

POSTERS: NON-INDUSTRIAL CROPS*N-1***DEVELOPMENT OF A SOLO-CROP GRAIN AMARANTH PRODUCTION TECHNOLOGY IN TARIJA, BOLIVIA: PRELIMINARY STUDIES.**

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Grain amaranth has shown potential for the conditions of the Central Valley of Tarija, Bolivia. In this region, *Amaranthus caudatus* L., has been traditionally produced through an intercropping system, which is adequate for subsistence agriculture. Large-scale amaranth production requires the development of a solo-crop production technology.

Two preliminary studies were conducted to determine the optimum fertilization formula and plant density for a solo-crop amaranth production in the region.

These studies were carried out in two Tarija locations during 1990-1991. One study consisted of eight levels of fertilizer (control, chemical (40-40-20, 80-80-40 NPK), organic (7.5 Mg ha⁻¹, 15 Mg ha⁻¹ dried ovine manure), and mixed (20-20-10 + 3.75 Mg ha⁻¹, 40-40-20 + 7.5 Mg ha⁻¹; and 60-60-30 + 11.25 Mg ha⁻¹), and two grain amaranths (one local and one introduced). The other study consisted of four plant densities (55 000, 110 000, 166 000, and 222 000 plants ha⁻¹) and four grain amaranths (one local and three introduced).

Across fertilizers, the introduced cultivar yielded 1.59 Mg ha⁻¹, 17% higher than the local type. However, the local type was more responsive to the levels of fertilizer applied (1.5, 3, and 1.7 times more responsive under chemical, organic, and mixed fertilizers, respectively). Grain yields showed a linear response to chemical and organic fertilizers, and a quadratic response to the mixed fertilizer. Highest response corresponded to chemical and mixed fertilizers (1.65 Mg ha⁻¹, 80% and 29% higher than control and organic, respectively). The fertilization levels delayed the phenology of the crop although not uniformly between cultivars. Cultivars responded similarly to variations in plant density (avg. 2.14 Mg ha⁻¹). Grain yield increased linearly within the range of densities (approx. 2 kg of grain per 1000 plants). Maximum grain yield (2.30 Mg ha⁻¹) was obtained at a density of 220 000 plants ha⁻¹. Grain yield per plant decreased quadratically with increased plant density. Interplant competition appeared strongly associated with the ability of the plant to store nutrients in the stem.

Solo-crop amaranth production in the region should be carried out under a fertilizer formula of at least 80-80-40 NPK or 60-60-30 NPK + 11 Mg dried ovine manure, and a plant density of at least 220 000 plants ha⁻¹.

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*N-2***PRODUCTION, FRUIT QUALITY, AND NUTRITIONAL VALUE OF SPAGHETTI SQUASH**

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Developing new kinds and types of vegetable crops is beneficial to both the grower and the consumer. Diversification of vegetable crops expands a grower's market and simultaneously increase a consumer's choice of vegetables. New cultivars can also improve fruit nutritional components.

The objective of this investigation was to determine the adaptation and nutrient content of two spaghetti squash (*Cucurbita pepo* L.) cultivars grown in south Florida.

Spaghetti cultivars 'Vegetable' and 'Hast La Pasta' were evaluated for yield, fruit quality, and nutrient composition during the fall of 1999 at

Green Cay Farms, Benton Beach, FL. 'Vegetable' spaghetti squash had significantly higher marketable fruit number (no./hectare) and marketable fruit yield (kg/hectare) than 'Hasta La Pasta'. Fruit size (kg/fruit) and culls were not significantly different between cultivars.

Fruit N, Mg, S, B, Fe, Mn, and Zn contents were not significantly different among cultivars. 'Hasta La Pasta' had lower fruit P and Ca content, but higher K and Cu content than the 'Vegetable' cultivar. 'Hasta La Pasta' fruit also had lower glucose and sucrose content than the 'Vegetable' fruit. Cultivars did not differ in fruit fructose content. 'Vegetable' fruits were significantly higher in percent dry weight and percent alcohol insoluble solids (AIS) as compared with the 'Hasta La Pasta'.

Based on yields and overall nutritional value, the 'Vegetable' cultivar would be a viable spaghetti squash type for Florida's conditions.

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CHAYA (CNIDOSCOLUS ACONITIFOLIUS SSP. ACONITIFOLIUS) YIELD AND LEAF CHEMICAL COMPOSITION IN FOUR LOCATIONS OF GUATEMALA

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PRELIMINARY INVESTIGATIONS ON CANNIBALS TOMATO *SOLANUM ANTHOPOPHAGORUM*

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EVALUATION OF LUPIN AS A NEW FOOD/FEED CROP IN THE MID-ATLANTIC REGION OF USA

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Development of lupin as an alternate winter crop has the potential to increase the productivity and income of wheat farmers in the states of Delaware, Maryland, Pennsylvania, and Virginia where wheat prices have decreased from \$4 to \$2 per bushel from 1995 to 1999. The New Crops Program of Virginia State University has been evaluating white lupin (*Lupinus albus* L.) in Virginia for the past several years to aid in crop diversification, sustainability of food/feed production, and for protection of environment from pollution from inorganic nitrogen fertilizers.

The existence of significant variation in plant-microbe interaction between lupin lines and *Bradyrhizobial* strains has been established to indicate that specific *Bradyrhizobial* strain and lupin line combinations need to be identified for successful utilization of lupin's capability to fix atmospheric nitrogen for use in low-input and sustainable agriculture. USDA-3044, USDA-3051, and USDA-4114 have been identified to be efficient *Bradyrhizobial* strains for effective nodulation in white lupin.

The efficiency of using lupin as a winter legume cover crop-green has been demonstrated by experiments where cantaloupe fruit yields yield following lupin, hairy vetch, Austrian winter pea, 100 kg/ha N, and a control treatment were 40.7, 35.7, 15.9, 9.4, and 3.9 MT/ha, respectively, and corresponding yields for sweet corn were 6.8, 4.8, 3.6, 3.2, and 0.9 MT/ha, respectively. Additional research in Virginia has indicated that growing

environment significantly affects the nutritional quality of lupin. However, the protein content of lupin seed produced in Virginia varied from 32-43 percent with a mean of 37 percent.

The seeds of sweet lupin do not contain alkaloids or trypsin inhibitors and do not require high temperature cooking before use as a livestock feed. Limited production research has indicated the superiority of indeterminate cultivars over determinate cultivars (seed yield of 4787 vs. 3777 kg/ha), early planting over later planting (seed yield of 6547, 4260, and 3554 kg/ha) with an indeterminate cultivar, respectively following plantings done in early October, late October, and middle of November), and closer row spacing over wider row spacing (seed yields of 6362, 4449, and 3549 kg/ha with an indeterminate cultivar, respectively following 30, 60, and 90 cm row spacing). We are making progress with development of winter-hardy lupin lines by selecting from USDA's collection and material received from Auburn University.

Preliminary research with alkaloids has indicated that "Bitter" lupins (high alkaloid content) have an advantage over "Sweet" lupins (alkaloid-free or low alkaloid content). However, considerable variation existed among lupin germplasm for development of high yielding sweet lupin cultivars.

Based on these observations, the prospects of developing lupin as an alternative grain crop in Virginia and adjoining areas are good.

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TEPARY BEAN: A SHORT DURATION NEW SUMMER CROP IN VIRGINIA

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Increasing world population, increasing incidences of drought in crop production areas, and decreasing amounts of available irrigation water necessitate development of crop plants that could produce food and feed by using lesser amounts of water. In addition, Virginia farmers need a short-duration crop for production in rotation with winter wheat. Most wheat farmers finish harvesting their wheat crop by the middle of June and then leave either the soil fallow or plant double-crop soybean. The productivity of double-crop soybean in this system is extremely low and unpredictable due to dependence upon rainfall.

A short duration crop, such as tepary bean (*Phaseolus acutifolius* A. Gray), could provide a remedy for this situation. Preliminary research has indicated that tepary bean, native to southwestern United States and known for its drought and heat tolerance, has potential as a new crop in Virginia. The mean seed yields of eight tepary bean lines during 1997 and 1998 were 2656, 2097, and 1608 kg/ha, respectively for experiments planted around May 29, June 19, and July 10. It has been observed that seed yield is dependent upon planting time but given that seed yield of 2097 kg/ha, averaged over eight lines and two years, was obtained from experiments planted on June 19 or later, tepary bean can be commercially produced in rotation with winter wheat in Virginia.

The nutritional quality of Virginia-grown tepary bean has been equal to or better than those produced in the southwestern United States. The protein content of tepary bean lines produced in Virginia varied from 20.9 to 30.6 percent and the oil content varied from 1.4 to 3.4 percent. The contents of saturated, unsaturated, monounsaturated, and polyunsaturated fatty acids in tepary beans produced in Virginia varied from 30 to 42 percent, 58 to 70 percent, 28 to 40 percent, and 25 to 33 percent, respectively. The contents of calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sulfur, and zinc compare favorably with those in the seeds of tepary beans produced in the southwestern United States. Based on comparison of seed composition values, tepary bean has a higher contents of protein, oil, calcium, iron, magnesium, zinc, phosphorus, copper, manganese, and potassium contents compared with navy, kidney, and pinto beans. The tepary bean also had lower content of polyunsaturated fatty acids compared with navy, kidney, and pinto beans.

Further details of these experiments will be presented and discussed to demonstrate that tepary bean can be developed as a new summer crop for Virginia.

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ARTOCARPUS LAKOOCHA ROXB., A MULTIPURPOSE FRUIT TREE OF WARM CLIMATE

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The escalation in the world population and the implications this has for food production is probably the most motivating factor when considering the need for germplasm conservation. An obvious consequence of crop uniformity and neglect of wild related species, which often contain many useful traits, is a narrow gene pool and resultant vulnerability. Much of the research into biotechnology has been carried out in industrialized countries, resulting in the comparative neglect of regional crops in developing countries, where many of the tropical and subtropical fruit species are grown.

Artocarpus lakoocha belongs to the family Moraceae and is a multipurpose tree used for wood, timber, fodder and fruits. The bark contains tannin and is chewed like betel nut. It yields a fiber for cordage. The wood and roots yield a dye of rich color. Both seed and milky latex are purgative. The bark is applied on skin ailments. The fruit is believed to act as a tonic for the liver. Seed viability is very critical and the main reason behind the declining population over the years. Once the seeds are extracted out of the fruit, they lose viability within a week, sometimes even in a few days. Attempts for rooting of hardwood or softwood stem cuttings have not been quite successful. The objective of this study is to review and organize all the information about *A. lakoocha* and to develop an *in vitro* protocol for the rapid multiplication of this plant.

Murashige and Skoog (MS) medium at various concentrations of naphthalene acetic acid (NAA) and benzyl amino purine (BAP), individually and in combination, was used to study callus induction and regeneration potential of different explants, e.g., leaf disc, shoot tip, and nodal segment. Once shoots were produced, they were excised and incubated in a root induction medium to develop into a complete plant.

An efficient protocol was developed for rapid *in vitro* micropropagation of *A. lakoocha* plants. The shoot tip and nodal segment both were responsive for the induction of callus and multiple shoot production. The best protocol was to initiate calli in the dark in the presence of NAA and then transfer them to BAP supplemented medium under 16 h photoperiod. This process resulted in 10 to 12 shoots per explant at the end of the three-month culture cycle. Microshoots rooted easily in the presence of indole butyric acid (IBA) in ½-MS medium supplemented with activated charcoal. However, leaf discs in the present experiment did not show any response.

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GROWTH AND DEVELOPMENTAL RESPONSE OF '20TH CENTURY' ASIAN PEAR ON FOUR ROOTSTOCKS UNDER NORTHWEST MISSOURI CONDITIONS

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Certain *Pyrus* rootstocks are known to alter scion cold hardiness. Presently, no data are available to quantify growth, developmental response, and cold hardiness of Asian pear for Northwest Missouri conditions. The central theme of the Alternative Crop Research Center is to commercialize potential cash crops.

A research program was established to determine the eco-physiological response of 'Twentieth Century' Asian pear (*P. pyrifolia* (Burm.) Nakai) on four rootstocks, *P. betoulaefolia*, *P. ussuriensis*, *P. serotina*, and *P. communis*. Scions of 'Twentieth Century' were chip-budded onto one-year-old rootstocks, and growth and development was observed from 1990-1993. Ten trees per replication and three replications per rootstock were maintained in a completely randomized block design.

Differences in cumulative scion trunk diameter growth among rootstocks were significant in 1992 ($P = 0.05$) and highly significant in 1991 and 1993 ($P = 0.01$). Rootstocks *P. betoulaefolia* and *P. serotina* showed higher scion trunk diameter growth than *P. ussuriensis* and *P. communis*. The cumulative growth in height was greatest in *P. serotina* and lowest in *P. communis* during 1992 and 1993. Visual observation of percent cold stress injury showed highly significant differences among rootstocks ($P = 0.01$). *P. betoulaefolia* showed highest susceptibility to cold stress injury and *P. communis* showed the least.

During 1995, artificial freezing tests were conducted to evaluate the response of 'Twentieth Century' Asian pear on four rootstocks to freezing temperatures. Electrolytic conductance tests indicated all rootstocks to be affected by freezing tests with only *P. betoulaefolia* showing a consistent

pattern of response. *P. communis* showed better cold tolerance compared to all the other rootstocks in terms of index of injury.

