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Indigo from *Indigofera* spp.: Historical and Cultural Overview[1]

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This EDIS publication is intended to introduce indigo as a potential crop in south Florida. It highlights the historical and cultural background, including identification and distribution, uses, and history of indigo. The information included in this publication could be of interest to researchers, students, Extension agents, growers, the dye industry, and the public.

Identification and Distribution

Indigo is an important natural dye that has been commercially used for centuries. Indican, the dye compound that produces the blue color, can be found in several plant species, most notably those in the genus *Indigofera* (primarily *Indigofera tinctoria* L. and *I. suffruticosa* Mill.) (Ahmed 2009). *Indigofera tinctoria* is native to south Asia and spread to southeast and east Asia in prehistoric times. Similarly, *I. suffruticosa* is native to southern Mexico and Central America and spread into other areas of the Americas. The *Indigofera* genus is a member of the Fabaceae family, and its species are tropical perennial legumes. *Indigofera tinctoria* has a global distribution (Figure 1a), which includes Florida (Figure 1b). The matured plant is about 1 to 2 meters tall with light-green pinnate leaves and pink or violet flowers. It is grown as a perennial in Florida. Seven other species of *Indigofera* are found in Florida (*I. caroliniana*, *I. colutea, I. hirsuta*, *I. miniata*, *I. pilosa*, *I. spicata*, and *I. trita* subsp. *scabra*). Three of these species (*I. caroliniana* Mill., *I. miniata* Ortega, and *I.trita* L.f. subsp. *scabra* (Roth) de Kort & Thijsse are native, and the last species is also listed as "Endangered" at the state level (Wunderlin et al. 2022). Two of the species (*I. hirsuta* and *I. spicata*) are listed as "caution" plants in Florida, which means that proper management practices should be followed in order to prevent escape. (See the Atlas of Florida Plants at https://florida.plantatlas.usf.edu/Results.aspx for more information on each species. See also the UF/IFAS Assessment of Non-Native Plants in Florida's Natural Areas at https://assessment.ifas.ufl.edu/ for more information on the invasion risk of these species).

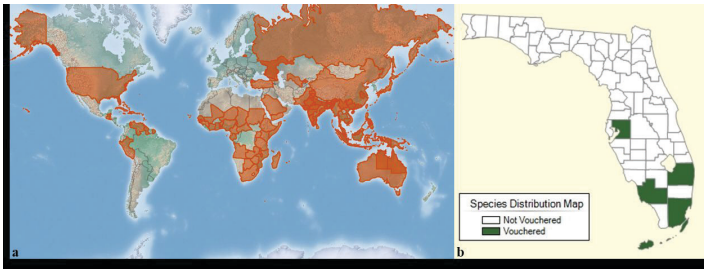

Figure 1. The distribution of *Indigofera tinctoria* worldwide (a) and in Florida (b).
Credits: CABI (2014; https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.28613) and Wunderlin et al. (2022)

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Uses

The dye is produced from indigo leaves. One advantage of indigo is that it can dye fabric without using a mordant (i.e., a substance that helps fix the dye to the surface of the material being colored). For fabrics, this means that the item to be dyed can simply be dipped in an indigo solution and then removed. Oxidation upon exposure to the air causes a blue color to appear (Pastoureau 2001). As a legume, indigo can fix nitrogen in the soil; it is also not a favorable host for root-knot nematode, which makes it a perfect green manure crop (Thomas et al. 2019; Leelahawonge et al. 2010; Reddy et al. 1986). In Florida, hairy indigo (*I. hirsuta* L.) is recommended for such use in the northern and central portions of the state (Crow and Dunn 2019). Species of indigo growing in Florida are larval hosts for native butterflies such as the Ceraunus Blue and the Zarucco Duskywing (Minno, Butler, and Hall 2005).

In many countries, especially those of Africa and Asia, *I. tinctoria* has been used in traditional medicine to treat a wide range of maladies. The most well-documented uses include treating neurological disorders, dental problems, inflammation, and certain skin diseases, but there are many other known uses (Gerometta et al. 2020). It is also thought to have antimicrobial properties and can aid burn healing (Jisha and Benjamin 2009; Samanta, Basak, and Chattopadhyay 2014).

