

Agave sisalana Perrine

by Karen Brown,

University of Florida, Center for Aquatic and Invasive Plants, 7922 N.W. 71st Street, Gainesville, FL 32653; kpb@mail.ifas.ufl.edu

Introduction

Agaves are often associated with the alcoholic beverages *tequila* (produced from *A. tequilana*) and *mescal* (produced from *A. salmiana* and other species). *Agave sisalana* Perrine is known for its fiber production, and is commonly known as “sisal” or “sisal hemp”. It is the primary agave cultivated for fiber in eastern Africa, Brazil, India, and various countries in Asia. In the first half of the twentieth century, sisal supplied about 70 percent of the world’s long hard plant fibers (Nobel 1994). The fibers run the entire length of the leaves, which can grow to five feet, and have been used for rope, twine, nets, upholstery padding, carpet pads, blankets, baskets, jewelry, sandals, clothing, fish stringers, musical instruments, ceremonial objects, construction material, paper pulp, and even dart boards (Nobel 1994). Although sisal is native to Mexico, commercial hard fiber from Mexico is produced primarily from henequen (*A. fourcroydes*) and lechuguilla (*A. lechuguilla*). According to Nobel (1988), *A. sisalana* was exported from Mexico in the 19th century and formed the basis of fiber industries in Indonesia, the Philippines and, in the

Agave sisalana

This somewhat startling picture is taken from a postcard photographed at Bridon Fibres, Gateshead, UK. It depicts fibers extracted from sisal leaves (*Agave sisalana*) that are “...combed and carded and loosely twisted into... slivers before being spun into rope.” (copyright, Trustees, Royal Botanic Gardens, Kew. Used with permission.)



20th century, East Africa. Later, Mexico prohibited the export of the plant to protect its own fiber industry but, by then, plants were available in Florida, having been imported and established by Dr. Henry Perrine (Morton 1952, Nobel 1994, Trelease 1913). Nobel reports that 1,000 bulbils were sent from Florida to Germany in 1893. Bulbils are young plantlets, usually at least four inches in length, that occur on

the inflorescence and can be planted directly in the soil. Approximately 200 bulbils survived the trip and 62 survived the ensuing trip to German East Africa (now Tanzania). Within five years, these plants multiplied into 63,000 starter plants for large plantations in Tanzania, Kenya, Mozambique and Uganda. These plantations eventually supplied approximately half of the world’s hard fiber (Nobel 1988, 1994). By the early 20th century, *A. sisalana* also was cultivated in India, Southeast Asia, many Pacific islands, and Australia (Nobel 1988).

Field reports

Agave sisalana Perrine, commonly known as sisal hemp, is on the FL-EPPC Category II list of invasive species. According to a FL-EPPC database search in January 2002, there were 24 field reports for this species, with the most reports coming from Dade County (7), followed by Monroe County (5), Martin (4), Palm Beach (3), Lee (2), Broward (2) and Sarasota (1). Lee County leads in acreage reported at 600 acres, followed by Martin at 84, Monroe at 34, and Broward at 19. However, only 7 of the 24 field reports included estimates of acreage. Of the 15 density estimates provided, one “dense monoculture” was reported in Dade County, one in Sarasota County, and one in Monroe County. All other density estimates were “scattered plants.” The University of South Florida’s online *Atlas of Florida Vascular Plants* (www.plantatlas.usf.edu/), which is based on vouchered herbarium specimens, lists *Agave sisalana* in Brevard, Manatee, Lee, Collier, Monroe, Dade and Martin counties, (i.e. it lists specimens in 3 counties *not* listed in FL-EPPC field reports (Brevard, Manatee, and Collier), while FL-EPPC has field reports for 3 counties *not* listed in the online atlas (Palm Beach, Broward, and Sarasota).)

Origin of *Agave sisalana*

The genus *Agave* was established by Linnaeus in 1753 and contains approximately 136 species in the Agavaceae family (Nobel 1988). Agaves are native to North America, with their center of origin in present-day Mexico (Gentry 1982, Nobel 1988). Gentry reports that the “origin of *Agave sisalana* is uncertain. Because it was originally exported from Mexico via the port of Sisal in Yucatan, it has long been erroneously reported as of

Yucatan origin. However, no botanical collections of the plant have ever been made in Yucatan, and botanists who have worked in Yucatan have told me they did not find the plant there."

