Chapter 4: Science and Microscopy

Part 1: The Botany of Henna

Species and Dispersion

Henna, *Lawsonia inermis* Fam. *Lythraceae* at dawn after a summer rainstorm[1]

Henna is *Lawsonia inermis* Fam. *Lythraceae*, a monotypic genus, the single example being *L. inermis*,[2] native to North and East Africa, introduced and cultivated in the Persian Gulf region, the Arabian Peninsula, the Levant, and South Asia.[3] It grows in semi-arid tropical zones, in dry sandy, iron-rich soils, and is adapted to extended drought. It does not tolerate frost and thrives where temperatures are between 11C and 45C.

Henna is a biennial dicotyledonous, herbaceous, shrub-like desert tree. It will naturally grow six to twenty feet in height; under cultivation the tree is pruned once or twice a year to a short bush to produce more henna leaves per hectare. The leaves are smooth, opposite, sub-sessile, elliptically-shaped and broadly lanceolate, with depressed veins clearly visible on the dorsal surface.[4]

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[1] Henna grown by Catherine Cartwright-Jones Phd, photograph by Roy Jones

[2] Scientific classification: Kingdom: Plantae; Division: Magnoliophyta; Class: Magnoliopsida; Order: Myrtales; Family: Lythraceae; Genus: Lawsonia; Species: L. inermis.

[3] Semwal, R. B, D. K. Semwal, S. Combrinck, C., Cartwright-Jones and A. Viljoen. (2014) "Lawsonia inermis L. (henna): Ethnobotanical,phytochemical and pharmacological aspects." *Journal of Ethnopharmacology* 155(1): 80-103.

[4] Kumar, S., Singh, Y.V., Singh, M., (2005) "Agro-history, uses, ecology and distribution of Henna (Lawsonia inermis L. syn. Alba Lam)." *Henna: cultivation. Improvement and Trade*, 11–12.

Young henna leaves have sub-sessile opposite lanceolate leaves with depressed veins on the dorsal surface. [5]

Merck's Report, Volume XXIX, 1920,[6] notes that nineteenth century western botanists erroneously claimed that the one species, L. *alba,* had two varieties, L. *inermis* (unarmed) and L. *spinosa* (with spines). This confusion arose from the fact that the young henna plants are devoid of spines while the older plants have branchlets that harden into spines: they were both the same plant at differing stages of maturity.

During the quaternary glaciation, henna would have had the best chance for survival in the semi-arid frost-free biomes in North Africa. The single genus implies a relatively recent genetic bottleneck from henna withdrawing to a relatively small survival area during the most recent glacial period, probably along 15° N, across what is presently the Sahel. During the Neolithic Subpluvial,[7] the henna growing range may have expanded across the greening Sahara when it was a savannah, when Africa's seasonal monsoons shifted slightly north.[8] People living across that region probably first became familiar with henna during that period; henna was certainly used in Egypt, at the eastern edge of the region, to mask graying hair by around 3000 BCE.

During the Holocene Climate Optimum, henna spread northward to the Mediterranean coast, probably spread by birds which consumed henna berries and excreted the seeds as they flew northward out of Africa along wadis (seasonally dry riverbeds) and oases. As the North African ecosystem warmed and became arid, henna was reduced to the Saharan oases and wadis and was pushed to the perimeters of the region where it grows now: the Mediterranean rim of North Africa, the Atlantic coastal region of Africa, the Sahel, and the eastern coast of Africa. Since henna is a tree, producing flower and seed only after three to five years, and the tree's lifespan is about fifty years, a warm, dry climate must be sustained for decades without interruption for the species to survive. The proposal that henna is native to North African tropical semi-arid zones is supported by the relative genetic diversity of henna in African oases and wadis.[9]

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[5] Henna grown by Catherine Cartwright-Jones, 1200 dpi scan