Chlorophyll fluorescence studies indicated significant differences ($P = 0.05$) for the temperature and rootstock interaction. No single rootstock showed consistent response to the cold stress treatments. The chlorophyll fluorescence technique appears to be a good indicator of change in the bioenergetic status of *Pyrus* rootstocks in response to freezing stress. Potential lies in understanding the chlorophyll fluorescence pattern of matured leaves of *Pyrus* rootstocks at specific above and below zero degree temperatures.

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EFFECT OF STORAGE TEMPERATURE ON THE NUTRITIONAL VALUE OF CURRY LEAF

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Curry leaf (*Murraya koenigii*; Rutaceae) is a leafy spice characterizing authentic Asian-Indian cuisine. Since curry leaf is used in small quantities for its distinct aroma, most studies report on the concentrations of volatile oils. Very few studies report on the nutritional value and functional properties attributed to high content of antioxidant vitamins and plant pigments.

Interest in greater use of curry leaf has been stimulated since its high antioxidant potency was reported. Additionally, changing demographics nationwide have created a ready market and greater demand for new crops including curry leaf. However, it is important to evaluate the new crops for nutritional value and develop suitable cultivation as well as storage methods for extended shelf-life. The objective of this study was to evaluate the local curry leaves as a source of a-tocopherol, b-carotene and lutein and study the effect of storage temperature on the concentrations of these vitamins and plant pigments.

Fresh curry leaves were purchased from three local Asian-Indian grocery stores in Connecticut and pooled for sampling and chemical analysis. The leaves were divided into four samples and analyzed fresh, oven-dried (45°C) for 1 day, air-dried (22°C) for 10 days, or frozen (-15°C) for 10 days for a-tocopherol, b-carotene, and lutein. One g of leaf tissue was ground in a Waring Blender with 20 ml phosphate buffered saline, transferred to a tube, and 2 ml methanol containing butylated hydroxytoluene (0.5 mg/ml) was added. The homogenate was extracted in 10 ml hexane containing 1mg/ml a-tocopherol acetate as internal standard, vortexed for 5 min, and centrifuged at $3000 \times g$ for 10 min. The upper layer was collected through 1 mm anhydrous sodium sulfate layer. The extract was analyzed by HPLC-UV and the molecular mass of these compounds identified and confirmed by APCI LC-MS. A reverse phase column (Ultra C18 5 μ m, 150 mm \times 4.6 mm i.d., Restek Vancouver, WA) fitted with a guard column (Restek 10 mm \times 4 mm), and 50 μ L injection loop was used for the analysis. Solvent A consisted of 85% acetonitrile, 2.5% methylene chloride, 2.5% hexane, 10% methanol, while solvent B consisted of 50% acetonitrile, 20% methylene chloride, 20% hexane, and 10% methanol. The gradient consisted of 100% solvent B for 25 min and 90% A for 25 min at a constant flow rate of 1 ml/min. The column was stabilized for 20 min with 90% solvent A.

Results showed that fresh leaves had higher chlorophyll, a-tocopherol, lutein and b-carotene compared to the stored leaves. The oven-dried leaves stored at the highest temperature had lower a-tocopherol (~50%), lutein (~60%), and b-carotene (~71%) compared to the fresh leaves. The leaves stored at the lowest temperature (frozen) were similar to the fresh leaves in their a-tocopherol, and chlorophyll content, but had lower b-carotene (22%) and lutein (~70%) than the fresh leaves. Air-dried leaves had lower a-tocopherol (~13%), lutein (~64%), and b-carotene (30%) compared to the fresh leaves.

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EFFECT OF NITRATE: AMMONIUM NITROGEN RATIO IN HYDROPONICS ON THE OXALATE LEVELS OF PURSLANE

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Purslane (*Portulaca oleracea* L.) has been identified as an exceptionally rich source of α -linolenic acid (LNA), an essential omega-3 fatty acid that is beneficial in reducing the incidence of coronary heart disease and certain cancers. Since then, purslane has been described as a "power food of the future" and strong interest has developed in this species as a highly nutritious salad green or potherb. Purslane has also been reported to enrich the meat of animals with omega-3 fatty acids, when fed to animals, poultry, and fish.

Despite its high nutritive and antioxidant potential, the high oxalate levels reported in purslane are a health concern because a diet high in oxalate can increase the risk of kidney stones and also may affect calcium absorption. Previously, we found that the omega-3 fatty acid concentrations in purslane were influenced by a number of environmental factors including mineral nutrition in the growing medium. The objective of this study was to study the effect of nitrate to ammonium ratios in hydroponics on the oxalate levels in purslane leaves.

A cultivated variety of purslane was grown hydroponically in a complete nutrient solution with 14.3 mM nitrogen provided as nitrate (NO_3^-) and ammonium (NH_4^+) forms to yield NO_3^- -N: NH_4^+ -N ratios of 1:0, 0.75:0.25, 0.5:0.5, and 0.25:0.75. The four N-form treatments were arranged in a randomized complete block design with five replicates of each treatment.

At the eight true-leaf stage, fully expanded young leaves from the 2nd, 3rd and 4th nodes (counting down from the shoot tip) were harvested and were analyzed to determine the oxalate concentrations. The data was analyzed using SAS General Linear Models procedure (SAS Inst., 1994).

The results showed that the leaves of plants grown with an NO_3^- -N: NH_4^+ -N ratios of 0.5:0.5 and 0.25:0.75 contained 30 to 40% lower oxalates than the leaves grown with ratios 1:0 and 0.75:0.25, respectively. The nitrate to ammonium ratios did not alter the plant growth characteristics relative to fresh weight, dry weight, and leaf area.

In previous studies, we found that NO_3^- -N: NH_4^+ -N ratios of 0.5:0.5 and 0.25:0.75 also enhanced the omega-3 fatty acids in purslane levels. The results of this study showed that combinations of nitrate and ammonium in the ratios of 0.5:0.5 or 0.25:0.75 are beneficial for purslane growth as well as enhanced the quality of the produce at harvest (lower oxalate and higher omega-3 fatty acid concentrations).

Characterizing environmental conditions for decreasing the oxalate levels and enhancing omega-3 fatty acids will certainly improve the likelihood of purslane cultivation commercially as a food crop and its wider consumption as a terrestrial source of omega-3 fatty acids.

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ASPARAGUS AS A NEW EXPORT CROP FOR EAST AFRICA: POTENTIALS AND PROBLEMS

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Agricultural export from east Africa can be grouped into regional and transcontinental categories. The regional export is transacted primarily in African currencies and consists of commodities such as cereals, beans and oil crops. The hard currency earning depends mostly on transcontinental agricultural export. The crop base for this type of export is rather limited with coffee accounting for a large portion of the trade. However, the export revenues from coffee have fallen significantly over the years and earnings fluctuate dramatically from year to year based on market supply and demand. This situation creates the need to spread the total earning more evenly over a wider range of commodities. A number of flowers, vegetables, essential oils and spices, and fruits have been identified for evaluation as potential new export crops from east Africa. Asparagus (*Asparagus officinalis* L.), bush beans (*Phaseolus vulgaris* L.), and snow peas (*Pisum sativum* L.) are among non-traditional vegetables short-listed for testing.

East Africa possesses two important advantages for asparagus export industry to flourish. Asparagus is a labor intensive crop and should benefit from the low labor costs in Africa. The region is also situated close to the equator with a year round growing season making it possible to produce asparagus for export to temperate countries during winter. However, asparagus is a cool season crop needing 24 to 29°C day and 13 to 19°C night for optimum growth and thus the cultivation of the crop in the tropics can be attempted only at high elevations. A dormancy requirement before the onset of spear production may also pose a potential problem for the production of asparagus in east Africa. In the absence of the rest period, the crop may lose vigor quickly and optimum spear yields may be limited to one to two years. Lack of postharvest handling facilities may also pose an

impediment to successful asparagus production.

In recent years, several tropical countries including Peru, Thailand, Philippines, Columbia, and Guatemala have taken up asparagus production for export with reasonable degree of success. In African continent, South Africa leads in asparagus production followed by Zimbabwe and Lesotho, respectively. Kenya, Uganda, and Ethiopia in east Africa also have small acreage under asparagus. However, comprehensive research to develop management practices suitable for asparagus production in east Africa is still awaited. Spacing, fertilization, intercropping, pest and disease control, time and frequencies of spear harvest, and productive life of asparagus planting under east African conditions need determination. Yield trials conducted at the Makerere University in Uganda indicate promise for asparagus in east Africa but also point to several constraints needing remedy through future research.

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LEAF LETTUCE - AN ALTERNATIVE CROP FOR VIRGINIA'S EASTERN SHORE

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A committee of growers identified several alternative or non-traditional vegetable crops that they believed would fit into the existing production systems in this vegetable growing area. Of these, leaf lettuce (*Lactuca sativa* L.) may be economically feasible provided production and post-harvest requirements can be met. A preliminary study to examine the feasibility of growing lettuce on a Bojac sandy loam soil indicated that stand establishment may be difficult and that sand movement into the crowns during rain events was detrimental to head quality. These studies were initiated to determine the potential of producing commercial quality Boston and Romaine lettuce for this area.

Therefore, the objectives were to:

1. Evaluate effectiveness of tillage or anti-crustants on emergence of direct-seeded lettuce,
2. Examine the influence of desiccated cover crops on soil movement into the head of transplanted lettuce

Studies established in the fall of 1996 and 1997 compared the influence of physical anti-crustants, including peanut hulls, pine bark, vermiculite (1996), and straw to unamended soil on stand establishment of direct-seeded lettuce. The potential of rye (*Secale cereale*) or wheat (*Triticum aestivum* L.) planted as cover crops in the fall of 1998 and 1999 and desiccated prior to spring transplanting was compared to that of bare soil in reduction of sand movement into the crowns of lettuce. A subsample of five randomly selected heads per plot in the second study was visually inspected for the presence of sand/soil. The core was cut below the first clean leaf junction of each head and the percentage of the sample that would be marketable (clean) was calculated. Each trial was planted in a randomized complete block design with four replications.

In 1996, stand establishment (37.2-49.4%) was inadequate and was not influenced by anti-crustant treatment. The crop was irrigated in 6 mm increments, twice daily for 7 days because of extremely dry conditions (30 mm in 1996 vs. 91 mm for a 61-year average for September). Band applications of vermiculite, and to a lesser extent peanut hull and pine bark, resulted in wind movement off the plots prior to germination. In 1997, stand establishment varied from 60 to 93%, but was not significantly influenced by pre-plant treatment. The decision was made to use transplants in future studies to obtain plant establishment needed for lettuce to be economically feasible in this area.

In both 1999 and 2000, sand was found in more than 50% of the Boston lettuce plants grown on bare ground. Soil movement into the crowns grown in wheat varied between the two years, whereas 51% of the plant was free of sand when grown on rye. Sand movement was less in Romaine lettuce in 1999, with 68% of the plant free of sand regardless of treatment.

Production of clean, high quality Boston lettuce has been consistently more difficult than the more upright Romaine lettuce in this growing area. Additional studies are needed to determine cultural management practices that minimize the movement of soil into the crown of Romaine and other types of upright leaf lettuce.

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PREPARATION OF A GRAIN-AMARANTH-BASED CANDY BAR

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DEVELOPING NEW VARIETIES AND METHODS FOR PRODUCING HIGH-VALUE PRODUCTS IN GENETICALLY ENGINEERED TOBACCO

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As the commercial production of high-value products in genetically engineered plants increases, there is a need to develop an efficient production system. Many suitable products have been identified for this plant-based production, especially in the medical field, and the technology is being perfected for large-scale implementation. From an economic standpoint, optimizing production practices and developing new plant varieties are essential as the technology moves from lab-scale production to larger-scale commercial enterprises.

The objective of this research was to use both conventional breeding and biotechnology-based options to develop new tobacco varieties for value-added production. In addition, efficient management practices are being explored as this new tobacco crop has different production requirements compared to traditional tobacco.

Trials conducted included a species nursery for plant breeding, the development of a direct seeding scheme for tobacco, and a study to evaluate varieties for total biomass yield in a growing season (including experimental irrigation and harvesting methods). In addition, special emphasis is being placed on developing varieties that are easily distinguished from conventional tobacco as a tool for identity preservation due to co-mingling concerns.

The species nursery included 54 *Nicotiana* species and 20 commercial and experimental tobacco varieties. After evaluating the plants for desirable characteristics, crosses were made and progenies were evaluated for expression of desirable characteristics. Varieties are being screened for cold tolerance, seedling vigor, gene expression, disease resistance, protein content, overall phenotype and biomass production, etc.

The direct seeding study was a split block design, with three tobacco varieties and three herbicide treatments in two replications. Stand establishment time, herbicide effectiveness, and yield data were collected. This study included tobacco varieties engineered for herbicide resistance, as weed control is a limiting factor in the ability to direct seed tobacco.

The biomass study was a split block design consisting of six tobacco varieties and two fertilizer treatments in four replications. Several commercial tobacco varieties known for high biomass production were planted in closely spaced rows. Drip irrigation, coupled with a fertilizer injector was used to apply nitrogen fertilizer at pre- and post-harvest intervals. Plots were mechanically harvested multiple times during the growing season. Total yield, leaf to stem ratio, and protein content were measured and evaluated.

