenate yielded higher latex than the Oster. Additional experiments demonstrated that this discrepancy could be overcome by increasing the grinding time of the Oster blender. We found that the Oster (18,000 rpm) had a lower blade rotation than the Waring (22,000 rpm) blender. Thus, it is apparent that the blender extraction method can introduce large differences in the amount of extractable latex, primarily due to insufficient tissue disruption during grinding. We must know the grinding capabilities of the different blenders used and adjust the procedure properly to insure that the latex analytical results from the various laboratories are comparable.

Homogenate preparation is the most time consuming step in latex quantification. It requires 20 min to process one analytical set of shrub material with one blender. However, where a large amount of plant materials must be analyzed, the overall analytical process can be shortened by using multiple sample centrifugation and by running several blenders simultaneously.

STABILITY OF GUAYULE LATEX IN STORED BRANCHES AND HOMOGENATES

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Reports indicate that the total rubber content and the latex rubber fraction of harvested guayule decrease during storage. Factors affecting the stability and extractability of the latex fraction need to be understood in order to maximize latex yields. The objectives of this study were to examine the effects of long-term storage on the stability of the latex in branches and in homogenates prepared from them.

Latex content was quantified in fresh homogenates made from three different sizes of branches (small $\leq$ 0.5 cm, medium > 0.5 to $\leq$ 1.0 cm, large > 1.0 cm diameter) stored at 4°C, and in homogenates stored at room temperature, using the microfuge method described in another poster by these authors. Total rubber and resin contents of branch and bagasse were determined by homogenizer solvent (acetone and cyclohexane) extraction.

Irrespective of storage time, the medium-size branch consistently had the highest content of extractable latex. The stability of the latex and solid rubber components in intact guayule branches was dependent upon of the size of branches stored. After two weeks of storage, the proportion of rubber extractable as latex was similar in all three branch sizes. By five weeks of storage, the latex percentage had declined in all three branch sizes, but to considerably different extent. This was not the result of dehydration during storage, because the branches absorbed water during storage. The largest branch showed the greatest decline in extractable latex but this decline was balanced by an increase in the total rubber in the tissue, and thus an increase in the solid rubber component, rather than by rubber degradation. In contrast, the decline in latex extractable from the smallest branch paralleled a loss in total rubber, although it was not possible to determine whether this loss reflected degradation of either or both the latex and solid rubber pools in the branches. The smaller loss of latex from the intermediate-size branch also was largely balanced by a loss in total rubber. Also, we found that the amount of resin extracted from the guayule shrub along with the latex was disproportionally less than the latex. Thus, the latex has a lower resin content than might be predicted from the resin levels in the intact shrub.

Latex stability in filtered homogenate was investigated by storing homogenate from shrub of three different branch sizes ground for 60 s in a Waring blender, and also from a second grind of the bagasse from the first grind. Homogenates were stored at room temperature and maintained at pH 10, and aliquots were periodically sampled and quantified. The latex content of the first-grind homogenates showed little decline over 25 weeks. However, the stability of the latex in the twice ground material remained stable for four weeks, and then rapidly declined to approximately 20% of the starting concentration. Additional storage experiments on homogenates of guayule shrub eliminated pH and grinding duration as factors in the observed instability. However, homogenates diluted to

less than 5 mg/ml showed a decline in the latex concentration over time, suggesting that concentration may be critical to latex stability in stored homogenate.

In conclusion, harvested guayule branches can be stored only for a limited time without compromising latex yield. Homogenate, however, can provide a stable environment for latex.

NATURAL REGENERATION OF WILD GUAYULE SHRUBS AFTER CUTTING

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During the late seventies and early eighties, native guayule shrubs were cut and processed for rubber extraction. The cuttings decreased the number of plants in the area, particularly those taller than 60 cm. The cut plants were allowed to regenerate naturally since 1984. The present paper evaluates the shrub density, and the rubber and resin contents reached from harvest to present in the wild stand. No previous data on density and rubber content in regenerated wild stands have been found.

The wild stand studied is located near Saltillo at the Gomez Farias area. Shrub density and spatial pattern distribution were estimated by size classes. Plant heights were determined. To measure the rubber and resin contents, plants with different stem diameters ranging from 2-3, 1.5-2, 1-1.5, and 0.7-1.0 cm. were collected and separated into 4-5 sections depending on the number of branches, including the root system. The sections were dried, weighted and chopped for quantitative analysis. Resin and rubber were measured by Soxhlet extraction.

Total dry weight for the 2-3 cm stem diameter was between 39-145 g, for the 1.5-2.0 cm from 28-102 g, for the 1.0-1.5 cm from 26-48 g, and for the 0.7-1.0 cm from 9-21 g. The weight of the crown for the first-year, second-year, and third-year branches varied depending on the plant. Rubber and resin contents correlated with these data.