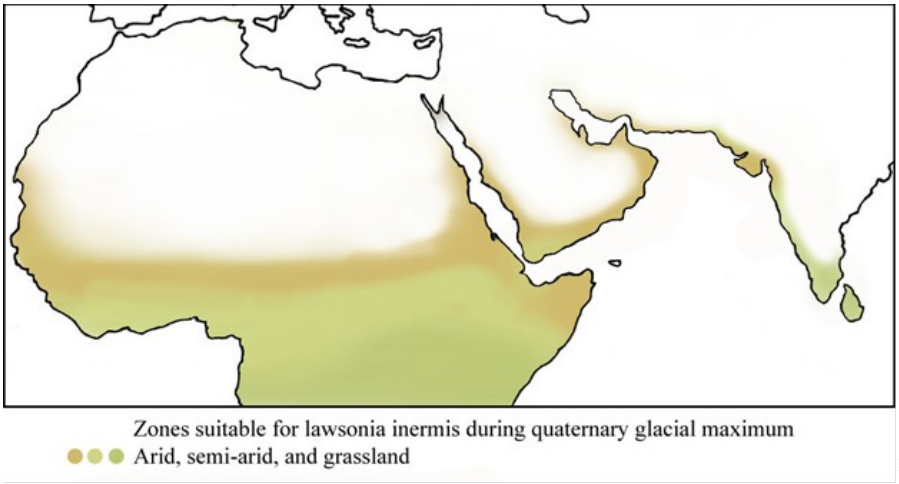
[6] Benjamin H. Hoffstein, (1920) "NOTES ON HENNA: Comprehensive Digest of History and Uses" *Merck's Report*, Volume XXIX, P. 140

[7] 7500–7000 BCE to about 3500–3000 BCE

[8] Sereno et al. (2008) "Lakeside Cemeteries in the Sahara: 5000 Years of Holocene Population and Environmental Change." *PLoS ONE*; 3 (8)

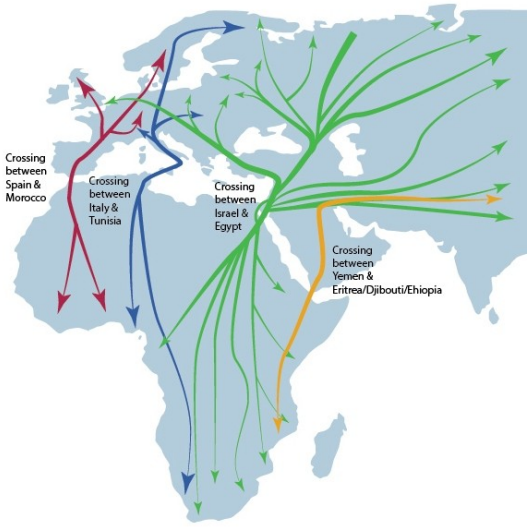
[9] Anissa Boubaya, Hédia Hannachi, Nidhal Marzougui, Tebra Triki, Ferdaws Guasmi, Ali Ferchichi (2013) "Genetic diversity assessment of Lawsonia inermis germplasm in Tunisian coastal oases by ISSR and RAPD markers" *Dendrobiology* 69, p. 31- 39.

The mosaic of frost-free semi-arid zones would have varied over the centuries of the Last Glacial Maximum (LGM),[10] but the general area of potential survival was greatest across the width of Africa. *Lawsonia* is a monotypic genus: variants may have been lost to climate change during the LGM. Deglaciation began in the Northern Hemisphere at approximately 20 ka; and henna gradually moved northward and eastward during warming periods.



[11]

Area hospitable to henna during the Last Glacial Maximum (LGM) 26.5 ka BP



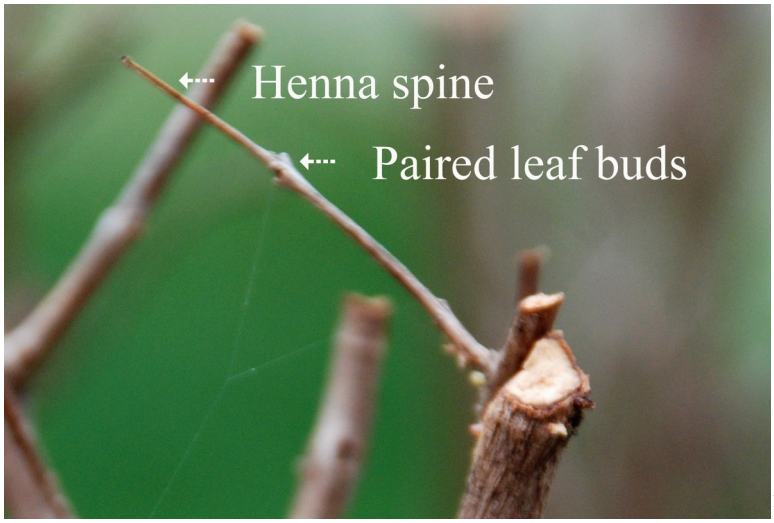
Bird migration routes suitable for transmitting henna seed from frost-free zones in Africa into north and eastern regions to the perimeter of frost-free regions[12]