Fiber plantations in Yucatan are reported to be henequen, *Agave fourcroydes*. Residents in the neighboring state of Chiapas grow *Agave sisalana* as fence rows and for fiber, which is made into rope, nets, hammocks, and other functional items. Gentry states that the "occupation appeared indigenous and, since this is the only area in which *A. sisalana* has been observed and regularly employed in the village complex, I regard the area as a likely place of origin."

Growth of Agave

Gentry describes *Agave sisalana* as a sexually sterile clone, probably of hybrid origin, due to its general inability to produce seed and by its chromosomes. He also notes that night temperatures of 24-25° F (-5° C) often cause leaf "burn" and dieback. Nobel (1994) reports that sisal grows best on free-draining non-saline soils, and that in regions of Kenya and Tanzania with 1200 millimeters of rainfall per year (similar to Florida's range of from 1000 to 1,500 millimeters per year), *A. sisalana* has a total above-ground dry weight productivity of about 20 tons per hectare per year. Under plantation conditions, *A. sisalana* produces about 220 leaves per plant before the emergence (referred to as "bolting") of the 5-6 meter high inflorescence at about



Control

Agave sisalana has not been the focus of major control efforts in Florida, although it has been a minor component of a few projects (G. Jubinsky, personal communication, Jan. 30, 2002.) However, thousands of *Agave* understory plants covering approximately thirty acres on Loggerhead Key were destroyed after *Casuarina equisetifolia* was burned off in a prescribed fire treatment. For plants not controlled by the fire, Tony Pernas reports that good results were obtained by breaking the "heart" from the main plant and spraying with 20% Garlon 4 herbicide. Smaller plants were removed by hand. (personal communication, Feb. 11, 2002) (See *Dry Tortugas National Park - Loggerhead Key Exotic Plant Management & Island Restoration Project*, T. Pernas, et al., *Wildland Weeds* (2001) 4(4):13-17.)



Sisal plantation on the Perrine Grant, ca. 1920. The plantation ultimately failed. (Used with permission from the Historical Museum of Southern Florida.)

seven years of age (Nobel 1994). Leaves can be harvested after two years of age, which will postpone the "bolting" for 15-20 years. After "bolting", the plant dies.

The United States Sisal Trust

The United States Sisal Trust was a company (ca. 1919) organized to develop and grow sisal commercially in south Florida. According to a brochure for the company, 22,400 acres

Mature sisal plant with bloom stalk, ca. 1920. (Used with permission from the Historical Museum of Southern Florida.)

Described by Gentry (1982) as "forming rosettes 1.5-2 m tall with stems 4-10 dm long, suckering with elongate rhizomes; leaves ensiform. . . fleshy, finely fibrous, smooth, the margins of mature leaves usually toothless, the young leaves with a few minute teeth; spine 2-2.5 cm long, dark brown . . . panicle 5-6 m tall with 10-15 lateral branches of umbellate clusters in upper half, bulbiferous after flowering; flowers 55-65 mm long, greenish yellow, malodorous . . ."

of land in Dade County (Florida City) were to be developed into a plantation, 10,000 acres of which was to be devoted to sisal production. 750,000 plants were grown in a nursery to supply the first unit of 1,000 acres. The expected market for the sisal was American farmers who needed "binder twine, rope and other cordage." The brochure for this company states that 220,000 tons were imported into the U.S. in one year, primarily from Mexico, Cuba and the Bahama Islands. The company intended to capitalize on this market. The brochure goes on to describe the introduction of sisal into south Florida:

"The first sisal plants in Florida were introduced at Indian Key in the year 1826 by Dr. Henry Perrine, American Consul at Campeche, Yucatan, who applied for and received from the United States Government a grant of a township of land conditioned upon its being planted to this product. Later the Indians murdered him and drove his family away. A few years later Mrs. R.V.S. Carpenter, who lives four miles south of Miami gathered a number of these plants from the Perrine grant and planted them at her home overlooking Biscayne Bay at Coconut Grove. From these original plants others have been set out as ornaments all over Dade County, and as far north as Jupiter. A large number being recently planted for ornamental purposes at the entrance of the palatial home of James Deering in the city of Miami, where they are seen to thrive on rock walls and fences without practically any soil."

The advent of synthetic fibers during and after World War II severely depressed the natural fiber industry and many plantations failed or were converted to other crops. Current attempts to boost the economic returns of sisal cultivation include research

into uses for leaf pulp by-products and sap.