Data on biomass production, identity preservation traits and novel production methods for this new type of tobacco indicate avenues for further research. The results are promising in the development of this new tobacco crop. The large biomass production and the ease of scale-up and engineering make tobacco an excellent new crop for the commercial production of high value materials in genetically engineered plants.

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RAMPS: CULTIVATING A NATIVE PLANT FOR FOOD AND MEDICINE

J.M. Davis

Ramps, *Allium tricoccum* or *Allium tricoccum*, var. *burdickii*, also known as wild leeks, is native to the Appalachian Mountain region and can be found growing in patches in rich, moist, deciduous forests. In early spring, the bulbs have the pleasant taste of sweet spring onion with a strong garlic-like aroma. As one of the first plants to emerge in the spring, ramps were traditionally consumed as the season's first "greens." They were considered a tonic because they provided necessary vitamins and minerals following the long winter months without any fresh vegetables. Traditions evolved around the annual gathering and preparation of this pungent and flavorful plant. In many areas, annual spring ramps festivals are held. These festivals have become major tourist attractions and are actively promoted by the communities in which they are held. The tremendous volumes of ramps consumed at these festivals are gathered from the forests, often seriously damaging the wild populations of ramps. In recent years, white-table cloth restaurants have also begun serving ramps, increasing the demand for large, consistent supplies of the little forest plant. There is also interest on the part of the medical community because ramps have been shown to inhibit cancer formation in laboratory animals.

In an effort to conserve native populations and meet the rising demand for ramps, we are developing cultivation practices for ramps.

The few people who grow ramps usually propagate them by transplanting small plants or bulbs. Since there are few commercial sources of ramp planting stock, it is assumed that new growers will dig plants from wild populations. To reduce damage to these populations, propagation by seed is being studied. Fresh and dried seeds were planted in the spring and fall in sites in natural forest, open field, and under artificial polypropylene shade structures providing 30%, 47%, 63%, and 80% shade. There is disagreement about whether it is better to plant bulbs in the spring or fall, so a study was also established on a forest site with spring and fall planted bulbs. Research conducted on several other forest plants indicates that soil pH and calcium and magnesium levels are important for growth and survival. Analysis of soil samples collected from native ramps sites indicated that ramps might have a similar requirement. Thus, a study was established in which ramps are being grown in soil adjusted to pH 4.9, 5.5, 6.0, and 6.5 in a factorial arrangement with soil calcium levels of 0, 1000, 3000, and 5000 lbs. Ca/acre. Materials used to make the soil adjustments were magnesium oxide, olivine, and gypsum.

Ramps are a slow-growing plant and final results from these studies will not be available for several years. Early results of the seed studies, however, support previous research which indicated that ramp seeds require a warm-cold cycle to germinate. Seeds sown in fall did not germinate until the second spring whereas spring sown seeds germinated the following spring. Interestingly, seeds sown in the forest germinated before any of the other sites.

This research should help provide ample supplies of ramps for consumers, create a new product for the commercial grower, and ultimately, allow native populations to regenerate.

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N-17

NEW CROP OPPORTUNITIES IN KENTUCKY

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INFLUENCE OF SOWING DATE AND WATER AVAILABILITY ON SEED YIELD AND COMPOSITION OF THREE GUAR (*CYAMOPSIS TETRAGONOLOBA*) CULTIVARS

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Guar is a summer legume adapted to semiarid areas. It is cultivated mostly in India and Pakistan and possibly can be grown elsewhere such as the semiarid regions of Argentina. The seed contains up to 40% galactomannans (guar gum), which is used in the food and beverage, cosmetic, and other industries. Gum content is genetically determined although it can be influenced by environmental conditions acting directly on gum

synthesis, and indirectly through seed growth and other physiological variables.

The present study was aimed to determine the effect of the environment explored by the crop on seed yield and composition of three guar cultivars: Easer, Brooks, and Teasel differing in growth cycle and seed-gum content. A range of environmental conditions was generated by manipulating sowing dates (30 October, 27 November, and 28 December) and water availability (460 mm to 1129 mm) in a field experiment located in San Juan, Argentina (30° 38' S, 67° 27' W).

Early planting dates (October) resulted in higher seed-yield compared to later dates ($P < 0.01$). No differences in yield were found among irrigation treatments or among cultivars. The higher yield found in early planting dates could be associated with higher total radiation accumulated during the growth cycle. Among cultivars, Brooks showed the lowest seed-gum content (9%) with no differences found between Teasel and Easer (15%; $P < 0.05$). A significant reduction in gum content was found for the late December planting compared with the other planting dates ($P < 0.01$). This reduction was associated with a lower seed weight. The response to the earlier planting dates was different among cultivars. For Brooks (the cultivar with the lowest gum content), the highest seed-gum content was found for the October planting date, associated with the highest seed-yield per plant, highest biomass, and highest harvest index. Seed-gum content of both Easer and Teasel was maximum for the second planting date, which showed lower plant yield than the first planting date, but still with a high harvest index and seed-size.

These integrated responses to environmental conditions during the growth cycle indicate a trade off between seed yield and seed gum content for Easer and Teasel, but not for Brooks, a cultivar with low seed-gum content and high seed-yield potential. A better understanding of the direct and indirect influences of the environment on biomass production and partition, and on gum synthesis will help to develop better agricultural practices toward high yielding guar crops.

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MANAGEMENT AND ADAPTATION OF SAFFLOWER FOR THE HIGH PLAINS

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Management, variety, and systems trials in the High Plains region have been conducted over the past 10 years using safflower, *Carthamus tinctorius* L. All trials incorporated safflower after winter wheat (*Triticum aestivum* L.) harvested the previous summer. Yield trials on deeper soils have consistently averaged 1,200 kg/ha range, whereas shallower, higher elevation sites have been significantly lower yielding at 500 kg/ha. Drill opener-type and row-spacing studies have been conducted and the best stands and yields averaged over years have been produced with double-disk drills with 18 cm spacing. With favorable conditions, there was little difference between opener types, but in years with thunderstorms soon after emergence, stands were reduced by soil covering when hoe openers were used. During years with hot dry periods at the end of the season, plants senesced more rapidly with 18 cm rows than with 31 cm rows. Wheat yields in the wheat-safflower-fallow rotation were similar to wheat yields where corn, (*Zea mays* L.), sunflowers (*Helianthus annuus* L.) or proso millet (*Panicum miliaceum* L.), were substituted for the safflower. In continuous crop systems comparing safflower with spring wheat, safflower reduced both proso yields the following year and wheat yields two years later.

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BIOPROSPECTING FOR PODOPHYLLOTOXIN

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Podophyllotoxin, the starting material for the semi-synthesis of the anticancer drugs etoposide, teniposide, and etopophos, is commercially extracted from *Podophyllum emodi*, which has been considered an endangered species.

As part of our bioprospecting study for alternative sources of podophyllotoxin, we evaluated 10 genera (*Podophyllum*, *Juniperus*, *Teucrium*, *Hyptis*, *Dysosma*, *Linum*, *Nepeta*, *Jeffersonia*, *Thymus*, and *Thuja*) for the presence of the lignan.

High performance liquid chromatography was used for the separation and quantization of podophyllotoxin from extracts.

Podophyllotoxin concentration was highest in the leaf blades of *Podophyllum peltatum* (23 mg g⁻¹ dry weight) and needles of *Juniperus virginiana* (0.42 mg.g⁻¹).

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BORAGE : A NEW CROP FOR SOUTHERN CHILE

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Borage is a plant from the Boraginaceae family. Current interest in this crop is for its seed. Borage seed oil contains high amounts of gamma linoleic acid (GLA) (all- cis 6,9,12-octadecatrienoic acid). This compound is a precursor of prostaglandins in the human body. Several trials have been conducted in Chile to determine the potential of this crop as a profitable alternative for producers.

Borage has been tested on trials in southern Chile for three years in regions VIII and X of Chile. Plant density, and planting and harvest dates studies have been conducted as well as adaptation trials at several locations. With the information collected in the trials, the X Region of Chile has the best potential to produce borage crops with GLA contents higher than 22% and yields of 300 kg ha⁻¹. However, one of the limitations of these regions is excessive rainfall at harvest that may impede harvest on rainy years.

Our plant density trials indicated that plant densities described in the literature are much lower than optimum. The best yields were obtained with plant densities of 183,000 plants ha⁻¹. No significant difference was observed with the row spacings of 40 cm and 60 cm.

Planting-date study indicated that borage should be sown in October (spring) because plants in the fall planting are susceptible to root damage when the soil freezes in the winter. Also, maturity of the seed influences GLA content, where immature seeds have a lower concentration of GLA.

Borage appears to be a promising alternative crop. Contracts have been written with processors interested in developing this crop for southern Chile.

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EFFECT OF DIFFERENT DRYING TEMPERATURE ON *LIPPIA ALBA* ESSENTIAL OIL PRODUCTION AND YIELD

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The drying of medicinal plants is important to maintain the quality of the product. The objective of this work was to evaluate the influence of drying on yield and chemical composition of *Lippia alba* essential oil.

Leaves of *Lippia alba* were dried under two types of environment, natural (sun) and artificial (circulating air greenhouse), at temperatures of 40, 50, 60, and 70°C. Essential oil extraction was performed by hydrodistillation of dried leaves and the extractant analyzed by GS/MS. Chemical components were identified by comparing their mass spectra and retention index. A completely randomized block was employed for the experimental design using five treatments and four replications. Tukey and Scheffé tests were used to evaluate temperature effects and analyze the differences between the two types of drying.

Higher essential oil yields were obtained with the higher drying temperatures of 50, 60, and 70°C with no significant difference among these temperatures. Yields were lowest at 40°C with the natural drying and required a longer drying period. The main essential oil components were b-myrcene, carvona/neral, geranial, and germacrene regardless of the drying temperatures used for the *Lippia alba* leaves.

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CLOVE-BASIL PRODUCTION (*OCIMUM GRATISSIMUM* L.) AS A FUNCTION OF ORGANIC FERTILIZATION AND HARVESTING SEASON

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ARUGULA: ANCIENT MEDITERRANEAN GREEN AND NEW SALAD CROP FOR THE UNITED STATES

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Arugula, also known as rocket, roquette, rucula, or rughetta, is a diploid annual species (*Eruca sativa* Miller, Brassicaceae) cultivated in many Mediterranean countries as a specialty green or cooked vegetable. It has been known since Antiquity and is referred to in the Greek Herbal of Dioscorides written in the first century.

Arugula is widely consumed in Italy where its pungent qualities are appreciated either consumed alone as a green or as part of a salad mix. Arugula is a fast growing, cool season crop and bolts under long days and high temperature. It can be harvested after 20 to 27 days and then sequentially harvested from regrowth. Recently, arugula has appeared in U.S. markets, particularly in California.

The plant appears well adapted to the Midwest and offers the possibility of a specialty green. The crop can be sequentially harvested and an almost continuous supply can be achieved with multiple plantings and season expansion with plastic tunnels. It is adapted to greenhouse production. Early bolting is an impediment to summer production but considerable genetic variability for late bolting exists.

In a study of greenhouse-grown arugula under continuous illumination, flowering occurred over an 80-day period. Late blooming selections were later flowering than unselected seed lots. Variability also exists for leaf morphology ranging from highly parted to entire and strap-like, stem color (green to red), plant vigor, and pungency.

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BUCHU – ASPECTS OF PROPAGATION TO ASSIST COMMERCIALIZATION OF NEW INDIGENOUS CROPLouisa Blomerus, Cobus Coetzee, and Emmy Reinten

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Buchu (*Agathosma* spp; Rutaceae) is a component of the Flora Capensis or fynbos vegetation in South Africa. There are about 135 species of which 2-3 are used for commercialization. The plant material has been used by the indigenous people for many years to anoint the body, probably for cosmetic reasons as well as for antibiotic protection. For medicinal use, leaves were chewed to relieve stomach complaints, and a buchu vinegar was used for cleansing wounds. An infusion of buchu is often taken as a diuretic. Buchu oil is used in the food industry and especially *A. betulina* is used for its high isomenthone and diosphenol contents.

These uses of the wild harvested buchu have resulted in over exploitation of the natural stands and a definite need to establish cultivated plantations. Being a 'wild' crop, very little is known about its horticultural traits. In the wild, the plants propagate by seed. In this study, propagation aspects by using clonal cuttings were investigated. Seed germination received further attention as very few seeds collected in the wild germinated. Farmers have also indicated a low percentage germination of seed.

Cuttings were taken from active growing plants at regular intervals to determine the rate of rooting. Different medium compositions and climate regime were applied. Results indicate that the time of taking the cutting is crucial and a strike rate of 60% was obtained. *In vitro* propagation was also investigated. Multiplication was possible, but rooting is still a problem.

Seeds were collected at the time when they are naturally shed from their seed pods. Open flowers, presumed to be pollinated, were covered by a gauze bag to obtain the fully ripened seeds on their release. Various seed germination techniques were applied in a laboratory situation. These included smoke water, dry heat (80°C), gibberellic acid, oxygen, and wet heat (50°C). Seed germination results indicate that it is of crucial importance that the seed must only be harvested when fully mature. Another important factor for successful germination is the alternating day/night temperatures (20°C/8°C).