The plant and its products have been used by many peoples for a myriad of other uses, as well. Indigo was historically used as a cosmetic (eye shadow) in India (Lee 2010) and is still used as a hair dye, sometimes in conjunction with henna (Sri Bhuvaneswar et al. 2021). It can also act as an insect repellant (Zheng 2018), with documented activity against mosquito larvae (Gerometta et al. 2020). A recent use for indigo is as a biodegradable, organic semiconductor (Austrian Science Fund 2017; Krishnaswamy and Sundaresan 2013). Fabrics treated with indigo can have improved flame-retardant characteristics (Timpa, Segal, and Drake 1974) and were used for the uniforms of Japanese firefighters in the seventeenth century (Jisha and Benjamin 2009). Such fabrics also have enhanced protection from ultraviolet radiation, especially when the dye concentration is high (Sarkar 2004). Indigo can also be incorporated into paintings or drawings, usually as a wash or to tint the paper before use (Pastoureau 2001). Until it was replaced by synthetic dyes, indigo was used to add blue color to Chinese paper currency (Shi and Li 2013).

History

Indigo dye has been used in many cultures for millennia and was one of the earliest trade commodities (Table 1) (Balfour-Paul 2011; Pastoureau 2001). Since the dye was usually packaged as compressed bricks, people in some cultures did not recognize that indigo had a vegetable origin and thought it was mineral (Pastoureau 2001). As far back as ancient Egypt, India was the source of much of the early international trade in indigo (Abdel-Kareem 2012). It has been identified as being used in China 3,000 years ago and in Egypt more than a thousand years before that. A textile from Peru that is 6,000 years old has been verified to have been dyed with indigo, probably derived from a species of *Indigofera* (Splitstoser et al. 2016). Several regions in Africa produce indigo, some with an artisanal culture that goes back 700 years (Fagbohoun and Vieillescazes 2020). Its documented use in the Arabian part of the continent goes back several thousand years (Abdel-Kareem 2012).

Despite the wide variety of documented uses of indigo, it is possible that the plant was even more important to ancient cultures than is realized, since the climate of many regions is not conducive to the preservation of textiles (Balfour-Paul 2012). Preservation is somewhat enhanced in some artifacts, such as those from pre-Hispanic Mesoamerica, where indigo was combined with a type of clay to produce a color known as Maya Blue (Grazia et al. 2020; Sánchez del Río et al. 2006). Maya Blue was considered a sacred color and was used in frescos on the walls of the Mayan temples (Figure 2).

Figure 2. Painting made of Maya blue pigment that was derived from *Indigofera*.
Credits: Carlos Rosado van der Gracht (https://yucatantoday.com/en/the-fascinating-story-of-the-vibrant-maya-blue/)

During the Middle Ages, indigo-dyed clothing was popular among the European aristocracy (Pastoureau 2001), although much of it was probably dyed with woad (*Isatis tinctoria* L.), an indigo-producing plant from the cabbage family. When the *Indigofera* dye supply increased in Europe,

local woad producers retaliated with a series of protectionist measures. These ranged from taxes to import prohibitions to death threats (Balfour-Paul 2011; Pastoureau 2001). Indigo was one of the imports banned under Napoleon's "Continental System," in place in the early 1800s, which crippled England's trading power by denying ships access to European ports. Ultimately, these efforts failed, and indigo once again became an important trading commodity in Europe (Balfour-Paul 2011).

In the United States, indigo became a commercial crop in the 1740s, with the first plantations established in South Carolina by Eliza Pickney (Balfour-Paul 2011; Rembert 1979; Fryer 1998). In Florida, indigo was an important crop during the late colonial period when the British controlled the area since it was the major export crop in the 1760s and 1770s (Lane 2011); wars among European countries increased the importance of North American plantations (Rembert 1979). In addition, the climate there was favorable, allowing three harvests per year. Production was very labor-intensive, especially during the soil preparation stage (Beeson 1964; Lane 2011). Slave labor was required in order for the enterprise to be profitable (Lane 2011). Although usually replanted every spring, in years with mild winters, plants could regrow and produce a crop the following year. In comparison, plantations in Georgia and South Carolina could only produce two crops each year (University of North Florida 2019). The importance of indigo in Florida is memorialized by a marker in Bulow Plantation Ruins Historic State Park in Flagler County (https://www.hmdb.org/m.asp?m=191593). Indigo was grown commercially in Spanish-controlled Central America, with production in Guatemala alone having a commercial value of two million dollars at the end of the eighteenth century (Beeson 1964).