Agave in the Literature

Following are some of the more interesting and unusual citations found on *Agave sisalana* in the scientific journal literature. The wide ranging list covers research from Oribatid mites to the invasion of sandy beachfronts to electrical behavior of fibers to permethrin-impregnated sisal curtains to mushroom cultivation to toothbrush sticks to an Olduvai skull.

Aoki, J.I., Wang, H.F. (1986) Two Oribatid mites injurious to economic plants *Acari-formes oribatida*. *Acta Zootaxonomica Sinica* 11(4):375-377. "Another species collected from Guandong and Guangxi Provinces formed many spots on the leaf surface of *Agave sisalana* which were cultured in the field."

Banerjee, A.K. (1972) Trial of *Agave* species in lateritic areas of West Bengal. *Indian Forester* 98(7):432-436.

Batianoff, G.N., Franks, A.J. (1997) Invasion of sandy beachfronts by ornamental plant species in Queensland. *Plant Protection Quarterly* 12(4):180-186. "In this study, the most important factors contributing to ornamental weed invasions are human assisted plant introductions through the dumping of garden plants into native vegetation."

Bos, J.J., Lensing, F.H.G. (1973) A new cultivar in sisal from East Africa: *Agave sisalana* Perr. ex Engelm. cv. *hildana*. *East African Agricultural and Forestry Journal* 39(1):17-25.

Castorena-Sanchez, I., Escobedo, R.M., Quiroz, A. (1991) New cytotoxicological determinants recognized in six taxa of *Agave* in the sections Rigidiae and Sisalanae. *Canadian Journal of Botany* 69(6):1257-1264.

Chand, N. (1991) Electrical behaviour of sisal fibre. *Indian Journal of Fibre and Textile Research* 16(4):287-288. "Electrical properties such as dielectric, constant, dissipation factor and resistivity of sisal fibre have been determined."

Ding, Y., Chen, Y.Y., Wang, D.Z., et al (1989) Steroidal saponins from a cultivated form of *Agave sisalana*. *Phytochemistry* 28(10):2787-2791.

El-Gamassy, A.M., El-Rahman, A.A.A., Hassib, M., et al.

(1974) Vegetative patterns and water economy of *Agave sisalana* in saline soils. *Zeitschrift fuer Acker- und Pflanzenbau*. 139(3):165-171.

Ewusie, J.Y., Ghatak, J. (1972) Studies on reproduction and cytology of sisal (*Agave sisalana* Perrine ex Engelm.) *Ghana Journal of Science* 12(1):42-50.

Githeko, A.K., Adungo, N.I., Karanja, D.M., et al (1996) Some observations on the biting behavior of *Anopheles gambiae* s.s., *Anopheles arabiensis*, and *Anopheles funestus* and their implications for malaria control. *Experimental Parasitology* 82(3):306-315. "Studies were carried out in three villages in western Kenya on the biting behavior of *Anopheles gambiae* s.s., *Anopheles arabiensis*, and *Anopheles funestus*. . . . Under the influence of permethrin-impregnated sisal curtains placed under the eaves of village houses, there was a marked egress of blood-fed *A. funestus* and *A. gambiae* s.s."



Agave decipiens, false sisal
Photo by Sherryl Furnari

NOT Targets for Control in Florida: Two Endemic Agaves

Natural resource managers in central and south Florida may encounter the invasive exotic *Agave sisalana*, sisal hemp, in coastal middens, thickets, or hammocks, the common habitats of two uncommon native agaves: false sisal, *Agave decipiens*, and wild century plant, *Agave neglecta*. With only a little practice, though, the target invasive is easily distinguished from these endemics.

False sisal, found in the Keys and mostly the southwest peninsular coast, has relatively narrow leaves (5-10 cm), and the leaves are concave or cupped, with margins bearing regularly spaced, conspicuous recurved (hooked) prickles. The more rare wild century plant, known from three counties, has broad leaves (20-25 cm wide) that are concave, with straight margins bearing numerous close, minute prickles. Sisal hemp leaves are around 10 cm wide, flat, and usually smooth on the margin, with no prickles, or just a few tiny ones. Other characters differ as well, but these are easy ones for novice agave lovers and haters.

– K.C. Burks, Invasive Plant Mgt., Florida DEP

Grob, K., Artho, A., Biedermann, M., et al (1993) Contamination of hazelnuts and chocolate by mineral oil from jute and sisal bags. *Zeitschrift fuer Lebensmittel Untersuchung und Forschung* 197(4):370-374. "Before spinning, jute and sisal fibres are treated with a batching oil commonly consisting of a raw material oil fraction. Such oil is transferred to foods packed into jute or sisal bags, i.e. primarily cocoa beans, hazelnuts, coffee, almonds, oil seeds, and rice."