This information is needed to establish successful plantations. In the cultivation of buchu, aspects of crop science such as irrigation, pruning, sustainable harvesting and possibly fertilization can be studied. Organic cultivation and relevant mulches are also to be investigated. Concurrent selections can be made to improve the genetic diversity and develop cultivars.

By cultivation of this indigenous wild crop, the natural stands can be conserved and an industry can develop to fill the niche market of essential oils and herbal medicines. The propagation methods and improved seed germination will aid in this agricultural activity.

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TYPE OF PROPAGULE AND TIME OF PLANTING AFFECT FIRST YEAR GROWTH OF FIELD-ESTABLISHED MAYAPPLE (*PODOPHYLLUM PELTATUM*)K.E. Cushman¹, M. Maqbool¹, and R. Moraes²

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The American Mayapple is a rhizomatous herbaceous perennial found in the wild throughout North America from Quebec and Minnesota to Florida and Texas. Three lignans have been identified with health-related activity: podophyllotoxin, a-peltatin, and b-peltatin. Podophyllotoxin has anti-cancer, anti-mitotic and immunostimulatory properties and is used as the precursor in the manufacture of the semi-synthetic derivatives etoposide, teniposide, and etopophos. Podophyllotoxin is found in leaves and rhizomes of the American Mayapple. However, the toxin content of wild populations has been shown to be highly variable. Identification and multiplication of high-yielding genotypes may interest producers of specialty crops to cultivate mayapple in field plantings as a commercial source of podophyllotoxin. The objective of this study was to determine the effect of type of propagule and time of planting on growth of mayapple for its potential use as a cultivated crop.

Mayapple rhizomes of known podophyllotoxin content were harvested from the wild and transplanted to raised beds in northern Mississippi in the fall of 2000 or spring of 2001. Three types of propagules were transplanted: rhizome segments with a single terminal node (T), segments with a

single dormant node (D), or segments with a terminal and dormant node (T+D). A 2 × 3 factorial arrangement of treatments was used in a randomized complete block design with four replications. Each experimental unit consisted of 30 propagules arranged in two parallel rows. Rows were spaced 30 cm apart and were 1.5 m long. Propagules were spaced 10 cm apart within each row and planted 4 cm in depth. Plantings were mulched with a 10 cm layer of wheat straw and were watered and fertilized via drip irrigation. Plant emergence, height, and leaf area were recorded during the spring and summer of 2001.

Type of propagule and time of planting significantly affected growth of mayapple shoots arising from rhizomes transplanted from the wild. Spring-planted T and T+D exhibited significantly greater shoot emergence, total leaf area, leaf size, and plant height than fall-planted T and T+D. In contrast, spring-planted D exhibited significantly less shoot emergence than fall-planted D. Regardless of time of planting, however, T+D had greater total leaf area and leaf size than T or D. Spring-planted D had greater leaf size but less total leaf area than fall-planted D.

In conclusion, spring-planted T+D propagules exhibited the greatest overall performance. These propagules were larger than the two other propagules used in this study and may have benefited from having more resources to promote vigorous shoot emergence and growth. These propagules also appeared to be negatively affected by overwintering because fall-planted T+D and were slightly less vigorous than spring-planted T+D. The American Mayapple is a slow-growing plant and we report here our first-year observations of a continuing three-year study.

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ADVENTITIOUS PLANTLET DEVELOPMENT IN CHAPÉU DE COURO (*ECHINODORUS GRANDIFLORUS*) RELATED TO SHADING AND WATER LEVELS IN THE SOIL

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"Chapéu de couro" (*Echinodorus grandiflorus* (Cham. & Schldl.) Micheli, Alismataceae) is a medicinal plant occurring in wet soil and along river banks in partially shaded places in some regions of Brazil. This species is extensively used in traditional medicine. Aqueous extracts from the leaves have been used as a diuretic, anti-rheumatic, anti-inflammatory, and to control uric acid. It has also been used as a raw material in soft drinks.

The objectives of this study were to determine the effects of soil water content and the extent of shading on the development of adventitious plantlets of "chapéu de couro."

Adventitious scions approximately 8 cm long with 3 to 4 leaves were planted in 5-liter containers. The substrate consisted of an equal mixture of soil and dry horse manure. The experimental design was a randomized 2x3 factorial with two water levels (saturated and field capacity) and three light intensities (full sun, 70%, and 50%) with four replications. Total fresh and dry weight, foliar area, and leaf blade fresh and dry weights were determined after a six-month developmental period.

The results indicate that the combination of saturated and 50% shading treatments were the most favorable for adventitious plantlet development. Exposure of the plantlets to direct sunlight decreased foliar area. The presence of higher oxygen levels at field capacity could be a factor in decreasing the development of this plant.

We conclude that the best conditions for cultivating this species are similar to its natural habitat. Thus, the successful cultivation of this medicinal species should be similar to those occurring naturally.

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SOMATIC EMBRYOGENESIS IN *NIGELLA SATIVA* (BLACK CUMIN) – AN ALTERNATIVE APPROACH

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INDUCTION OF CARDENOLIDE BIOSYNTHESIS CONCOMITANT WITH THE INDUCTION OF SOMATIC EMBRYOGENESIS IN CALLUS CULTURES OF *PERGULARIA TOMENTOSA*

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ANTIFUNGAL ACTIVITY OF *ALOE VERA* GEL AND JUICE AGAINST PLANT PATHOGENIC FUNGI

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In folk medicine the parenchymous cells in the leaf pulp of *Aloe vera* plant (gel), and the bitter yellow juice (containing aloins and aloe emodin) has been used for healing purposes in humans and animals. There are also reports about gel antifungal activity against postharvest fruit pathogens: *Penicillium digitatum*, *Penicillium expansum*, *Botrytis cinerea*, and *Alternaria alternata*. The knowledge of the antifungal activity of *Aloe vera* gel and juice would be useful for fungal control in commercial industrial crops such as potato.

The objective of this work was to evaluate the antifungal effect of the *Aloe vera* gel and juice.

Aloe vera leaves were cut from plants grown in the experimental plot at the university, disinfected with sodium hypochlorite, and separated in two groups. One group was hand extracted, longitudinally cut and the gel scrapped from the exposed surfaces, blended in a food processor three times for 10 s each, and freshly used. The other group was mechanically extracted, passed through a leaf processor for gel and juice separation, the gel was blended as previously mentioned, and the juice homogenized prior to use. Gel and juice extracts were evaluated for inhibition of mycelium development of *Rhizoctonia solani*, *Fusarium oxysporum*, and *Collectotricum atramentarium* isolated from a potato crop by the hyphae point and monosporic techniques.

Antifungal activity was evaluated on previously mentioned fungi at concentrations of: 0, 10, 100, 1,000, 10,000 and 100,000 ppm of the plant extract. Fungal plugs 0.4 mm diameters were obtained and placed at the center of Petri dishes with potato-dextrose-agar culture media and gel or juice in the noted concentrations. The cultures were incubated at $24 \pm 2^\circ\text{C}$ and the mycelia development measured at 3, 6, and 9 days. The antifungal effect was measured under a totally random design with four replications.

Preliminary results show an inhibition effect of the juice extract from leaves of *Aloe vera* on mycelial growth of *Collectotricum atramentarium*, but no effect on the others. Complete results will be discussed in the full paper.

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GRAIN YIELD AND FATTY ACID COMPOSITION OF SUNFLOWER OIL FOR VARIETIES DEVELOPED UNDER DRYLAND CONDITIONS.

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México imports about 85% of oilseeds for edible oil extraction. Sunflower is an option for local oilseeds production particularly in dryland areas due to its well developed root system. The sunflower oil quality is high due to its fatty acids composition that depends on the climatic conditions.

The objective of this study was to evaluate the grain yield and oil fatty acid composition in five cultivars of sunflower, grown under dryland conditions in Northern México.

Seeding was performed in the experimental field of the University, located at Saltillo, Coahuila, México, on June 21, 2000 under a randomized block design with four replications. Five days after sowing, water was applied for plant establishment and later left under natural conditions. The cultivars studied were GORDIS, RIB77, SAN-3C, SANE 23578, and SANE 1278. The evaluated parameters were: number of leaves, plant height, head diameter, plant dry weight (total and by organs), grain yield, protein content, oil content, and fatty acid concentration. The last three parameters were measured at physiological maturity and harvest.

Grain yields were 1.4 t/ha (SANE 23578 and GORDIS), 1.8 t/ha (SANE 1278), 1.99 t/ha (RIB 77), and 2.3 t/ha (SAN-3C). Oil contents were 32.1% (SANE 23578) 24.85% (GORDIS), 37.0% (SANE 1278), 34.55% (RIB 77), and 32.65% (SAN-3C). The oil fatty acid composition in the improved Mexican cultivars bred at the University showed that the oil quality is similar to that of a commercial sunflower oil.

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ALOE VERA RESPONSE TO PLASTIC MULCH AND NITROGEN FERTILIZER LEVELS

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There is a great demand for Aloe vera gel and juice due to their applications in medicine, cosmetics and health foods with an annual market of one billion U.S.dollars. Consequently, the cultivation of *Aloe vera* for industry is important. However, limited scientific information related to agronomic management is available.

The objectives of this paper were: to study the Aloe vera growth, the gel and juice accumulation as a response to plastic mulch and different nitrogen fertilization levels; to determine the quality of gel and juice; and to evaluate yields of the leaves.

Seeding was performed at the University experimental field at Saltillo, Coahuila, México, using a random block design with four replications arranged in a split plot. The large parcel consisted of two treatments: mulched and without mulch. The subparcels included three levels of nitrogen fertilization, 0, 100 and 150 kg/ha. Nitrogen, as ammonium nitrate and sulfate, was distributed in four equally split blocks with monthly application. The mulched parcels consisted of one bed 1.2 m wide x 6 m long. Two drip irrigation tapes were placed under the black polyethylene mulch. The plants were seeded in two rows to obtain 25,000 plants/ha. The parcels without mulch were two rows 6 m long, separated 1 m between them. The plant separation was 0.4 m yielding 25,000 plants/ha. One drip irrigation tape was installed in each row. Irrigation was applied when the moisture reading at 30 cm depth was 70 centibars. For the evaluation of the plant growth, four plants were sampled by treatment measuring monthly: number of leaves; plant fresh weight; length, width and thickness of the leaves; leaves, juice, and gel yield. The quality of the juice and gel were determined by measuring nitrates, phosphorous, potassium, and pH. Yield was evaluated using 2 to 3 leaves from 32 plants per treatment; these leaves were cut when maximum development was reached. The data were analyzed by ANOVA using a split plot design.

No differences in plant growth between the 100 and 150 kg/ha fertilizer applications in the mulched experiment were found after 105 days. Similar result was found for the gel weight.

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N-33

MOLECULAR MARKERS: A DIAGNOSTIC TOOL FOR THE ASSESSMENT OF GENETIC DIVERSITY IN *PODOPHYLLUM PELTATUM*

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Podophyllum peltatum is a herbaceous and rhizomatous species of great medicinal value. It is a natural source for the lignan podophyllotoxin, a compound from which the semisynthetic anti cancer drugs - etoposide, tenniposide, and etopophos, are derived. The plant grows in the forest under storey in extensive colonies of shoots. The relationship between nearby colonies is unknown.

The production of podophyllotoxin in leaf blades varies from colony to colony ranging from 0 to 4% on dry weight basis. For production purposes, it is essential to determine if this variation is due to genetic or environmental factors.

We are investigating different molecular techniques: RAPD (Random amplified polymorphic DNA), AFLP (Amplified fragment length polymorphism), cloning and sequencing for studying the genetic relationships between intra- and inter-specific populations of *Podophyllum peltatum*. These molecular markers are based on DNA amplification by PCR. Genomic DNA was extracted from frozen leaf samples using CTAB method. In the study, sixty arbitrary decamer primers have been used to characterize the variation among accessions of *Podophyllum peltatum*.

RAPDs revealed low level of polymorphism and had problems of low reproducibility. Therefore, the characterization using AFLP is in progress confirming the low level of polymorphism within species.

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***ANEMOPSIS CALIFORNICA*, A POTENTIAL NEW MEDICINAL CROP**

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Anemopsis californica (Nutt.) Hook. & Arn., in the family Saururaceae, is a herbaceous perennial native to riparian habitats of northern Mexico and the southwestern United States, with known medicinal properties. It is called by various names as manso, yerba mansa, yerba del manso, or swamproot, it has traditionally been and continues to be used by indigenous and Hispanic cultures in its geographic range for the treatment of colds, flu, sinus problems, gastrointestinal discomfort, cold sores, and other problems relating to mucus-lined membranes.

Manso has the potential to become a widely-used herbal cold and sinus remedy in the rapidly growing medicinal herb industry in North America. However, because the plant normally confines itself to riparian habitats, its availability for mass marketing remains limited unless it can be brought under cultivation. Research is currently being conducted at the New Mexico State University Sustainable Agriculture Science Center in Alcalde, New Mexico, with the aim of determining the feasibility of cultivating this native plant under small-scale farming conditions typical of this region.