IN VITRO CHARACTERIZATION OF APOMICTIC REPRODUCTION IN GUAYULE

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Guayule (*Parthenium argentatum* Gray, Asteraceae) is a latex-producing perennial desert shrub that is potentially of economic importance as an industrial crop for the desert Southwest. It is known to possess complex reproductive modes. Diploids are predominantly sexual and self-incompatible, whereas polyploids show a range of apomictic potential and self-compatibility.

This paper describes the development of a relatively rapid and simple technique for characterizing reproductive modes of breeding lines of *P. argentatum*. Initial field experiments were based on an auxin test used successfully to characterize reproductive mode in the Poaceae. The application of 2,4-dichlorophenoxyacetic acid inhibited embryo formation in *P. argentatum*, but this was not the case with other auxins tested.

Results of field experiments were ambiguous because: 1) the floral structure of *P. argentatum* is such that auxins might not have penetrated to the ovules, and 2) there was potential self-fertilization by pollen released within isolation bags. Therefore, *in vitro* culture of flower heads was tested because it provided much better control of environmental conditions, growth regulator application, and pollen release. Auxin alone, or in combination with

gibberellic acid or kinetin, inhibited parthenogenesis *in vitro*. Embryo production did not vary using two substantially different nutrient media. *In vitro* flower head culture using a (Nitsch and Nitsch) liquid nutrient medium without growth regulators enabled characterization of the reproductive mode of seven breeding lines, ranging from predominantly sexual to predominantly apomictic. The results of this technique were substantiated using RAPD analysis of progeny arrays from controlled crosses.

AGROBACTERIUM TUMEFACIENS-MEDIATED TRANSFORMATION OF GUAYULE LEAF EXPLANTS

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Guayule (*Parthenium argentatum*) has been promoted as a source of hypoallergenic natural rubber. However, despite years of plant breeding, commercial lines average about 10% rubber content. To increase commercialization of guayule cultivation and guayule natural rubber, we propose to increase the amount of rubber produced in guayule by using genetic engineering.

Pan *et al.* (1996) have described a method to transform guayule using *Agrobacterium tumefaciens*. While we have successfully employed the published method to transform guayule using *Agrobacterium* infection of shoot axillary meristem wounded with a 23-gauge needle, we have devised less labor intensive process where chopped leaf explants are infected with *Agrobacterium*, followed by regeneration of shoots on selection medium. Prior to *Agrobacterium* treatment, the leaf explants are cultured for four days on shoot regeneration medium lacking antibiotics (MS + 4 mg/l BA + 0.1 mg/l NAA + 200 mg/l glutamine). Following co-cultivation on shoot regeneration media lacking antibiotics, the explants are transferred to shoot regeneration medium containing 50 mg/l kanamycin and 500 mg/l carbenicillin. The regenerated shoots are transferred successively thereafter to shoot multiplication medium + kanamycin (MS + 1 mg/l BA + 25 mg/l NAA + 50 mg/l kanamycin) and then to rooting medium (see Pan *et al*.) before planting in the greenhouse. Transformants are verified by DNA gel blot hybridization. This method has been employed on *P. argentatum* lines N6-5 and G7-11 and the hybrid line AZ101.

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HERBS

GENETIC CONTROL OF THE FORMATION OF REBAUDIOSIDES A AND C IN THE SWEET HERB *STEVIA REBAUDIANA*

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Stevia rebaudiana Bertoni produces, in its leaves, steviol glycoside sweeteners that are up to 240 times sweeter than sugar. In addition, the sweet steviol glycosides have functional and sensory properties superior to those of many other high potency sweeteners. If stevia is to become a major source of high potency sweetener for the growing natural food market in the future, it must be converted from a wild plant to a modern crop well suited to efficient mechanized production.

One step along that path is a breeding program aimed at optimizing not only agronomic performance, but also glycoside content and composition. Rebaudioside A is considered to be the most commercially desirable of the seven steviol glycosides known to occur in stevia leaves. Steviol glycosides are derived from the mevalonic acid pathway, which is involved in the synthesis of all isoprenoid compounds. The biosynthetic sequence of glycosylations that gives rise to the different glycan side chains is still in the early stages of elucidation. Understanding the genetic control of sweet glycoside composition is an essential step in the development of an effective long-term strategy aimed at its manipulation using plant breeding.

The experiments conducted in this study were focused on the genetic control of the proportions of rebaudioside A and rebaudioside C. Using crosses between two sets of parents with divergent glycoside profiles and analysis of the resultant F_2 populations, we found that the presence of rebaudioside A is controlled by a single dominant gene. The proportions of rebaudioside C were shown to be controlled by a single additive gene.