After the United States became independent, the British transferred much of their attention concerning indigo production to its colony in India. Mercenary practices implemented to increase production led to the Indigo Revolt of 1859 (Prasad 2018). The exponential rise in the demand for indigo took place simultaneously with the industrial revolution and continued for several decades after that era. This period saw a huge increase in demand for textiles in general and for indigo-requiring products, such as denim blue jeans, in particular (Balfour-Paul 2011).

Arguably the most dramatic events in the history of indigo occurred in the second half of the nineteenth century. In 1870, Adolf von Baeyer and Adolf Emmerling succeeded in synthesizing indigo in Germany. The amount of dye produced by their method was relatively low, so alternative techniques were researched. Karl Heumann identified a more efficient method and by 1897, the first commercial synthetic indigo production was underway (Reed 1992).

The impacts of synthetic indigo dye were severe. As an example, just before the commercialization of synthetic dye, India had over 1.5 million acres of land devoted to indigo production, and its export to Britain in the 1895–1896 season was over 9,000 tons. By the mid-1910s, indigo cultivation had dropped below 400,000 acres (Reed 1992). However, the natural indigo industry was given a reprieve with the outbreak of World War I. During this time, exports from Germany were blockaded, so production in India was increased—to over 750,000 acres in the 1916–1917 season (Balfour-Paul 2011; Reed 1992). This expansion in planting was detrimental to the peasant farmers, who were forced to grow indigo at the expense of food crops. Discontent over this situation culminated in the Champaran Satyagraha uprising in 1917. This was the first nonviolent resistance movement led by Mahatma Gandhi (Singh 2017). There was a similar, albeit relatively smaller, increase in indigo production during World War II, but after the conclusion of that conflict, the natural indigo dye industry declined (Balfour-Paul 2011).

The extraction of natural indigo dye has historically posed environmental and health risks (Ayebidun and Ajibare 2023), but recent proprietary innovations have rendered the process more environmentally friendly. Indican, the precursor of indigo dye, is primarily sourced from plant leaves using a bean harvester. Compared to synthetic indigo, natural dye is deemed more sustainable and environmentally friendly (d'Cruz 2012; Rai et al. 2021). The use of excessive and toxic synthetic dyes in textile and apparel manufacturing processes often leads to environment pollution and health hazards to the surroundings where they are sited (Kabish et al. 2023). Despite concerns, synthetic indigo dominates the blue dye market due to scalability, with natural indigo facing constraints in supply and cost. The indigo crop is nearly extinct commercially, but small-scale production persists in the southern United States (Tennessee, Georgia, and Florida). The motivation for using natural indigo stems from environmental and sustainability considerations. Recent studies highlight the stable pH of indigo dyes, making them suitable for food coloration as an alternative to toxic synthetic dyes (Wahyuningsih et al. 2017). However, the economic feasibility of indigo dye as a food colorant is still undetermined.

Table 1. Timetable of indigo being used globally as an agricultural product.