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CHARACTERIZATION OF THE ENVIRONMENTS AND GEOGRAPHICAL DISTRIBUTION OF CATUABA (*TRICHILIA CATIGUA* A. JUSS., MELIACEAE) IN SOUTHERN BRAZIL

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FOOD, INDUSTRIAL, NUTRACEUTICAL, AND PHARMACEUTICAL USES OF SESAME GENETIC RESOURCES

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Sesame (*Sesamum indicum* L.) is a plant used not only in the industrial, and food additive industries but also in the nutraceutical and pharmaceutical areas. Modern agricultural research is changing due to consumer preferences plus discoveries and identification of new crops and their phytochemicals for nutraceutical and pharmaceutical applications.

The objective of this study was to identify past and present uses plus added-value uses from sesame.

A synopsis of progress regarding the discovery for future uses of sesame will be discussed in detail.

Several novel phytochemicals have been discovered and identified in sesame with application in the nutraceutical and pharmaceutical industries.

Sesame's nutraceutical and pharmaceutical phytochemicals will help people with certain ailments and improve its added value use as a new, alternative crop.

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ASSEMBLING AND CHARACTERIZING A COMPREHENSIVE *ECHINACEA* GERMPLASM COLLECTION

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During the 1990s, the popularity of the genus *Echinacea* as a dietary supplement in the US increased markedly once the general public learned of its putative efficacy in fighting colds and other illnesses. Plant and medical scientists responded to this phenomenon by increasing their efforts to understand the biology, cultivation, and pharmacology of these plants. Unfortunately, very few, well-documented living collections of *Echinacea* were readily available to support that research.

In response, during the mid-1990s, the North Central Regional Plant Introduction Station (NCRPIS) began assembling germplasm collections from wild *Echinacea* populations from throughout its native range in the United States and Canada. These efforts were given a great boost in 1997, when the USDA-Agricultural Research Service awarded the junior author a grant to locate and collect seed samples representing the diversity of all known *Echinacea* taxa. Through those efforts, by the end of the decade, the NCRPIS acquired samples of more than 130 different wild populations, including all recognized taxa.

In 1999, the NCRPIS began a project to produce sufficient quantities of seeds from these populations, both to conserve the populations (which are often threatened in nature by commercial exploitation) and to make seeds available to the research community. The regeneration project cultivates individual populations within screened cages with honeybees as pollinators to produce control-pollinated seeds. In 2000, sufficient seeds were produced from more than 80 populations to allow their distribution. During the course of the regeneration project, notes were collected on a wide range of morphological descriptors, and taxonomic identities were verified. At the end of three years in the cage field, once seeds are harvested, roots will be removed for chemical characterization. These characterization data are being prepared for inclusion in the Germplasm Resources Information Network (GRIN) database, which is accessible on the Internet at <<http://www.ars-grin.gov/npgs>>. In addition to morphological and chemical characterization, the genetic diversity among regenerated populations will be estimated by amplified fragment length polymorphism (AFLP) analysis. Nucleotide sequence variation will be used to further characterize the genetic variation in a phylogeographical context.

Forty populations have been selected for sequence analysis under the geographic criterion of lying on or closest to 1° separated longitudinal lines running between 78° and 99° West, a span that generally brackets the east-to-west range of the genus. Haplotype distribution will be mapped to

show if and how genetic variation is localized geographically. DNA sequences will be deposited in GenBank.

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ADVANCES IN THE INVESTIGATION OF SEED GERMINATION OF SOME MEDICINAL PLANTS IN CHILE

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Due to an increasing world demand for medicinal plants, the farmers in Chile have started to cultivate them. The country has geographic and climatic advantages, which allow the adaptability of species ranging from semitropical to mild and cold climates. Because germination and cultivation methods are not yet known, we are attempting to develop an understanding of the medicinal crops. In previous trials, it was noticed that ethylene had an influence on radicle elongation of *Echinacea angustifolia*. The *Calendula officinalis* achenes are of three types and we do not know the one to use for adequate propagation. We do not have information on the germination requirement for *Taraxacum officinale*.

All the 1999 trials were conducted in Chillán (36° 26' S, 72° 06' W). The *Echinacea angustifolia* achenes were incubated for 30 days / 4°C on a mixture of sand:soil (3:1) (sterilized) and imbedded with water, 1 mM and 10 mM Ethephon, 10 mM thiourea, Promalina (GA4+7 + 6-BA, 1.8% w:w), 1 mM and 10 mM KNO₃, and subsequently incubated in the dark at 20°C. Germination was evaluated daily as well as the root length of the germinated seeds.

The three *Calendula* achenes (winged, hooked, and worm-shaped) were placed on sterilized sand. One group was incubated at 20°C with continuous white light, red light, or in the absence of light, humidifying them with water or in darkness by wetting the substrate with 0.2% w.v. KNO₃. The other group was incubated at 7°C for a period of 15 days and subsequently at 20°C, applying the same treatments as on the preceding trial.

The *Taraxacum officinale* achenes were deposited on filter paper or sterilized sand and were hydrated with water, 7 mM Ethephon solution, 0.2% w.v. KNO₃, 0.2% w:v thiourea, or 20 ppm GA3. In another trial, dry achenes or hydrated achenes were incubated at 4°C or -4°C for 24 h, and subsequently at room temperature.

With the 10 mM Ethephon, the highest germination percentage (87.5%) was observed on *Echinacea angustifolia* achenes, with the shortest radicle (1.84 mm), whereas with the 10 mM KNO₃, the germination percentage decreased to 70.2%, but the radicle length was 4.3 mm.

In *Calendula*, the greatest germination (70.3%) was observed when hooked achenes were exposed to dark at 20°C, and the lowest with stratified worm-shaped achenes, exposed to white light (5.7%). The germination percentage for both trials was lower when the three achene types were exposed to white or red light with the achene germination lowered. However, in this case, the germination of the three types treated with KNO₃ increased with respect to white or red light and darkness.

The highest germination (86%) of dandelion achenes was obtained when they were deposited on sand and humidified with 0.2% thiourea at room temperature. On filter paper with room temperature, the germination was inhibited. With stratification at 4°C and at -4°C, a rate of 77.5% was reached by germinating them on filter paper. The germination period was between 3 and 4.7 days.

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SEEDLINGS - NEW PRODUCTION SYSTEM FOR OIL PUMPKINS?

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The Štajerska region of northeastern Slovenia and southern Austria has a long tradition for growing pumpkins (*Cucurbita pepo* L. convar. *giromantiina* var. *oleifera* Pietsch., Syn. convar. *citrullina* L., Greb. var. *styriaca* Greb.). The edible seeds are used mostly for producing oil for salad dressing. Depending on genotypes, the oil content ratio of a pumpkin seed amounts 40 to 50%. The oil is dark green and contains free fatty acids. The content of vitamin E, especially gamma-tocopherol, is very high. Seeds and oil can be used in pharmacology and alternative medicine, especially when biologically produced. Consequently, the production of pumpkin seeds is on the increase and the research of its cultivation techniques needs further research.

Production of oil pumpkins based on planting seedlings is an original idea that has not yet been studied or observed in practice. The objectives of this study were to check production possibilities using alternative seedlings grown in seedling tray to developed compact root systems, to shorten growth and development periods, to increase the yield, and to evaluate economic justification of the new production technique compared with the traditional method.

In a three-year field experiment, the effects of non-germinated, germinated seed sowings, and seedling plantings on growth and yield of oil pumpkins (cv. Gleisdorfer Öilkurbis) were investigated. Seeds for seedlings were sown in plug trays on 29 April and 1 May, and than the seedlings were planted on the sowing date of experiment (16 May).

Plants developed from seedlings grew vigorously and produced more fruits that exceeded the weight of fruits produced directly from seeds. The grain yield obtained by seedling plants was significantly higher ($3.35 \text{ kg } 20 \text{ m}^{-2}$) than the yields obtained by sowing non-germinated seeds ($2.06 \text{ kg } 20 \text{ m}^{-2}$) and by germinated seeds ($2.54 \text{ kg } 20 \text{ m}^{-2}$). However, the break-even cost per kg grain yield from seed sowings (0.98 EUR kg^{-1} grain yield) was lower than the cost from seedlings (1.20 EUR kg^{-1}). In this case, the 30% greater grain yield in seedling treatments did not compensate for the seedling cost. It is possible to increase production economy by reducing seedling and other expenses.

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POTENTIAL SOURCE OF REDUCED SATURATED PALMITIC AND STEARIC FATTY ACIDS IN SUNFLOWER OIL FROM A POPULATION OF WILD *HELIANTHUS ANNUUS*

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The present trend in human diets is to decrease the consumption of the saturated palmitic and stearic fatty acids. Healthy diets restricting not only total fat, but the saturated portion of that fat would decrease blood serum cholesterol and the risk of coronary heart diseases. Edible vegetable oils are the principal source of fats in many diets. Sunflower oil, which is fourth in production among edible vegetable oils in the world typically contains 6.5% saturated palmitic and 4.5% saturated stearic fatty acids. These levels are high compared to rapeseed oil with 4% palmitic and 2% stearic fatty acids. A reduction of saturated fats in traditional sunflower oil would lead to a healthier edible oil.

The objective of this preliminary study was to search the vast genetic diversity available from the wild ancestors of the cultivated sunflower for a potential source of reduced saturated fatty acids. A survey of wild annual *Helianthus annuus*, the closest relative of the cultivated crop, was undertaken to identify potentially useful populations with low (less than 7% combined) palmitic and stearic fatty acids.

Achenes of eighty-six populations of *H. annuus* were collected from the central Great Plains of the USA. For each population, a composite sample of 20 achenes was analyzed for saturated fatty acids using organic base-catalyzed transesterification of fatty acid methyl esters and capillary gas chromatography.

The average palmitic acid concentration ranged from 3.9% to 6.5% for the populations. Average stearic acid concentrations ranged from 1.9 to 3.7%. Achene oil of one population of wild *H. annuus* from Holmquist, SD had a palmitic acid level that averaged 3.9%, whereas stearic acid averaged 1.9%. The combined 5.8% palmitic and stearic acids is almost 50% lower than the present level of these fatty acids in sunflower oil. The level of saturated fatty acids observed in the population remained low when plants were grown in the greenhouse under uniform conditions. In the greenhouse, palmitic acid of this population averaged 4.0%, while stearic acid averaged 1.9%. This would indicate that palmitic and stearic acids have a genetic potential for selection. Crossing this population with an inbred cultivated line produced F1 plants with an achene oil that averaged 3.9% palmitic and 2.1 % stearic acids. The inbred cultivated parent averaged 6.1% palmitic and 5.1% stearic acids. Achene oil of F2 plants averaged 4.1% palmitic and 1.8 stearic acids, for a total of 5.9%. When F1 plants were backcrossed to the cultivated inbred, palmitic acid averaged 3.8% and stearic acid averaged 1.9% for a total of 5.7%.

Preliminary information indicates that palmitic and stearic acids in sunflower oil can be reduced by introducing genes from a population of a wild annual progenitor into cultivated sunflower. Further research will be needed to determine the inheritance of these fatty acids. Other agronomic traits will need to be monitored during the introgression of the fatty acids genes into cultivated sunflower.

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SORGHUM GENOTYPES WITH FOOD AND FEED POTENTIAL IN SEMIARID ZONES OF MEXICO

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Sorghum [*Sorghum bicolor* (L.) Moench] possesses a high degree of adaptability to a wide range of environments and can be cultivated on marginal lands. Sorghum is used as a source of food and feed, and as a raw material for industry. In 1998, 1,953,000 ha of sorghum was planted in the states of Tamaulipas (northeast), Guanajuato, Michoacán, Jalisco (Bajío), and Sinaloa (northwest) to yield 6,455,000 t.

The objective of this study was to select sorghum genotypes with food and feed potential.

Sorghum was seeded in the locality of Derramadero, Coahuila, México during the spring-autumn cycle of 2000. Fourteen white sorghum [*Sorghum bicolor* (L.) Moench] genotypes of the Sorghum Program of the University Antonio Narro were utilized. A randomized block design with three replications was used.

The agronomic traits evaluated were plant height, days to flower, excision, head size, weight of 1000 grains, grain yield, and green feed yield. Grain analysis included water content, digestible protein, raw fiber and total of digestible nutrients (TDN), as well as mineral (calcium, phosphorus and potassium) contents.

Results showed that grain yield ranged from 1.79 to 5.27 t/ha and feed yield from 14.2 to 23.9 t/ha. Protein content varied from 9.49 to 12.25%. The more promising genotypes were Cel95 N-997, Cel95 -754, Cel95N-755, and Cel95N-756.

Genotypes with food and feed potential, as well as with interesting genetic traits for the development of hybrids adaptable to the semiarid regions of Mexico were identified.

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A THIN-FILM PLANT ORGAN BIOREACTOR FOR IN VITRO GROWTH OF STORAGE ORGANS OF MEDICINAL AND NEUTRACEUTICAL CROPS: WASABI AND KONJAC

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Storage organs of herbaceous perennial species produce many valuable phytochemicals. The harvested organs often take several years to develop in the field, requiring intensive labor inputs for culture and harvest. A simple, thin film bioreactor has been developed for in vitro production of a wide variety of important plants. Differentiated plant organs, or whole plants are grown to large sizes and advanced developmental stages. This is in contrast to more often studied approaches of cell or callus cultures to produce phytochemicals, or micropropagation to produce juvenile transplants. We present two plant systems that demonstrate novel bioreactor technology for production of plant storage organs that produce bioactive compounds.