[10] deMenocal, Peter; Ortiz, Joseph; Guilderson, Tom; Adkins, Jess; Sarnthein, Michael; Baker, Linda; Yarusinsky, Martha (2000-01-01). "Abrupt onset and termination of the African Humid Period: rapid climate responses to gradual insolation forcing". *Quaternary Science Reviews*. 19 (1–5): 347–361

[11] Map by Catherine Cartwright-Jones PhD

There is evidence consistent with henna growing around the Mediterranean coast during the Bronze Age, particularly in texts and artifacts from the Levantine coast. The presence of henna was probably the result of bird-spread henna seed excreted during migrations from the Sahel along the Nile northward as the climate warmed. It is possible that around 5000 BCE, henna had found suitable habitat as far north as coastal Anatolia; it probably grew in the Cycladic islands, certainly in Crete, and the areas that are now the coastal plain of Syria, Jordan, Lebanon, and Palestine during the Bronze Age. During the Mid-Holocene Warm Period, henna gradually spread northward into Sicily and coastal Spain, as well as eastward into the Arabian Peninsula, later to the coastal regions of the Persian Gulf.

The growth of henna in South Asia occurred after the western areas became seasonally dry. During the glacial retreat, South Asia was more damp, cool, and forested than it is now. It is possible that henna was introduced by Muslim traders to Australia, the Philippines, and Indonesia. Henna is not native to any part of the western hemisphere. Henna was introduced to the Americas through bonded West Indian sugar plantation labor from India. Henna can be cultivated as an ornamental bush in Florida, or as a potted plant brought inside during cold weather in other areas of North America.



[13]

Henna can remain semi-dormant and leafless during extended drought. As the tree matures, branches develop spines on the opposing budding tips, an effective defense of leaf buds against hungry animals when the plant is dormant in a semi-arid zone ecosystem. A hungry browsing animal reaching out with its tongue for leaves would be deterred by the spine.

The Pali district in India grows henna as a commercial crop with 450 mm of rain per year and no additional irrigation. The pH of Pali's deep, sandy soil ranges from 7.7 to 9.0. The dry, sunny weather has relative humidity averages less than 50%, and 30 – 35 °C average daily temperatures during its period of active growth following the monsoon. This greater seasonal aridity, sun, and

[12] WysInfo Docuwebs (2014) "Birds Without Boundaries: Migratory, Nomadic & Other Wandering Birds" http://wysinfo.com/Migratory_Birds/Migratory_Birds_Without_Boundaries.htm accessed September 2018

[13] Henna plant grown by Catherine Cartwright-Jones PhD, photograph by Roy Jones

heat foster higher leaf dye content at harvest.[14] The October – November harvest following the withdrawal of the monsoon rains at the end of September has the highest dye content of the year according to samples tested.[15]

[16]

In wild henna growth, nibbling by animals such as gazelles is followed by greater density of the foliage which returns rapidly after the onset of rain. Heavy pruning in agricultural harvesting takes advantage of this characteristic: a hectare of pruned henna produces more leaves per season than unpruned henna.


[17]

Growth following rain in a warm season is rapid, with shoots growing more than one inch per day from pruned branches.

[14] Rao, S. S.; Regar, P. L.; and Singh, Y. V. (2005) "Agrotechniques for Henna (*Lawsonia Inermis* L.) Cultivation" *Henna, Cultivation Improvement and Trade*. P. 25. Central Arid Zone Research Institute, Jodhpur, India.
[15] Singh, M.; Jindal, S. K.; Kavia, B. L.; Chand, J.; and Chand, K.. (2005) "Traditional Methods of Cultivation and Processing Henna" P. 24 *Henna, Cultivation Improvement and Trade*. Central Arid Zone Research Institute, Jodhpur, India.
[16] Henna plants raised by Catherine Cartwright-Jones PhD, photography by Roy Jones
[17] Ibid

[18]