YIELD AND COMPOSITION OF CORIANDER (*Coriandrum sativum* L) ESSENTIAL OILS RELATED TO SOIL ENVIRONMENT AND WEED COMPETITION

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When environmental conditions are favorable, vegetative growth generally receives resource priority over secondary metabolism and storage.

The objectives of this work were to study the effects of different soil environments related to agricultural use, N availability, and weeds, and on the production and composition of volatile terpenes in two genotypes of coriander with different potential for essential oil production.

A field experiment was carried out at Bs As, Argentina (34° 33' S, 60° 59' W). A factorial randomized design with three replications was used. The factors were: soil degradation level (high and low, defined considering the number of years under agriculture and aggregates stability); genotypes (high potential 2% (HP) and low potential 0.5% (LP) of essential oils production), N availability (control and fertilized with 125 kg N/ha), and weeds (without weeds and 50% cover with weeds). Essential oils extraction was carried out by hydrodistillation using a Clevenger glass apparatus. Oil composition was determined by gas chromatography. Yield data were analyzed by ANOVA, and composition by cluster and principal component analysis.

There was an interaction between degradation and fertilization in essential oils production ($P< 0.03$). In the soil with low degradation, HP produced a lower percentage of essential oils than in the soil with high degradation, and no differences between degradation treatments were observed for LP. Classification of volatile terpenes showed two main groups: genotypes HP and LP, and two subgroups related to high and low soil degradation. Separate ordination of each genotype showed that the genotype LP presented in axis 1 (eig 86% of variation) a contrast between fertilized and control treatments. Gamma terpinene and alpha pinene were positively correlated with axis 1 (r = 0.82 and 0.88), and linalol was negatively correlated with axis 1 (r = -0.99). A contrast between low and high soil degradation appeared in axis 1(eig 89.7% of variation) for HP genotype. Gamma terpinene and alpha pinene were positively correlated with axis 1 (r = 0.85 and 0.97, respectively), and linalol was negatively correlated with axis 1 (r = -0.99).The percentage and composition of essential oils production were not affected by the presence of weeds.

When soil quality was high (related to high N availability or low soil degradation), the linalol concentration was favored (from 74 to 81% for LP and from 68 to 77% for HP), and gamma terpinene (from 6 to 4.2% for LP, and from 6 to 3.3% for HP), and alpha pinene (from 5.7 to 3.1% for LP, and from 7.3 to 3.6% for HP) concentrations

were decreased. These results show that environmental soil conditions (related to soil degradation and N availability) can affect the essential oils production and quality in the coriander crop.

AN ON-FARM EVALUATION OF SUSTAINABLE HERB PRODUCTION FOR SMALL FARMERS IN THREE STATES

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Fifteen species of herbs common to the botanical trade and adapted for the temperate climate are under farm-level evaluation in New Jersey, North Carolina, and Missouri. The purpose is to ascertain whether cultivation of the botanicals can be economical for small farmers seeking to diversify their income. The cultivation techniques used are typical of vegetable crop and ginseng production, but adapted to the land and equipment of the specific farm. Capitalization costs are being reduced by integrating the production into the farmers operation and sharing of specialized planting, harvesting, and drying equipment.

The species under cultivation are black cohosh (*Cimicifuga recemosa*), burdock (*Articum lappa*), dandelion (*Taraxacum officinale*), *Echinacea spp*. (*angustifolia, pallida, purpurea*), feverfew (*Tanacetum parthenium*), goldenseal (*Hydrastis canadensis*), nettle (*Urtica dioica*), St. John's wort (*Hypericum perforatum*), skullcap (*Scutellaria lateriflora*), valerian (*Valeriana officinalis*), vervain (*Verbena officinalis*), wild quinine (*Partenium integrefolium*), and yellowdock (*Rumex crispus*). Data are being recorded on production costs, crop yield and market price, characteristics of dried botanical quality, winter survival, and production cycle length. Other influential factors under observation are ease of integration with current farming practices, weed control without herbicide use, and mechanization techniques to reduce labor requirements.

CULANTRO (*Eryngium foetidum* L.): A MUCH UTILIZED BUT LITTLE UNDERSTOOD HERB

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Eryngium foetidum L, culantro, is a biennial herb indigenous to continental tropical America and the West Indies. Although widely used in dishes throughout the Caribbean, Puerto Rico, and Mexico, culantro is relatively unknown in the United States and many other parts of the world and is often mistaken and misnamed for its close relative cilantro or coriander (*Coriandrum sativum* L.). Some of its common names descriptive of the plant include: spiny or serrated coriander, shado beni and bhandhania (Trinidad and Tobago), chadron benee (Dominica), coulante (Haiti), recao (Puerto Rico), and fitweed (Guyana).