Wasabi japonica, a perennial dicot, produces a fleshy rhizome that is harvested after two years of intensive stream-bed culture. *Wasabi* has purported activities against parasites in the digestive system and is a valued condiment accompanying the highest quality sushi plates. *In vitro* culture requires manipulation of plant growth regulators, low temperature, and physical orientation during transitioning from micropropagation of buds, to shoot development, to swelling of petiole, to enlargement of rhizome. In a few weeks, shoots form a series of thickened nodes at the base

of the petiole. Over three to five months of sucrose loading in liquid media, the fleshy rhizome expands to weigh tens of grams.

Ammorphophallus riveri, a perennial monocot, produces a corm attached to a fleshy petiole. The corm is the source of b-1,4 glucan-rich polysaccharides and consumed as konjac. The polysaccharide fraction of konjac reduces high-density lipids in the cardiovascular systems. Unlike wasabi, konjac is determinate, producing one leaf per season, and the single leaf serves as the source of carbohydrates for corm development. *In vitro*, higher temperatures and light levels are necessary for konjac shoot development. Accumulation of biomass in corm organs requires a dark environment under water stress.

In both plant systems, storage organs in the lab accumulate field-years of storage tissue in months of culture time. The size of the tissue culture vessel and methods of nutrient replenishment afforded by thin film bioreactors allow progress to continue in producing high value biomass. One such device, the Liquid-Lab™ Kit, is under prototype development with commercial beta sites.

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EFFECTS OF PLANT GROWTH REGULATORS ON SPINY CILANTRO (*ERYNGIUM FOETIDUM*)

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Spiny cilantro is an important seasoning crop in the Caribbean, but little research has been done on this crop. While there are several publications related to its production practices, little is known about the effects of plant growth regulators on the crop. Information on such relations can be useful for the growers.

Experiments were conducted in Santo Domingo, Dominican Republic, to determine the effects of selected plant growth regulators on the growth of spiny cilantro.

Single plants were grown in 12-cm diameter plastic containers that were filled with a loamy clay soil from San Cristobal, Dominican Republic. Folkestone (0, 25, 50, 75, and 100 ppm), Biozyme® (100, 300, 500, and 700 ml/ha), gibberellic acid 3 (0, 25, 50, 75, and 100 ppm), kinetin (0, 25, 50, 75, and 100 ppm), methanol and ethanol (5, 10, 15, and 20%) in aqueous solutions were sprayed separately on plants at the 2 to 3 true-leaf stage. The treatments were arranged in randomized blocks with six replications. Plant height, leaf number, and dry weight were determined 35 days after the treatments. Analysis of variance and regression analysis were performed on the data.

Kinetin did not significantly influence the growth of spiny cilantro. In general, increasing the rates of Biozyme®, folcysteine, and gibberellic acid 3 enhanced growth. Ethanol and methanol did not affect growth at rates up to 10%, but at the higher 15 to 20% rates, the crop dry weight decreased compared with the untreated plants.

Production of spiny cilantro could be improved by the utilization of plant growth regulators such as Biozyme®, folcysteine, and gibberellic acid 3.

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INFLUENCE OF GIBBERELLIC ACID, BENZYLAMINOPURINE, KINETIN, TRIADIMEPHON, PACLOBUTRAZOL, AND NITROGEN ON THE GROWTH OF SAPODILLA (*ACHRAS SAPOTA*) AND TAMARIND (*TAMARINDUS INDICA*)

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Due to unexpected demands from buyers, transplant growers may be required to accelerate the growth of transplants, or to retard it when demand is lower than expected. While plant growth regulators have been tested to achieve the acceleration or retardation of the growth of many plants, there is little documentation regarding their utilization to manipulate the production of transplants of tropical fruit trees such as sapodilla and tamarind.

Container experiments were conducted in Santo Domingo, Dominican Republic, to determine the influence of selected plant growth regulators (PGR) in combination with nitrogen on the initial growth of sapodilla and tamarind transplants.

Plants of both crops were individually grown from seed in 15-cm in diameter by 20-cm high plastic containers filled with a 1:1 mixture of sand and clay loam soil. Nitrogen (N) from ammonium sulfate was applied to the soil at the rates of 0, 0.5, 0.75, 1.0, and 1.25 g per container. At all N rates, gibberellic acid (GA), kinetin (KIN), benzylaminopurine (BAP), triadimephon (TRI), and paclobutrazol (PAC) were individually sprayed on the crop leaves three weeks after emergence, at the rates of 0, 25, 50, 75, and 100 ppm. Combinations of PGR and N were arranged in randomized blocks with eight replications. Plant height was assessed weekly for seven weeks after application of PGR. Plant dry weight and leaf number were assessed seven weeks after PGR application.

Results were submitted to analysis of variance and regression. In both crops, increasing the N rate resulted in increased dry weight and plant height seven weeks after PGR treatment. Increasing the PAC and TRI rates resulted in reduced plant height. No effects were found for KIN and BAP on either sapodilla or tamarind. Gibberellic acid treatments increased plant height on both crops, with taller plants being produced at the higher rates.

These results suggest that KIN and BAP would be ineffective for growth regulation for tamarind and sapodilla in the nursery stage. However, TRI and PAC could be useful to constrain stem elongation, whereas GA could be utilized to favor vertical growth, depending on the requirements of the growers.

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N-46

IMPACT OF PHOSPHORUS FERTILIZATION ON THE COMPETITIVE ABILITY OF CILANTRO (*CORIANDRUM SATIVUM*) WITH LIVID AMARANTH (*AMARANTHUS LIVIDUS*)

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Management of mineral nutrients has been known to play a major role in integrated weed management strategies. There are research reports indicating that certain mineral nutrients affect the competitive ability of crops with weeds, in some cases in favor of the crop, in other cases in favor of the weed. Such reports are more frequent for major crops, but little are known about the influence of nutrients in the interactions of weeds with minor crops. Weedy amaranths commonly occur in cilantro fields, and these weeds have been reported to be little responsive to phosphorus (P). Determining the role of P in the amaranth-cilantro system would be an important asset in designing a management system for these weeds in cilantro.

The objective of this study was to determine the effects of phosphorus rates competitiveness of cilantro with weedy livid amaranth.

Experiments were conducted in Gainesville, Florida. Both species were grown from seed in plastic containers (20 cm in height × 15 cm in diameter) filled with sandy soil from Gainesville. A replacement series of cilantro: livid amaranth of 4:0, 3:1, 2:2, 1:3, and 0:4 plants per container were utilized to determine the inter- and intraspecific interference of both plant species when P at the rates of 0, 20, 40, 60, 80, and 100 kg/ha was applied to the soil before planting. Plants were grown for 50 days after the emergence of cilantro. The height of cilantro and livid amaranth plants was recorded every 10 days. At harvest, shoot fresh and dry weights were determined for both species. Analysis of variance and competitive ability were conducted on the resulting data.

Overall, livid amaranth was more competitive than cilantro in terms of dry matter accumulation. However, as P rates increased up to 60 to 80 kg/ha, cilantro became more aggressive in the crop-weed system. Increasing P supply to 100 kg/ha did not further improve the competitive ability of cilantro.

The results of this study indicate that interference of livid amaranth with cilantro was more severe under low P availability, whereas interference by this weed was mitigated when P is more abundantly supplied.

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INFLUENCE OF NITROGEN ON THE COMPETITIVENESS OF SPINY CILANTRO (*ERYNGIUM FOETIDUM*) WITH PURPLE NUTSEDEGE (*CYPERUS ROTUNDUS*)

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Purple nutsedge is categorized as the worst weed of the world, due to its aggressive interference with the growth of most vegetables and herbs. Previous research has found that manipulation of nutrients could be utilized to shift the balance of interference to favor crops instead of weeds. However, there is no documentation on the effects of nutrients in the interference of weeds with minor herb crops such as spiny cilantro. Information would prove valuable to improve weed management in this crop.

Studies were conducted in Gainesville (Florida, USA) and Santo Domingo (Dominican Republic), to determine the influence of nitrogen fertilization on the competitive ability of a spiny cilantro with the weed purple nutsedge.

Spiny cilantro (2 to 3 true-leaf stage) and viable purple nutsedge tubers from Gainesville and Agua, Dominican Republic, were utilized for the experiments. The crop and the weed were grown in plastic containers (20 cm in height x 15 cm in diameter) filled with sandy soil from Gainesville (in Florida) and from Azua (in Santo Domingo). A replacement series of spiny cilantro: purple nutsedge of 4:0, 3:1, 2:2, 1:3 and 0:4 plants per container were utilized to determine the inter- and intraspecific interference of both plant species at nitrogen fertilization rates of 0, 25, 50, 75, 100, and 125 kg/ha. Plants were allowed to interfere during five weeks after transplanting the spiny cilantro and the purple nutsedge tubers. The variables evaluated at harvest were dry weight and height in spiny cilantro, whereas in purple nutsedge plant height, as well as shoot and tuber number and dry weight were determined. Analysis of variance and competitiveness were performed on the resulting data.

Results indicate that purple nutsedge was more competitive than spiny cilantro at all nitrogen rates purple in a one to one plant basis. As nitrogen rate increased, purple nutsedge became more aggressive in its interference with the growth of spiny cilantro.

These results indicate that interference from purple nutsedge might drastically affect dry weight accumulation in spiny cilantro, and that increasing nitrogen availability in the crop-weed system would exacerbate the negative impact of the weed on the crop.

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DIGITARIA EXILIS AS A CROP FOR THE DOMINICAN REPUBLIC

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Digitaria exilis (known as "funde" in the Dominican Republic) is a plant in the family Poaceae. It seems to have originated in Western Africa, where it has been cultivated for centuries. The plant was introduced into the Caribbean during European colonization. The crop remained marginal in the Dominican Republic for generations. High market prices, fueled by a delicacy status and supposedly aphrodisiac properties have renewed interest in this almost-forgotten crop. A number of surveys have been conducted to gather local information on this species as a first step to explore the possibility to improve its production.

The objective of this study was to collect and report on the occurrence of *Digitaria exilis* as a crop for the Dominican Republic.

Interviews were conducted with past and present growers and consumers, marketers and crop production consultants that had knowledge of the crop, its utilization, and preferences of consumers. Data was gathered and, when possible, verified with other parties or observed *in situ*.

The information collected indicates that *Digitaria exilis* is mostly limited to marginal areas of the San Cristobal Province (southcentral coast of the country). It is grown in small areas with limited or no chemical inputs. Growers use the plant as a pasture in soils where other species do not prosper, but it is more valued for the seed, which is consumed in various forms. The crop has a strong reputation as an aphrodisiac. The price of the grain and the flour derived from it is higher than most cereals, and demand for it seems to be largely unsatisfied. A variety of cultural practices have been recorded for this crop. There are possibilities for plant breeding, as most growers save their own seed and genetic drift between the propagation material of different growers is likely to have occurred over time.

The results of these surveys suggest that *Digitaria exilis* has a high potential to become a more important economical crop for the Dominican Republic in the near future. A research group to work on this crop is already being formed.

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PLANT YIELD DETERMINES SEED COMPOSITION IN GUAR (*CYAMOPSIS TETRAGONOLOBA* L.) WITHOUT SIGNIFICANT CHANGES IN SEED ENERGY CONTENTS

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N-50

ANTIOXIDANT ACTIVITY OF BASIL (*OCIMUM* SPP.)

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The commercial development of plants as sources of antioxidants that can be used to enhance the properties of foods, for both nutritional purposes and food preservation, is currently of interest. Epidemiological studies have suggested positive associations between the consumption of polyphenol-rich foods or beverages and the prevention of diseases, and in part this appears to be due to their antioxidant activity. Basil, a common culinary herb, is cultivated in the United States as a fresh herb, dried spice, and source of aromatic essential oils. The varieties available in the market are found to contain a wide range of essential oils, some of which rich in phenolic compounds. The objective of this study was to evaluate the antioxidant activity of basil essential oils, its purified components, and ethanolic extracts.

Four green basil varieties including Italian large leaf, Basil, Cinnamon (*Ocimum basilicum*) and Sweet Dani Lemon basil (*O. citriodorum*), plus four purple varieties, Dark Opal, Osmin, Purple Ruffles, and Red Rubin (*O. basilicum*), plus one accession of *O. canum* (Holy Basil) were tested for *in vitro* antioxidant activity using two screens, the ABTS (TEAC) and FRAP assays. For comparison purposes, Greek Oregano and Green Tea were also assessed as products recognized for their high antioxidant activity.

In the essential oils of sweet basil, antioxidant activities were greatest in Dark Opal and Osmin, and both also contained high levels of eugenol. Purified eugenol also showed the highest antioxidant activity relative to other essential oils. In contrast, the antioxidant activity of the other basil oils was much lower, because their principal volatile constituents included components which also by themselves exhibited low antioxidant activity (methylchavicol, methyleugenol, methylcinnamate, and citral).