Gupta, R.K., Agarwal, M.C., Joshie, P. (1997) Phenotypic stability of *Agave* species on bouldery wastelands (riverbed) of Doon Valley. *Indian Forester* 123(4):331-337. "*Agave sisalana* was found to be the only stable *Agave* species and hence could be recommended for mass adoption on bouldery wastelands of Doon Valley."

Harkonen, M., Saarimaki, T., Mwasumbi, L. (1993) Tanzanian mushrooms and their uses 2. An edible species of *Coprinus* section *Lanatuili*. *Karstenia* 33(1):51-59. "*Coprinus cinereus* s. lat. is commonly grown in waste heaps of sisal (*Agave sisalana*) processing factories in Tanzania."

Hartemink, A.E. (1997) Input and output of major nutrients under monocropping sisal in Tanzania. *Land Degradation and Development* 8(4):305-310. "Much more nitrogen was lost from the topsoil than can be explained by the nutrient balance, indicating significant losses."

Ilanaga, C., Ramos, J., Young, R.A., et al. (2001) Biomechanical pulping of *Agave sisalana*. *Holzforschung* 55(1):42-46.

Inguine, M., Mayoral, M.L., Mays, E., Olivares, E., et al (1995) Effect of seasonal drought and cactus X virus infection on the crassulacean acid metabolism of *Agave sisalana* plants growing in a neotropical savanna. *Journal of Experimental Botany* 46(287):639-646. "Healthy and cactus X virus infected *Agave sisalana* plants were collected during the dry and rainy seasons in two contrasting savanna sites."

Kassu, A., Dagne, E., Abate, D., et al (1999) Ethnomedical aspects of the commonly used toothbrush sticks in Ethiopia. *East African Medical Journal* 76(11):651-653. "Twenty different species of plant[s] used as toothbrush[es] were collected and their botanical identity determined. . . . All the extracts showed antibacterial activity against *Staphylococcus aureus* and *Bacillus cereus* by agar diffusion method."

McLaughlin, S.H., Shud, S.M. (1991) Fiber properties of several species of Agavaceae from the southwestern United States and northern Mexico. *Economic Botany* 45(4):480-486.

Ludlow, W., Wachs, C., et al. (1983) Pollen of the genus of *Agave* from the Yucatan peninsula Mexico. *Boletin de la Sociedad Botanica de Mexico* 44:29-42.

Mukerjee, N. (1970) A preliminary report on the root-rot of *Agave*

sisalana (sisal). *Indian Phytopathology* 23(1):125-127.

Nikam, T.D. (1997) High frequency shoot regeneration in *Agave sisalana*. *Plant Cell Tissue and Organ Culture* 51(3):225-228. "The capacity for shoot regeneration remained constant in the callus for more than 32 months."

Nobel, P.S., McDaniel, R.G. (1988) Low temperature tolerances, nocturnal acid accumulation and biomass increases for seven species of *Agave*. *Journal of Arid Environments* 15(2):147-156.

Parsche, F. (1993) Peculiarities on the incisors in the mandible of the skull Olduvai I. *Homo* 44(1):30-36. "This can be interpreted as an indication that at least this individual used his teeth as a "tool" for treating plant fibres."

Pires, M.D.F.C., Purchio, A. (1991) Mycological evaluation of filtrated juice of *Agave sisalana* Perrine's leaf. *Revista de Microbiologia* 22(3):272-275. "... the filtrated juice of *Agave sisalana*'s leaf contains a compound capable of inhibiting *Aspergillus flavis* and *Aspergillus parasiticus* growth..."

Sahu, G.C., Mishra, A. (1994) Morphology, characteristic and classification of soils under sisal (*Agave sisalana*) cultivation. *Journal of the Indian Society of Soil Science* 42(1):111-114.

Salgado, A.L.D.B., Deuber, R., Forster, R. (1980) Weed control and herbicide selectivity to sisal *Agave sisalana*. *Bragantia* 39(1):7-14. "None of the herbicides affected the growth of sisal plants during the period of 600 days."