New henna growth after a summer rain

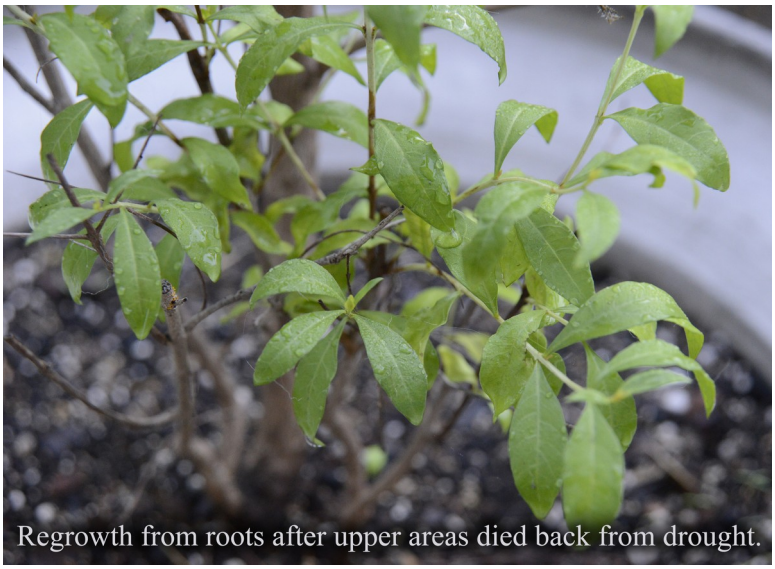

[19]

The vivid red in the new leaves diminishes as leaves mature and turn green.

Henna will survive seasonal droughts and is valuable to farmers who need to have a reliable cash crop on marginally cultivatable areas with little or no irrigation.[20] Decreased water resource results in smaller leaves and a general reduction in leaf volume and stem length. A henna crop may still be profitable after all other crops fail in a drought.[21] If the whole upper part of the henna tree is damaged by prolonged drought, there may be regrowth from roots under the soil surface as shown above. Henna bushes can be pruned for productive harvests from the third year

[18] Henna plants raised by Catherine Cartwright-Jones PhD, photography by Roy Jones
[19] Ibid
[20] Thakur, P. S. and R. Sood. (2005) "Drought tolerance of multipurpose agroforestry tree species during first and second summer drought." *Indian Journal of Plant Physiology* 10(11): 32-40.
[21] Enneb, H., A. Belkadhi, and A. Ferchichi1. (2015). "Changes in henna (Lawsonia inermis L.) morphological traits under different deficit irrigations in the southern of Tunisia." *Plant Science Today* 2: 2-6.

to the twentieth year, though the plants can remain in the ground to hold the soil and have smaller harvests for up to fifty years. Most farmers in India who depend only on rainfall harvest henna once a year following the monsoon. Farmers with irrigation and access to nitrogen supplements for their crops can harvest two or three times a year.


Regrowth from roots after upper areas died back from drought.

A henna plant may drop all of its leaves during extreme drought stress, but have renewed leaf growth after the rains return. Even if the plant completely dies, the roots will stay tenaciously in the soil for years afterward. Living, the henna acts as a hedgerow or windbreak preventing wind erosion and desertification. Even when dead, henna roots will still stabilize the soil, whereas plowed crops leave soil vulnerable to wind loss.

[22]

The plant is deeply rooted and holds soil tenaciously against soil erosion.

[22] Henna plants raised by Catherine Cartwright-Jones PhD, photography by Roy Jones

Farmers in the northern part of India, in the Andhra Pradesh, Orissa and Chhattisgarh have planted henna to create living fences and to protect their cultivated fruits and vegetables. Henna is also planted as a property boundary around their homesteads. As henna will remain in the ground for fifty years, and the leaves can be harvested as a cash crop through that period, a living henna fence is a pragmatic choice. Regular pruning of these henna fences maintains dense growth which helps to prevent browsing animals (both domestic and wild) from pillaging or trampling their other crops.[23]

In Mali, farmers had used dead wood, often *zizyphus Mauritania*, to create fences but were encouraged to try living fencing to enclose and protect their crops by the International Centre for Research in Agroforestry. Henna was the most commonly chosen plant for farmers to create living fences as cultivation was simple and the plant was familiar. Young henna bushes were planted half a meter apart alongside the previous dead wood fences for protection during the first few years. The farmers pruned the branches, brought them to the house. There, the leaves were stripped the leaves from the branches, dried in the sun, then crushed. They could grind the crushed leaves into powder, or send them to a mill for grinding, and sell it in the market or keep for family use. When pruned, the increasingly dense of henna fence effectively deterred marauding animals from their garden during the dry season.[24] It should be noted that animals which did nibble on henna leaves had orange stains on their lips, resembling lipstick, thus marauders are easily identified.

Henna during periods of climate change

During the Medieval Warm period, henna was commercially cultivated in southern Spain. In subsequent cooler centuries, henna could not survive snows that fell as far south as Andalusia. Though historical records indicated that henna grew and was used on Cyprus during the Bronze Age, when Victorians enumerated Cypriot flora, they found none and most dismissed the possibility that henna had ever grown there.