Location	BC	First through Tenth Century AD	Eleventh through Sixteenth Century AD	Seventeenth through Eighteenth Century AD	Nineteenth through Twentieth Century AD
Africa	Used in Arabian part of the continent for several thousand years.[1]	Establishment of dye center in Athribis, Egypt, during the second century and in use until the twentieth century.[3]	Dying centers established in Ghanaian Empire and Nigeria (Yoruba & Hausa) starting from the eleventh century.[3]		Indigo becomes a major crop in Jordan early in the nineteenth century.[3]
	Indigo from India may have reached Mesopotamia by the seventh century BC. Dying instructions found on a Babylonian tablet.[3]	Fabric fragments from India dating to the ninth century found in Egypt.[3]	In the Dogon region of Mali, indigo dyed textiles found in burial caves in use from the eleventh to sixteenth centuries.[3]		
	Yemen's location along east-west trade routes helped it to develop a dying technology.[3]		Evidence of artisanal production in several regions during the thirteenth century.[3,7]		
	Mummied person wrappings in 2000 BC.[3]		Kofar Mata dye pits established in 1498.[6]		
			The Muslim monopoly of the indigo trade broken by European sailors in fifteenth century.[3]		
Asia	India-grown indigo traded with ancient Egypt 4000 years ago.[1,13]	China possesses a textile industry in the first century.[3]	Exports to other regions, especially Europe, increase.[3]	Production in India reduced during the famine in 1630s.[3]	India is world's main source of indigo. Great demand with the Industrial Revolution.[3]
	India had a highly developed textile dying technology by 2000 BC.[3]	Asian trade from China to Korea and Japan in fifth century.[3]	Used to dye uniforms of Japanese firefighters.[2]	Control of the indigo industry in Java passes from the British to the Dutch in 1683.[3]	The Indigo Revolt of 1859.[12]
	Grown in Indonesia 1000 BC; Also traded with China.[3]			After the American Revolution, British transferred production to India.[12]	Collapse of Indian indigo industry post-1897 until resurgence of industry during WWI.[3,9]
	Documented use in China 3000 years ago.[13]				The Chamaran Satyagraha led by Mahatma Gandhi in 1917.[12]
Europe	Used during Greco-Roman period (332 BC–395 AD). Possibly imported from India. Very expensive, so limited use.[3]	Roman cultivation of *Indigofera* sp. during the second century.[3]	Since the thirteenth century, there has been an increasing use of Indian indigo in the European textile industry.[3]	East India Company, established in 1600, suppressed indigo prices, when possible, to undercut competitors.[3]	Baeyer synthesized indigo in 1865. Heumann develops a process in 1897 that makes commercialization cost-effective.[9]

Location	BC	First through Tenth Century AD	Eleventh through Sixteenth Century AD	Seventeenth through Eighteenth Century AD	Nineteenth through Twentieth Century AD
		During the Middle Ages, blue dye, including at least some imported indigo, used for textiles.[3,8]	Ban on indigo in Florence, Italy, 1317. Later, other bans were enacted. Some of these persist until the eighteenth century.[3]	During the seventeenth century, widespread demand for and availability of imported indigo. Extensive re-trading centers are established in London and Amsterdam.[3]	Indigo embargo from Britain during the Continental Blockade between 1806 and 1812.[3]
			Evidence of indigo in Valencia, Spain, 1322.[3]	French dyers allowed to use imported indigo in 1737.[3]	
			Vasco de Gama sailed around the Cape of Good Hope in 1498, leading to an increase in Indian indigo imports and eventually outcompeting woad.[3]		
North America		Sometime between the sixth and eighth century, Maya Blue invented. Used for textiles, murals, and ceramics.[3,11]	Interest in North American native species by the Spanish (1550s) and British (1580s).[3]	In 1631, Dutch ships carried over 300,000 pounds of indigo, which had a value equal to five tons of gold.[3]	Davis patent for blue jeans in 1873.[5]
				Establishment of indigo plantations in American and Caribbean colonies.[3] First commercial indigo cultivation in South Carolina around the 1740s. It became an important crop in Florida in the 1760s and 1770s.[4]	Large-scale commercial industry in the United States effectively ends with the Civil War.[3]
				In the seventeenth century, French established indigo industry in Louisiana, which increased after Spanish control.[3]	
Central and South America	A 6000-year-old indigo-dyed textile (probably *Indigofera*) from Peru.[13]		Spanish introduced *I. tinctoria* to their colonies.[3]	Portuguese attempted to establish an indigo industry in Brazil.[3]	Indigo was an important crop in El Salvador in the nineteenth century.[3]
			Cultivation of *I. suffruticosa* by native peoples.[10]	In the 1700s, the commercial value of Guatemala-grown indigo reached $2 million.[4]	In nineteenth century, Brazilian industry negatively impacted by the increase in Indian production.[3]
				About 250,000 pounds produced and exported from Brazil in 1790s.[3]	

Sources: [1] Abdel-Kareem (2012); [2] Jisha and Benjamin (2009); [3] Balfour-Paul (2011); [4] Beeson (1964); [5] Davis (1873); [6] Flynn (2007); [7] Fagbohoun and Vieillescazes (2020); [8] Pastoureau (2001), [9] Reed (1992); [10] Rembert (1979); [11] Sánchez del Río et al. (2006); [12] Singh (2017); [13] Splitstoser et al. (2016).

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