Culantro belongs to the parsley family Apiaceae (or Umbelliferae). It grows naturally in shaded, moist heavy soils near cultivated areas. Under cultivation, the plant thrives best under well irrigated shaded conditions. Culantro, like its close relative cilantro, tends to bolt and flower profusely under hot, high-light, long days of the summer months. Recent research at UVIAES has demonstrated that it can be kept in a vegetative mode through the summer when treated with GA_3 sprays.

The plant is reportedly rich in calcium, iron, carotene, and riboflavin. Its leaves are widely used as a food flavoring and seasoning herb for meat and many other foods. Its medicinal values include use as a tea for flu, diabetes, constipation, and fevers. One of its most popular uses is in chutneys as an appetite stimulant. The name fitweed is derived from its supposedly anti-convulsant property. The increasing West Indian and Latin-American immigrant communities in the U.S., Canada, and the UK represent a growth market for culantro. Large quantities of culantro are exported from Puerto Rico and Trinidad to these areas.

BASIL: A SOURCE OF RAW AROMA CHEMICALS AND A POPULAR HERB FOR THE CULINARY AND ORNAMENTAL MARKET

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Basil (*Ocimum* spp.) is one of the most popular culinary herbs in North America and is sold as a fresh-cut and dried processed product. Although cultivars have been developed specifically for the fresh market, the more than 60 available cultivars also include many that are primarily used as ornamentals (garden plants), and others that can serve as sources of raw aroma chemicals.

More than 80 available varieties of commercial basils were field-grown and comparatively evaluated for their horticultural attributes, commercial potential, and essential oil yield and composition. Purple pigmented basils were analyzed for anthocyanins. Basils could be grouped based upon their horticultural use(s), and varied greatly in growth and productivity. Basils could also be grouped based upon the aroma and chemical constituents in the essential oils.

Basil plants were identified that looked identical yet contained distinct aromas, whereas other plants that differed morphologically could also exhibit similar aroma profiles. Plants that were rich sources of linalool, methyl chavicol, camphor, citral, geraniol, and other volatile compounds were identified. From this large collection, some of the same varieties from different seed sources exhibited phenotypic variations, whereas several different named varieties from among the seed sources phenotypically appeared to be the same variety, but with a different name. Purple basils contained very high concentrations of anthocyanins and an abundant source of acrylate and glycosylated anthocyanins, thus suggesting their potential use as a new source of red pigments to the food industry.

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JOJOBA

OIL AND SIMMONDSIN YIELD VARIABILITY AND SELECTION CRITERION OF JOJOBA CLONES

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The commercial jojoba plantations in the world were planted for liquid wax production. Recentl studies have shown that simmondsin ([2-(cyanomethylene)-3-hydroxy-4,5-dimethoxycyclohexyl b-D-glucoside]), a chemical compound present in jojoba meal, and its derivatives regulate food intake in animals. This innovative use opens new potential markets for the crop. However, little information is available on simmondsin yield and its relations to liquid wax production in the current commercial plantation.

The relations between the oil and simmondsin and their variations among clones and years were studied. Statistically significant differences ($P<0.05$) were observed in liquid wax content, simmondsin and its derivatives between clones and years. The wax yields ranged from 58.8 to 50.5% of seed weight. The total simmondsin, didemethyl simmondsin, and simmondsin ferulate contents ranged from 10.3 to 5.4, 9.8 to 3.5, and 1.9 to 0.8% of

seed weight, respectively. Significant (5%) negative correlations between liquid wax content and total simmondsin content (-0.56) and between liquid wax content and didemethyl simmondsin content (-0.61) were found.

IN VITRO PROPAGATION OF JOJOBA

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Shoot-tip explants were collected from a jojoba (*Simmondsia chinensis)* plantation in Muzahimiya Center for Desert Plants located 40 km west of Riyadh. Shoot-tip explants from seven genotypes (4 females and 3 males) were used. These genotypes were selected as high-yielding fruits (female plants) or flowers (male plants). The explants were cultured on an MSB5 basal medium containing a combination of IAA and BA at 0, 0.3, and 3.0 mg/1 each in a factorial arrangement. After eight weeks in culture, the data revealed a significant genotypic effect and a medium composition (growth regulators) effect. The highest number of newly formed shoots per explant was produced by female plants F_3 and F_2. The male plants (M_1,M_2,M_3) were the least responsive. The higher BA/IAA ratio favored shoot multiplication with 3.0/0.0 and 3.0/0.3 mg/l combination producing the maximum response. Lower BA/IAA favored shoot elongation and callus production. Rooting of micropropagated shoots was attempted on various media (e.g., IAA, NAA, IBA, ½ MS or MS). The highest rate of rooting occurred on the medium containing IBA.

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