Henna is damaged by near-freezing temperatures and will not survive being frozen; even barely visible emerging leaf buds are damaged by cold temperatures, and the damage will remain on the leaf tips as the leaf grows. Subsequent growth emergent during warmer nights does not show damage. Henna thrives in areas where the minimum temperature never falls below 11 °C.[25] At the time of this writing, climate change is beginning to have an impact on the cultivation of henna, though not necessarily adverse. Seasons of drought and heat produce higher lawsone content in henna crops; moist, fertile soils produce lower level lawsone content.[26] In my experience in HPLC testing henna crops for lawsone over the last ten years, El Niño–Southern Oscillation (ENSO) events correlate with the highest lawsone content henna crops from the

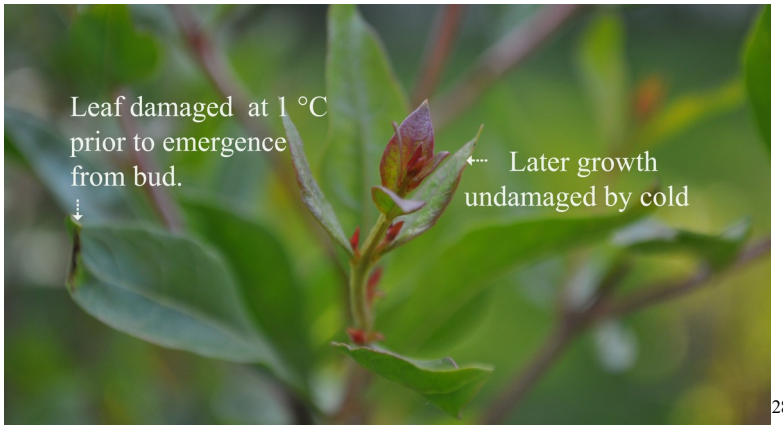
[23] Choudhury, P.R.; Rai, P.; Patnaik, U.S.; and Sitaram, R. (2004) "Live fencing practices in the tribal dominated eastern ghats of India" *Agroforestry Systems* 63: 111–123

[24] Levasseur, V.; Djimdé, M.; and Olivier,A. (2003) "Live fences in Ségou, Mali: an evaluation by their early users" *Agroforestry Systems* 60: 131–136.

[25] Kidanemariam, T. K., T. K. Tesema, K. H. Asressu and A. D. Boru. (2013) "Chemical investigation of Lawsonia inermis L. leaves from Afar region, Ethiopia." *Oriental Journal of Chemistry* 29:129–134.

[26] Yogisha, S., Samiulla, D.S., Prashanth, D.,Padmaja R. and Amit A. (2002) "Trypsin inhibitory activity of Lawsonia inermis." *Fitoterapia*. 73: 690–691

Punjab and Thar Desert, possibly correlating with the reduction in rainfall resulting from El Niño during the latter half of the monsoon season. La Niña crops have lower lawsone content, and Trans-Niño conditions yielded the lowest lawsone content henna crops.[27]



[28]


[29]

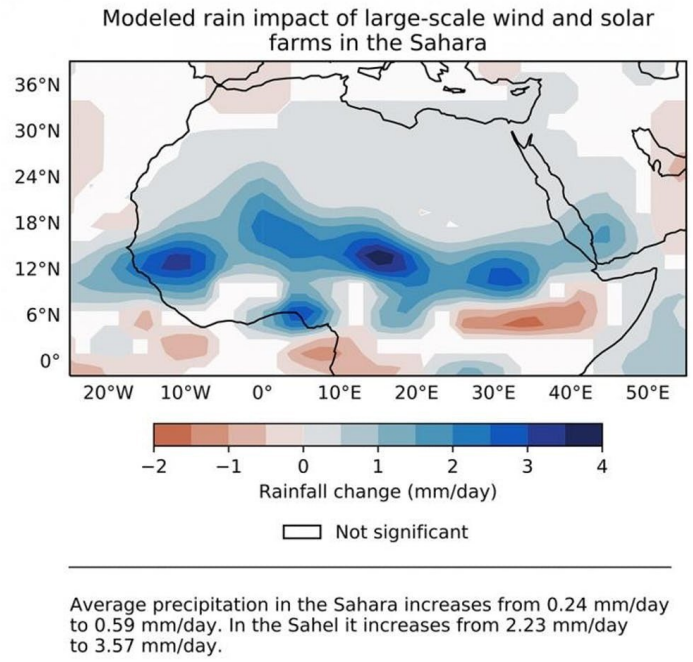
Emerging henna leaves were damaged at 1 ° C for one hour. Henna leaves exposed for four hours to -2 ° C withered and dropped; the plant did not recover.