Zuskin, E., Mustajbegovic, J., Kaneljak, B., et al (1992) Follow-up study of respiratory symptoms and ventilatory capacity in sisal workers. *Arhiv za Higijeno Rada I Toksikologiju* 43(4):339-347. "The prevalence of acute and chronic respiratory symptoms and ventilatory capacity was studied in 50 textile workers exposed to sisal dust."

Herbarium Specimens

The paucity of herbarium specimens for *Agave sisalana* is likely due to the difficulty of preparing a specimen from a large succulent plant with sharp one inch points on the tips of leaves that grow up to five feet long. In addition, the inflorescence can grow to thirty feet tall and six to eight feet in diameter. To learn how to prepare such a difficult specimen, go to the web site of Southern Illinois University Herbarium: Botanical Potpourri (www.science.siu.edu/herbarium/potpouri/prepare.htm) where detailed instructions are available under the heading "Suggested Techniques for Preparing Hard to Prepare Herbarium Specimens." A section on succulent xerophytes covers *Agave* specimens. Use caution when working with *Agave*; the juice or sap, which contains saponin and oxalic acid, is reported to cause skin irritation and eye damage (Perkins 1978; Morton 1995).

References:

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Morton, J.F. (1995). *Plants poisonous to people in Florida and other warm areas*. Hallmark Press, Miami.

Morton, J.F., Ledin, R.B. (1952). *400 plants of south Florida*. Text House (Florida) Inc., Coral Gables.

Nobel, P.S. (1988). *Environmental biology of agaves and cacti*. Cambridge University Press.

Nobel, P.S. (1994). *Remarkable agaves and cacti*. Oxford University Press.

Perkins, K.D., Payne, W.W. (1978). *Guide to the poisonous and irritant plants of Florida*. University of Florida, IFAS, Cooperative Extension Serv., Gainesville, Circular 441.

Trelease, W. (1913). *Agave in the West Indies*. *Memoirs of the National Academy of Sciences*, Vol. XI, Washington.

United States Sisal Trust. (1919?). *Sisal: the coming industry of Florida*. Hefty Press, Miami. Part of *Papers relating to economic endeavors, 1917-1919* by James Franklin Jaudon in the *Reclaiming the Everglades series* (2000), digitized from papers at the Historical Museum of Southern Florida, Miami [electronic resource].

NOTES FROM THE DISTURBED EDGE



Chapter 5

"Well... Once, upon a morning dreary, I walked with something on my head and though I sought to ignore the source, I wound up talking to the bird instead, I chatted with the fowl who fouled my head.

There, upon that humid morning, standing at the shallow shore
 Came a raven, droop-seed dropping, defecating on the forest floor
 Seeds were dropping, seedlings popping, falling to the forest floor
 Sternly, I addressed the raven: Drop those seeds here nevermore!
 Poop not upon this forest floor!

But lo, he looked at me and laughed – cawed, guffawed and queried me
 'Dare you command us creatures who, led by hunger, take our succor
 of a tree that you abhor?
 I must do what I must do, and so I feast and fill my crop,
 and when digested, I must drop, droppings to the forest floor.
 No harm intending, just a meal ending. The seeds fall to the forest floor'

But I rebuffed him – 'Nevermore!
 'This tree that feeds you and the seeds you, uh, deposit on the forest floor
 do not belong here, they are wrong here,
 they take the place of trees of yore...'

The Raven only laughed once more, and croaked these words:
 'You men dishevel nature and expect me to ignore?
 This fruit is sweet and I must eat. I'll eat the fruits that I adore.
 It's you must yank them evermore. It's you must plant them nevermore...'

He dropped this scat upon my hat
 and then flew off to eat some more...

So I stand here, hat in hand, a crappy-hatted soggy man,
 and although the raven I implored, that bird will listen never more
 The answer's clear, the seed is here, the raven spreads it ever more.
 It's time for man the truth to see - that only we can stop that tree..."

"Number 46?"

"Yep, that's me" – he stepped forward and picked up his tray, tipping his encrusted cap to the wide-eyed boy behind the counter.

She coughed insistently, and he turned to listen. "Thank you for that very complete and ever-so-artistic response," she muttered through clenched teeth. "Now, would you please go outside and scrape that off your hat?"

Sheepishly, he grinned and complied. No doubt, the surrounding patrons (inching towards the door) would never see a carrotwood tree or a water-bound crow in the same way. She stepped forward to retrieve her lunch off the counter, and thought "What a wonderful fool that mortal be..."

- J.A.

An excerpt from "The Adventures of Hack Garlon and his buxom sidekick Squirt."