In the ethanolic extract, the phenolic content was higher in the purple basil (Dark Opal>Red Rubin>Osmin>Purple Ruffles) than in the green varieties (Italian Large Leaf>Sweet>Lemon>Holy>Cinnamon). There was a close relationship between the phenolic content and antioxidant activity expressed as TEAC ($r^2=0.93$) and FRAP ($r^2=0.82$). These results demonstrate that the antioxidant activity in basil is mainly due to its phenolic content. In all basil, the essential oil contribution to the total antioxidant activity was low, varying between 0.25% in Italian large leaf and 5% in sweet basil with modest concentration of eugenol (18% rel. to total EO). These results suggest that the main antioxidant activity from these plants does not arise from their essential oils, but rather from other phenolics such as flavonoids in green basil and anthocyanins in purple basil.

Compared with green tea, the basil showed a low total phenolic content and antioxidant activity. However, the antioxidant activity of purple basil was similar to that of Greek Oregano, and they could contribute a significant amount of dietary phenolics.

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GENETIC AND CHEMICAL DIVERSITY OF ECHINACEA SPECIESJ. Kapteyn^{1, 2}, J.E. Simon¹, and P.B. Goldsbrough²¹Center for New Use Agriculture and Natural Plant Products, Rutgers University, New Brunswick, NJ 08901, USA; ²Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907, USA

Echinacea products are among the most popular natural products in the U.S. and in Europe. This popularity has spurred an interest in the expansion of commercial cultivation of the three commercially utilized *Echinacea* species (*E. purpurea*, *E. pallida*, and *E. angustifolia*). To date, there is no information available regarding the genetic diversity or chemotypic diversity present in available germplasm. The objective of this study was the estimation of levels of genetic diversity present in commercially and publicly available germplasm of these three *Echinacea* species using RAPDs (Random Amplified Polymorphic DNAs) markers and to evaluate the chemotypic diversity of the biologically active caffeic acid derivatives using HPLC analysis.

Plants representing a total of 18 accessions of the three *Echinacea* species and an outgroup *E. atrorubens* accession were grown from seed in a greenhouse, and total DNA was isolated separately from four individuals of each accession for RAPD analysis. PCR reactions were performed using random sequence decameric primers. PCR products were separated via agarose gel electrophoresis and scored. Pairwise similarity matrix generation, cluster analysis, and principal coordinate analysis were performed using NTSYS-pc. Population genetic structure was analyzed within each of the three species to identify potentially unique accessions using the AMOVA analysis feature of the Arlequin program

Analysis of caffeic acid derivatives was performed using an Agilent LC system. Analytes of interest included chicoric acid, chlorogenic acid, cynarine, echinacoside, and caftaric acid. Accumulation of these compounds was measured for dried roots of the 19 accessions harvested after four seasons of growth, with each accession represented by 15 individuals. Chemical analysis is underway and diversity information obtained from this data will be correlated to RAPD data.

One hundred and one RAPD markers were generated for this analysis. Seventeen diagnostic markers suitable for the discrimination of these three species plus *E. atrorubens* were identified. Overall genetic diversity levels were similar for the three species, and all species were clearly distinct from one another. AMOVA analysis revealed several accessions that were significantly different from others within the same species.

RAPDs was successfully applied to determine the level of genetic diversity present in germplasm of three *Echinacea* species. AMOVA analysis revealed accessions that appear to be genetically unique and may also be useful in identifying duplicate accessions. We expect that chemical diversity data will correlate with the RAPDs data and that the combined analyses will prove to be a useful tool in future germplasm evaluations for this genus.

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EXAMINATION OF VARIETAL DISTINCTIONS OF FRUITS OF OBLEPIHA (*HIPPOPHAE RHAMNOIDES*) IN THE ACCUMULATION OF HEAVY METALSE.R. Klevakin¹, I.I. Lobatcheva¹, and W. Letchamo²¹Faculty of Biochemistry, ASU, Siberia (Altai), Russia; ²Cook College, New Use Agriculture, and Plant Natural Products, Rutgers University, New Brunswick, N.J. 08901, USA

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IN VITRO REGENERATION AND TRANSFORMATION OF ECHINACEA PURPUREA LEAF EMPLANTSA. Koroch¹, J. Kapteyn^{1,2}, H.R. Juliani¹, and J.E. Simon¹

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Echinacea has gained considerable attention because of its increasing economic value and use as a medicinal plant. The genus *Echinacea* (purple coneflower) is represented by eleven taxa found in the United States and in south central Canada. *Echinacea purpurea* is the most widespread species and the most widely cultivated medicinal species of the genus.

The objective of this work was to develop an efficient *in vitro* regeneration method and an *Agrobacterium tumefaciens* transformation method for *E. purpurea* leaf explants.

Young leaf tissue was collected from *E. purpurea* plants grown in a greenhouse and was surface sterilized and cultured on Murashige and Skoog media containing myo-inositol (100 mg l⁻¹), thiamine (0.4 mg l⁻¹), and sucrose (2% w/v). This media was supplemented with different concentrations of 6-benzylaminopurine (BAP) alone or in combination with naphthaleneacetic acid (NAA). For rooting induction, elongated shoots were transferred to basal medium alone or in combination with indolebutyric acid (IBA). Transformation experiments were performed using *Agrobacterium tumefaciens* EHA105 carrying the neomycin phosphotransferase (*nptII*) selectable marker and the b-glucuronidase (*gusA*) reporter gene. Transformation conditions were optimized as determined by comparison of transient GUS expression.

Proliferating shoot cultures were achieved for leaf explants associated with a high number of shoots per explant (7.7 shoots/explant). Plantlets were rooted on MS medium alone or in combination with different concentrations of indole-3-butyric acid (IBA). All plantlets survived acclimatization producing healthy plants in a greenhouse. High levels of transient GUS expression were achieved. Transgenic plants were subsequently regenerated on selective media. Transformation was confirmed via histochemical GUS assays, PCR, and DNA blot analysis.

Establishment of an efficient regeneration system will facilitate the development of ornamental and medicinal genotypes by permitting the rapid clonal multiplication of large numbers of plants from a single elite parental selection. Clonal plant material will also facilitate ongoing secondary metabolic physiological investigations and agronomic studies. Lastly, this regeneration system coupled with the application of *Agrobacterium* transformation will permit genetic engineering and improvement of this important medicinal.

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HPLC EVALUATION OF ECHINACEA FROM VARIOUS SOURCES AND NEW SUGGESTIONS FOR CICHORIC ACID LEVELS AND FURTHER TRAITS FOR INDUSTRIAL PROCESSING

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Introduction of advanced cultural methods, selection and genetic improvement, standardization, and effective quality control measures of echinacea are important prerequisites to increase efficacy, and to build confidence by growers, manufacturers, marketers, and consumers. There has been an increasing interest for plant based natural products for health and personal care applications. The quality of the raw materials and the minimum standards needed for certain chemical components that are known to have the highest activity has always been decided by the supplier(s) of the product. Echinacea products obtained from various sources were analyzed to have extremely different quality and content of the active principles.

The objectives of this study were, therefore, to study the quality of the Echinacea raw materials obtained from various international and national sources, and study factors that contribute to the variations, and to establish the variations in the content of cichoric acid and other substances that have useful phytopharmaceutical applications.

Dried samples of field and hydroponically cultivated Echinacea were obtained from various sources in Europe, New Zealand, Africa, Latin America, Canada and the U.S.A. The samples were extracted by standard water-alcohol extraction method and subjected to HPLC analysis.

We found significant variations in crop yield, disease resistance, content of essential oils, cichoric acid, total phenolic substances, chlorogenic acid, kaffeic acid, echinacoside, and isobutylamides due to geographic conditions, cultivation methods and plant developmental stages of *E. purpurea*

and *E. angustifolia*. There was also clear difference between the species in resistance to diseases, frost and the chemical content. In line with this, we were able to identify and select Echinacea lines with promising ornamental values. The impact of various diseases and insect infestations on the raw material was clearly identified and the implication of this problem to the consumers is discussed. Significant genetic variations in natural product quality will also be reviewed. Based on the results of experimental analyses that were obtained from various sources, we suggest that a minimum of 2.2 % cichoric acid content in raw material of *E. purpurea* can be recommended as a standard for industrial processing.

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HIGH QUALITY ESSENTIAL FATTY ACID CONTAINING SIBERIAN OBLEPIHA CULTIVARS FOR NUTRACEUTICAL, COSMETIC, AND ENVIRONMENTAL APPLICATIONS IN THE UNITED STATES

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There is a growing interest in many countries to introduce, cultivate, process and bring into commerce oblepia (*Hippophae rhamnoides*) and its products. Although oblepia does not belong to the leguminous family, its roots are known to contain the highest amount of the atmospheric fixing symbiotic rhizobium, compared to other known species so far. The oil and extracts obtained from different organs, including its roots has high contents of oil, essential oil, essential fatty acids, flavonoids, other polypyphenols, minerals, amino acids, probably the highest concentration of natural serotonin and many other substances of health interest. Historically Russia or the former Soviet Union was the first country to introduce oblepia into systematic cultivation for nutritional, pharmaceutical, cosmetic and veterinary applications.

The objectives of this research were to find suitable oblepia varieties for industrial cultivation and processing for nutraceutical market in North America, to create competitive niche market for the U.S. farmers in the international market, and to find alternative crops that could improve the soil microbial and chemical conditions naturally due to the symbiotic relationship of the root rhizobium that can build natural nitrogen and other organic substances to the soil and positively influence the environmental conditions in general.

In 1996, five different cultivars (Dar Katugne, Tchyskaja, Oranzsevaja, Maslitchnajam, and Tchuiskaja) of oblepia cuttings were introduced into Washington State, U.S. The plants were then propagated in the greenhouse by cuttings. When rooted, they were transplanted to the field at the end of April. Among the five varieties, introduced Tchuiskaja, Dar Katugne, and Oranzsevaja were most successfully established and grown in the field. Data on the comparative studies of the plants and their quality (growth character, yield of berries, content and composition of the oil, carotenoids, essential fatty acid contents, and physical and organoleptic tastes) were carried out. We found that the three cultivars grown under the northwest conditions were comparable to the original material grown in Siberia. Further perspectives in relation to the potential of oblepia and recommendations for the development of the introduced varieties and additional varieties are given.

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KOREAN VEGETABLES: NEW FRESH PRODUCE FOR

THE EMERGING ETHNIC MARKETS

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In New Jersey, rapid urbanization coupled with increasing land values and a rapidly changing demography (> 32% ethnic population in 2000) provides a compelling case for agriculture based on high-value crops. As New Jersey now has the most diverse ethnic population of any state in the USA, the introduction of fruits and vegetables long known to those ethnic communities, but largely unknown to most American farmers creates

a potential production opportunity in the search for new market-driven fresh produce. A multidisciplinary research and extension team in concert with New Jersey agricultural leaders, growers and marketers have come together to examine the production and market potential of Hispanic/Latino, Asian, West African, Russian, and Korean fruits and vegetables.

This paper presents our preliminary work obtaining from our South Korean collaborators the most popular Korean vegetables from their commercial seed companies, and evaluating their production potential here in New Jersey. We are evaluating:

- 1). *Brassica campestris* L. ssp. *chinensis* Jusl./ CheongKyungChe/ Green bak choi. This originally was introduced into Korean from China;
- 2). *Brassica campestris* subsp. *napus* var. *pekinensis* Makino. /Baechu/ Chinese cabbage ('Kumchon', 'Summer Style', 'Winter Visitor'). This type of Chinese cabbage is used in the preparation of Kimchi, a very popular and important side dish of Korean foods;
- 3). *Chrysanthemum coronarium* L./ Sukgat/ Edible chrysanthemum('Jungyoup'); and used as a salad green;
- 4). *Cichorium endiva*: Endive, this popular salad green was first introduced into Korea from America and Europe, and was examined here to determine if the Korean variety differs significantly from that available and grown in the US;
- 5). *Lactuca sativa* L./ Sangchu/ Korean lettuce ('Local' and 'Sunny'). These local and bred varieties, respectively is consumed with roasted beef, called Galbi or also known as Bulgogi. The local variety has a bitter taste preferred by the older generation; while 'Sunny' is mild taste and less bitter and preferred by the younger generation;
- 6). *Raphanus sativus* var. *hortensis* for. *acanthiformis* Makino. / Muwu/ Radish ('Spring Bantam');
- 7). *Spinacia oleracea* L. /Sigumchi/ Spinach . This local Korean spinach has cold tolerance and a very sweet taste.

While these and other collections being introduced are standard popular vegetables in Korea and some may be new to the U.S., others originally from the U.S. have been developed to meet the environmental/agricultural/ and consumer needs of the Korean people. As this market-driven program seeks to introduce here fresh produce that the targeted ethnic communities seek, for vegetables we are first examining those commercially available varieties from that targeted country or region. Production results (quality of product plus potential yield) at two sites in central and southern Jersey in 2001 will be presented and discussed.

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DEVELOPING FUSARIUM TOLERANT BASIL

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Fusarium is the major disease problem affecting commercial basil growers. Our research has focused in screening basil varieties for tolerance to fusarium and in identifying genetic materials which exhibit tolerance.