As climate changes progresses, the periods of drought are often longer and hotter, and torrential rains are more extreme and destructive. The 2010 flooding in Pakistan damaged henna plantations by prolonged inundation; much had to be replanted. As climate warms, the boundary of Arctic Vortex becomes unstable, and unexpected flow of cold air can invade areas that normally support henna, such as the cold wave in Rajasthan during the month of January

[27] Observation from HPLC lawsone tests 2008 - 2018 by Catherine Cartwright-Jones PhD. This does not include testing all henna crops from all plantations, but is an observation based on over batch tests.
[28] Henna plants raised by Catherine Cartwright-Jones PhD, photography by Roy Jones
[29] Plants and photograph by Catherine Cartwright-Jones PhD

2017 when temperatures dropped to near freezing. May of the previous year had extremely high temperatures in the area, rising to 52 °C (125 °F). Henna trees, remaining in the ground for up to fifty years, will be vulnerable to increasingly extreme temperatures.
Limitations on irrigation in Egypt due to climate change and variations in the amount of water flowing into the Nile from eastern African monsoonal rains may improve the outcome for farmers who choose henna crops; when soil is salinized from irrigation, henna can remain a cash crop in the Aswan and other irrigated areas when other crops are no longer remunerative.[30]

The western Sahel is becoming more hospitable to henna during the present climate change and will continue for the probable future based on the warming of the southern Atlantic and Mediterranean.[31] Farmers in Mauritania, Mali, and Northern Nigeria grow henna for local use, but it has not supported by those governments as henna has been encouraged and supported in India. Henna is one of the few crops that is carbon negative; commercial henna development would benefit farmers in marginal and waste areas across the southern border of the Sahara.



[32]

World Economic Forum model of increased precipitation from solar panel and wind farming in the Sahara

[30] Jaimini, S. N.; Tikka, S. B. S; Prajapati, N. N.; and Vyas, S. P. (2005) "Present Status and Scope of Henna Cultivation in Gujarat" *Henna, Cultivation Improvement and Trade*. Central Arid Zone Research Institute, Jodhpur, India.
[31] Giannini, Alessandra, Michela Biasutti, and Michel M. Verstraete. (2008). "A Climate Model-Based Review of Drought in the Sahel: Desertification, the Re-Greening and Climate Change." *Global & Planetary Change* 64 (3/4): 119–28
[32] Li1,Y.; Kalnay, E.; Motesharrei, S.; Rivas, J.;Kucharski, F.; Kirk-Davidoff, D.; Bach, E;, Zeng N. (2018) "Climate model shows large-scale wind and solar farms in the Sahara increase rain and vegetation" *Science* Vol. 361, Issue 6406, pp. 1019-1022

Greening northward into the Sahara is triggered by an increase in summer precipitation, amplified by a positive feedback between vegetation and precipitation. Depending on how fast carbon dioxide increases in the atmosphere, the greening into the Sahara may be rapid, up to one tenth of the desert region per decade, though not reaching half of the total area.[33] Henna could be part of the leading edge of the reclamation of the Sahara. For the possible future, if solar panel and wind farming is expanded in the Sahara, climate models predict increased rainfall.
Henna probably sheltered in the Sahel and Sahara three to thirty thousand years ago. Perhaps it will survive the climate change there again.

Propagation

[34]

Henna seeds are 3 mm across, angular, with thick seed coat.[35]

In the wild, henna is effectively propagated by birds as they eat henna berries and excrete seeds during their migrations. The percentage of seeds which grow into plants in the wild is not high, but the number of seeds dispersed through excretion is prolific. In cultivation, henna seeds' hard seed coat must be soaked in water for eight to ten days with frequent change of water, and even then only about twenty percent germination can be expected. Soaking in a three percent salt water solution for one day improves germination to seventy percent. Optimal temperature for germination is 25 to 30 °C.[36] Conveniently for henna, a birds' digestive system and the water sources that are their rest stops during seasonal migration provide hospitable conditions for henna seeds to sprout and take root. Human cultivation from seed is dependent on finding a means of stabilizing moisture and temperature suitable for germination and growth for many weeks. Farmers in India may sow seeds in nursery beds in March, first soaking the seed in water, and watering daily for six months when they are 30 – 45 cm tall when they are planted in their

[33] Martin Claussen, Victor Brovkin, Andrey Ganopolski, Claudia Kubatzki, and Vladimir Petoukhov. (2003) "Climate Change in Northern Africa: The Past Is Not the Future." *Climatic Change* 57 (1/2): 99–118.
[34] Henna seeds, 1200 dpi scan by Catherine Cartwright-Jones PhD
[35] Agroforestry Database 4.0 (2009) *World Agroforestry Center,* (ICRAF)
[36] Rao, S. S.; Regar, P. L.; and Singh, Y. V. (2005). "Agrotechniques for Henna (*Lawsonia Inermis* L.) Cultivation" *Henna, Cultivation Improvement and Trade*. P. 25 Central Arid Zone Research Institute, Jodhpur, India.

permanent location towards the end of the monsoon in September or October. The yield from seed-started henna is low but is available to farmers who do not have access to cuttings.[37]

Henna cuttings may be rooted without hormone dips with a mean of nearly three quarters of cuttings succeeding. Cuttings in India are most likely to succeed in July with growth boosted by the onset of the monsoons.[38]

Pests and pesticide use

Ladybug eggs on a henna leaf.

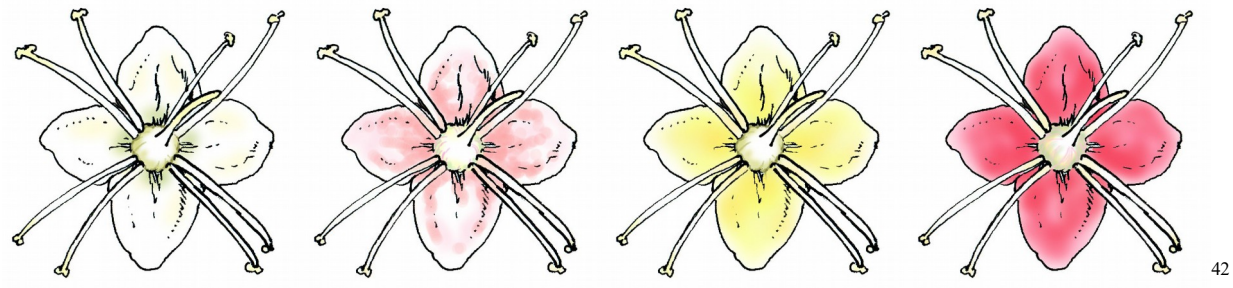
Cultivated henna crops rarely are bothered by pests in their native semi-arid tropical climate zones. When newly planted, they may be attacked by termites; Caster semiloopers may attack adult plants during the monsoons.[39] In damp climates, aphids may overrun henna; ladybugs will consume aphids. I have run LUKE II pesticide residue tests on every shipment of Ancient Sunrise® henna since 2008. The most commonly found pesticide residue has been synthetic pyrethrin, harmless to humans, though toxic to insects and fish.[40]

However, when henna is planted alongside of other crops and those crops are sprayed, the tests reveal residue drifted on the wind from nearby crops. This is a concern when henna is planted near cotton fields, where farmers are permitted to use organophosphates. One Luke II pesticide test on henna showed residue from an organophosphate which, though declared illegal in many countries, was used on farmers' fields where it was probably sprayed on cotton fields where

[37] Singh, M.; Singh. K. and D. (2005) "Natural Variability, Propagation, Phenology and Reproductive Biology of Henna" *Henna, Cultivation Improvement and Trade*. P. 13 Central Arid Zone Research Institute, Jodhpur, India.
[38] Ibid, p. 15
[39] Narain, P.; Singh, M.; Roy, P. K.; Chand, K.; Sikh, J. and Y. W. (2005) "Production, Trade and Future Prospects of Henna" *Henna, Cultivation Improvement and Trade*. P. 3. Central Arid Zone Research Institute, Jodhpur, India.
[40]Bifenthrine, Cyhalothrin lambda and Cypermethrin are pyrethroid insecticides; the residue of these pesticides occasionally occur in henna. Lab tests by Alkemists Pharmaceuticals.

pests had become resistant to other sprays.[41] When henna is growing near tomato fields, the pesticide drift is relatively benign. When henna is growing near a village or cluster of houses that were sprayed for mosquitoes, DDT may drift onto the crop. In the cases of pesticide drift discovered, the amount remaining on henna was too small to be a health risk, but it does contradict "Organic" claims. Henna is often raised as a hedge around other crops; if adjacent crops are sprayed, wind may carry pesticide onto henna for a mile or more, depending on wind and the height of the application, which may be a low-flying crop duster.