Three experiments were conducted in the United States and Israel to evaluate the levels of resistance of basil types (*Ocimum* spp.) to *Fusarium oxysporum* f. sp. *basilici* (Fob) isolates. In the U.S. experiments, 14 basil types consisting of 11 sweet basil, one cinnamon basil, one lemon basil, and one camphor basil were artificially inoculated, at a younger and older growth stage, with an American isolate of *Fusarium oxysporum* f. sp. *basilici*, in the greenhouse. Inoculations for the younger basil plants were conducted at the 6-8 true-leaf stage, while the older basil plants were inoculated at the 8-10, and 10-12 true-leaf stages. Disease progress was evaluated at 7- and/or 14-day intervals, post-inoculation using disease severity index, percent plant survival, and percent reduction in plant height to assess wilt resistance.

There was significant variability in *Fusarium* wilt resistance among the 14 cultivars. NUFAR, a Sweet basil type resistant to an Israeli pathogen isolate, manifested delayed symptom expression, though most plants died at the termination of the experiments. Sweet Basil and Chen, were the most susceptible cultivars, whereas Sweet Dani, a lemon basil type, expressed the highest level of resistance. All the basil types tested, except Sweet Dani, exhibited the same high level of susceptibility, and confirmed that lemon basil type can be used as a source for resistant germplasm. The Israeli study reconfirmed the resistance of NUFAR and the high degree of susceptibility expressed by Chen to the Israeli Fob isolate(s).

Large-scale screening of four basil varieties artificially inoculated with a mixture of four virulent fusarium isolates led to the identification of individual plants of each variety which exhibited no visual symptoms to fusarium. The screening of more than two generations of promising plants led to the selection of more than 50 lines, which did not exhibit any fusarium symptoms. These lines were screened in a commercial field in Richland, New Jersey, known to contain high concentrations of fusarium, during the 2001 growing season. Results indicate that most all the selections exhibited fusarium tolerance, with several accessions of each of the four original varieties showing high degree of tolerance (no symptoms), as well as vigor, uniformity and trueness to varietal type. From our greenhouse and field confirmation study, we now improved basil varieties of 'Sweet Basil', 'Large Italian Leaf' and 'Mammoth' that exhibit strong fusarium tolerance.

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MEDICINAL PLANTS FROM CENTRAL ASIA

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The former Soviet Union covers 1/6 of the earth's landmass and encompasses an extremely broad range of plant diversity. A large number of plant species including medicinal plants originated in this region. The germplasm from this area could be of value to ongoing breeding programs to provide new medicinal crops and/or new compounds for the pharmaceutical industry and the botanical/dietary supplemental industry in the US and Europe.

The Russian scientist, Nikolai Vavilov, and thousands of his colleagues collected germplasm from all over the world. The most extensive plant collections in the world are located at the Vavilov Institute in St. Petersburg, Russia and at the branch of the Vavilov's Institute in Tashkent, Uzbekistan. As part of a collaborative project between Rutgers University and Uzbekistan and Kyrgyzstan several medicinal plants were collected from these two independent nations of Central Asia and brought in the U.S. for evaluation. The objectives of this research were to evaluate each species for their potential under New Jersey conditions, and to generate basic information on the plant's growth, yield, and natural products content.

From Uzbekistan, we collected germplasm of *Acorus calamus*, *Echinacea purpurea*, *Ephedra equisetina*, *Rhamnus dahurica*, *Salvia sclerea*, *Zizyphus jujuba*; and from Kyrgyzstan: *Aerva lanata*, *Agrimonia asiatica*, *Althea cannabika*, *Ammi majus*, *Bidens tripartita*, *Bryonia abbi*, *Calendula officinalis*, *Chelidonium majus*, *Conium maculatum*, *Foeniculum vulgare*, *Filipendula hexapetala*, *Hyssopus seravschanicus*, *Inula grandis*, *Lavandula vera*, *Leonurus turkestanicus*, *Linum usitatissimum*, *Ocimum basilicum*, *Pastinaca sativa*, *Potentilla erecta*, *Inula helenium*, *Ricinus communis*, *Salvia officinalis*, *Sanguisorba officinalis*, *Silybum marianum*, *Scutellaria baicalensis*, and *Valeriana officinalis*. In the spring of 2001, each species was planted at the field at the Snyder Research and Extension Farm, Rutgers University, New Jersey.

Results of this new program will be presented along with background information on the medicinal values of each plant species.

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CHARACTERIZATION AND DIFFERENTIATION OF SEVERAL CITRUS PEEL OILS

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QUALITY ASSURANCE AND QUALITY CONTROL FOR THE AFRICAN NATURAL PLANT PRODUCTS FROM THE GROUND UP

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The demand for natural plant products and their formulations with minerals, vitamins and many other substances has been increasing during the last decade. In the past, herbs and essential oil plants were harvested from the wild and brought to the market without any question about their origin or methods of cultivation. With further improvement in communication and education, however, there has been a growing consciousness among the industrialized nations about the environment, health care, sustainable harvesting, and the loss of genetic diversity through wild harvesting of the wild species. Botanical misidentification, inappropriate methods of collection and processing with undesirable foreign matter, has all negatively impacted the competitiveness of the African natural products in the international markets.

The objective of this work was to establish dependable methods of standard operation procedures (SOPs) for the cultivation, sourcing of seeds and methods of their treatment, harvesting and processing, packaging, and forwarding systems for natural plant products developed through Agribusiness in Sustainable Natural African Plant Products (ASNAPP) for International markets. Unique African bush teas and essential oils from various locations were collected and investigated for their quality, antimicrobial, and antioxidative properties.

SOPs were designed and set up for the production and supply of the raw materials to the International natural products markets. Problems were identified that would limit the availability or acceptability of African bush teas and recommendations for the solution have been developed. Total microbial count issues were the most limiting factors that were found with the tea samples obtained. Lack of well-trained African partners who understand the issues of quality and standards for the preparation of the raw material from the ground up was another problem that was identified during this work. In addition to this, new methods were established for tracking of the plant materials from the cultivation or wild harvesting, processing to the packing and forwarding the products to their destinations. We developed hard copy and an electronic version of tracking systems for agricultural practices, plant introduction, cultivation, wild collection, drying, and in-house quality control procedures that could be well understood and handled by participating farmers, middlemen and processors, trading and promotional companies, including packing, and forwarding companies.

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NIGERSEED- A SPECIALTY GRAIN OPPORTUNITY FOR MIDWESTERN USA

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Nigerseed (*Guizotia abyssinica*) is native to east Africa from Ethiopia to Malawi and was probably domesticated in Ethiopia. Early introduction of nigerseed to India was followed by the development of sizeable commercial production. About 50 to 60% of the Ethiopian edible oil is derived from nigerseed, whereas it accounts for almost 2% of total oilseeds produced in India. Estimates of nigerseed production vary from a minimum of 440 to 750 million pounds worldwide.

Nigerseed has been marketed as bird food for about 40 years and is the only major ingredient of wild bird food imported into the U.S. from overseas. The U.S. imports of nigerseed in 1998 and 1999 were over 60 million pounds and exceeded 71 million pounds in 2000. The wholesale foreign price, before freight and importation costs, averaged (per pound) \$0.24 in 1998, \$0.32 in 1999, and \$0.28 in 2000. Imported nigerseed must be heat treated to kill any potential dodder seed contamination. After heat treatment and shipment, U.S. wholesale customers reportedly pay a wholesale price around \$0.50 per pound. Both the price and market proximity for nigerseed is attractive to Midwest grain producers and the

product would not require heat treatment.

Ethiopian niger crop breeding efforts have resulted in at least three maturity groups and plants which tend to be shorter, more branched, and tolerant of cool conditions than the Indian types. Nigerseed is cultivated in both temperate and tropical climates, being considered a temperate-region plant that has adapted to a semitropical environment. Nigerseed was grown in Minnesota for three years in the late 1970s to evaluate its potential. A conclusion was to try it in southern and central U.S. where a longer season should benefit the flowering and seed set. Ethiopian nigerseed planted in west-central Indiana in May of 2000 flowered by early July, peaked in flowering by late July/ early August and seed was apparent in most flower heads. Seed was harvested in mid-September, but yield extrapolation was impractical due to the large combine and small crop area. Data on nigerseed grown in 2001 at various Midwestern locations will be reported.

Yields of nigerseed reported in literature have varied from 224 to 448 lb/acre to 672 lb/acre to over 1,120 lb/acre. The latter yield figure was achieved by sowing newer cultivars. Given yields of 800-1000 lb/acre, 70,000 to 87,000 acres would be required for nigerseed production in the U.S. to supply the current demand. The USDA Western Plant Introduction Station maintains over 20 accessions from India and Ethiopia. Nigerseed appears to be a good niche market at an attractive price. A clear need is to determine if a current germplasm source could be increased into a viable variety, or if a substantial plant breeding effort is required to adapt nigerseed to a Midwestern location.

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Edamame: A New Nutritious Vegetable Crop in the United States

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Soybean [*Glycine max* (L.) Merrill] is a major source of edible vegetable oil for human consumption and protein in animal feeds. Currently, the price of commodity soybean is declining mainly due to increasing production in South American countries. Therefore, there is need for identification of soybean for specialty uses and diversification of its utilization to sustain future production of soybean in the U.S. Edamame (pronounced "eh-dah-MAH-meh) are vegetable soybeans with large seeds (seed dry wt. >250 mg), harvested for fresh green pods before maturity when the seeds are still green and approximately 80% matured (R6 stage). Edamame is the Japanese term for cooked green vegetable soybean pods served as snacks similar to peanuts in the shell. There is an increasing demand for edamame as fresh, canned or frozen vegetable, or as roasted soynuts. Fresh or frozen edamame can be cooked just like sweet peas (*Pisum sativum* L.) or lima beans (*Phaseolus limensis* L.), either stir-fried or added to stews and soups. They are highly nutritious and rich in phytochemicals beneficial to humans. The U.S. imports more than 10,000 t/y of frozen edamame and is likely to increase to about 25,000 t/y by 2005. However, lack of consumer base and adapted cultivars are the major factors limiting edamame production in the U.S.

A major objective of this study was to evaluate eight vegetable soybean cultivars of Japanese origin, four large-seeded plant introduction lines in comparison with two adapted U.S. cultivars for their production potential in southeastern U.S.

The genotypes were planted May/June in a randomized complete block with four replications and were harvested at the R6 stage to determine green bean yield, yield components, and fresh seed compositional traits. Crop management as per recommendations for soybean.

The genotypes produced a mean fresh pod yield of 18.5 t/ha and fresh seed yield of 9.6 t/ha. PI 181565, 'Tanbagura,' 'Shangrao Wan Gingsi,' and PI 200506 with mean fresh pod and seed yields in excess of 20 and 10 t/ha, respectively offer potential for commercial production in the southeastern U.S. Seed oil and protein contents ranged from 5.0 to 6.9% and 33.3 to 38.6% on fresh weight basis, respectively.

The study showed that edamame could be a potential vegetable crop with multipurpose uses in the southeastern U.S. The edamame has been reported to be nutritionally similar or even superior to green peas. Despite its strong beany flavor, edamame makes a more nutritious vegetable and a snack than green peas. Quality parameters for selections of marketable edamame, the nutritional composition of edamame compared with peas and beans, and yield data from four-year field experiments will be presented. Also, soybean as a potential vegetable will be discussed in relation to green peas.

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THE NORTH CAROLINA SPECIALTY CROPS PROGRAM

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The North Carolina Specialty Crops Program (SCP) was initiated in 1997 to identify and develop new agricultural commodities for a 13-county region in eastern North Carolina. In 2000, it became a statewide program. The program is a cooperative effort among research, extension, and marketing personnel from the College of Agriculture and Life Sciences at N.C. State University and the N.C. Department of Agriculture and Consumer Services, Division of Marketing.

When determining which new crops or value-added concepts to work on, the SCP solicits new ideas and proposals from growers, industry, researchers, and two advisory committees. The grower advisory committee and marketing advisory committee help choose which of these new crops to study. University researchers then grow the crops on one or more of the 18 research stations. The objective at this stage is to determine if the crops are appropriate for a particular region in the state, and if so, to identify the best varieties to grow and develop efficient production methods. At the same time, produce from the research studies are used in test marketing conducted by the marketing specialists. These include promotional events, taste tests, consumer surveys, and test-marketing sales with cooperating chain stores. If the crop looks promising, both in terms of production and marketing, the crop is moved into the grower-trial phase.

For this phase, county agents help select farmers to grow the first small-scale commercial plantings of the crop. The agents and SCP personnel provide assistance in production and marketing. The marketing specialists make arrangements with buyers and help develop appropriate packaging, labeling, and promotional materials. If successful in the market and in grower field trials, a grower education campaign is launched consisting of workshops, cultivation and marketing leaflets, and incorporation of the information on the SCP website. Those who decide to grow the crop are provided with assistance in growing and marketing the crop for the first several years.

Successes of the program include development of commercial production of seedless red watermelon, 'Sprite' melon, and fall lettuce in eastern N.C. The SCP was also involved in the establishment of the Southeastern Growers Association and shipping under the "Carolina Specialities" label. In 2001, research is being conducted on off-season production of several small fruits, vegetables for the several ethnic markets, new melons, several industrial crops for oil and insecticide production, and nursery production of crops for beach restoration. New ideas for the growing agritourism industry are also being examined.

The Specialty Crops Program has been successful in North Carolina and provided timely information for the many growers struggling with falling prices and shrinking markets for their conventional crops. For more information on the Specialty Crops Program, visit the website at <http://www.ncspecialtycrops.org>.

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