Flowers and Seeds



[42]

Henna flowers grow in clusters similar to lilacs comes in several colors: white, pink, yellow, and rose.

Henna flowers grow in pyramidal terminal cymes, comprise four sepals, a 2 mm calyx tube, with white or red stamens present as pairs on the perimeter of the calyx tube, and obvate, petals crumpled in the bud; The ovary is four-celled, with an erect style. The tree produces small cluster of flowers, then berries containing 32 to 49 angular seeds each.[43] The clusters resemble the flower clusters of lilacs, and are very fragrant. In India, the henna plant flowers form during the monsoon. Some farmers pluck the blossom clusters as they believe the berry formation lowers the leaf and lawsone volumes. Others sell the flowers to the perfume industry.

The henna cultivars most raised in the Pali district of India are yellow-flowering henna, the *desi* and the *muraliya* varieties. The *muraliya* type has a woody canopy with small greyish-green leaves, and the *desi* has a leafy canopy of larger leaves. The *desi* is preferred by producers because of the higher leaf potential.[44]

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[41]Profenofosis an organophosphate insecticide used on a variety of crops including cotton and vegetables such as maize, potato, soybean, and sugar beet. https://en.wikipedia.org/wiki/Profenofos Lab tests by Alkemists Pharmaceuticals.

[42] Drawings of henna flowers by Catherine Cartwright-Jones PhD

[43] "Lawsonia inermis L. (henna): Ethnobotanical, phytochemical and pharmacological aspects," Ruchi Badoni Semwala, Deepak Kumar Semwala, Sandra Combrinck, Catherine Cartwright-Jones, Alvaro Viljoen. Journal of Ethnopharmacology, June 2014

[44] Rao, S. S.; Regar, P. L.; and Singh, Y. V. (2005). "Agrotechniques for Henna (*Lawsonia Inermis* L.) Cultivation" *Henna, Cultivation Improvement and Trade*. P. 25 Central Arid Zone Research Institute, Jodhpur, India.

 [45]

Formation of a henna berry from henna flowers

Henna fruits are small, brown, globose capsules 4-8 mm in diameter, many-seeded, opening irregularly, split into 4 sections, with a persistent style.[46]

 [47]

Initial blossoming of a cluster of henna flowers

Henna flower oil contains alpha- and betaionone, with the latter being the main component and which are used in perfume.[48] The total yield of volatiles isolated was higher from the yellow flowers which were different from the red flowers composition. The yellow flowers have more β-ionone (48.6% vs 2.5%) and its derivatives. The red flowers have more 2-phenylethanol (11.5% vs 5.8%), benzyl alcohol and C_6 alcohols and aldehydes.[49] Henna attars may be either clear or henna-red. It is the author's impression that henna attar smells like a combination of chocolate, roses, and cigars.

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[45] Illustrations by Catherine Cartwright-Jones PhD
[46] Agroforestry Database 4.0 (2009) *World Agroforestry Center*, (ICRAF)
[47] White flowering cluster of henna grown by Catherine Cartwright-Jones PhD
[48] Agroforestry Database 4.0 (2009) *World Agroforestry Center*, (ICRAF)
[49] Wong, K. C,; and Teng, Y. E. (1995) "Volatile Components of Lawsonia inermis L. Flowers" *Journal of Essential Oil Research* Volume 7, Issue 4 Pages 425-428

 [50]

Red henna flowers are more common in wild North African species of henna.[51] Though the flowers can be sold to the perfume industry, henna farmers prefer to remove flowers from the maturing crop of henna because they believe they spoil the quality of the finished leaf. The seed and berries have no commercial value and have to be winnowed from the henna leaves before processing.

 [52]

Henna flower attar

[50] Red flowering cluster of henna grown by Catherine Cartwright-Jones PhD
[51] Kidanemariam, T. K., T. K. Tesema, K. H. Asressu and A. D. Boru. (2013). "Chemical investigation of Lawsonia inermis L. leaves from Afar region, Ethiopia." *Oriental Journal of Chemistry* 29: 129–134.
[52]Photograph of henna attar by Catherine Cartwright-Jones PhD

Ancient Sunrise® Henna for Hair Chapter 4: Science and Microscopy

Part 1: The Botany of Henna

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