LUNAR INFLUENCE

Understanding Chemical Variation and Seasonal Impacts on Botanicals

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Moon image taken by the Galileo Orbiter, 1998.
Image courtesy of NASA/JPL/USGS.
Kava *Piper methysticum*. Photo ©2010 Steven Foster

In developing new medicinal products, investigators sometimes rely on information from indigenous healers and traditional practitioners regarding their medicinal use of plants. In several well known examples, such as the formerly popular hypotensive drug reserpine from *Rauvolfia serpentina* (Apocynaceae) root or the widely used cardiac medication digoxin from *Digitalis purpurea* (Plantaginaceae) leaf, traditional herbal knowledge has led to the development of conventional pharmaceutical drugs. More often, these traditionally used species are developed into botanical products and phytomedicines from whole-plant or multi-plant preparations. But have researchers overlooked an important part of traditional healing practices while searching for such medicinal product leads? People from indigenous cultures who use plants for medicines often have an intimate connection with the environment around them, including knowledge of seasonal patterns of plant potency. Further, some cultures take special care to plant, collect, or harvest at only certain times of the day, or during specific moon phases. Could harvest and collection practices and the influences of the moon phase affect the chemical composition and efficacy of plant-based medicines? This review outlines several cases of lunar influence on medicinal and economic plants, based both on traditional knowledge and scientific literature.


St. John's wort *Hypericum perforatum*. Photo ©2010 Steven Foster

Traditional and Current Practices Relating to the Moon

Across the globe, farmers, craftsmen, and healers have carefully observed the phases of the moon, especially while planting, harvesting, or collecting plants. Gaius Plinius Secundus, or Pliny the Elder (23–79 CE), was a well known author and respected naturalist who wrote *Naturalis Historia*, the most comprehensive study of natural history to survive from the Roman Empire. During his life (he died suddenly during the eruption of Mt. Vesuvius), he advised Roman farmers to pick fruit at the full moon for the market, as it would weigh more, and pick at the new moon for personal consumption, as that fruit would store better. Pliny also recommended that lumber trees be cut at the new moon.[1] Following this practice, King Louis XIV passed a royal order during his reign that felling of wood should only occur during a waning moon (the period of time after the full moon) between the falling of leaves and the new growing season.

Traditional practices related to wood and wood usage in Europe still exist today, especially within cottage industries and in the production of specialty products such as cheese boxes, wine barrels, wooden shingles, wooden chimneys, and wood for musical instruments.[1] For example, a saying persists in France: "*bois tender en cours / bois dur en décours*" ("soft wood when waxing / hard wood when waning"). Similarly, in Western Jura (France), an ancient rule persists that firewood should be cut at the opposite lunar phase as construction wood.[2] Whenever plant materials were required to be strong and resistant to the environment, they were harvested during a waning moon, and medicines were often harvested following the new moon during a waxing period.

It is interesting to note that such practices are consistently found with striking similarities among cultures well-connected to nature across the globe, from remote islands and dense rainforests to small villages within 200 miles of Paris. In the middle of the Pacific Ocean, ancient Hawaiians believed that tubers (such as sweet potatoes [*Ipomoea batatas*, Convolvulaceae] and taro [*Colocasia esculenta*, Araceae]) must be planted on the third, fourth, fifth or sixth day of *Ku* (the new moon), to ensure that the crops would grow upright and firm.[3,4] Additionally, medicinal plants were gathered only during *La`aukkukah,* and *La`aukulua*, the third and fourth days following *Hoku*, the full moon.[4] Both of these cases suggest that vastly different physiological processes were linked to one large macroscopic observation: the cycle of the moon.

Polynesians were not alone in these observations; the Maya believed that the moon controlled sap flow in plants and that the nighttime draws the healing attributes of the plant into the roots.[5] Medicinal plants were therefore harvested only at specific times of the day or month. The First Nation's tribes of Tla'amin (Sliammon), Klahoose, and Homalco lived by the 13 moons of their ancestors, a calendar that controlled all aspects of their lives, including the harvest of plants for food and medicine, as well as cultural and social activities.[6] One elder of the Saanich people (Coast Salish) reported that the inner bark of red alder *Alnus rubra* (Betulaceae) was harvested only at high tide when it was "fat and juicy"; otherwise it was too thin (E. Claxton Saanich Nation, personal communication to N.J. Turner, e-mail to I. Cole, May 11, 2009). In Belize, Panama, and Puerto Rico, palm leaves and other resources harvested during or closely following the full moon are believed to be more resilient to insects and decay than leaves harvested "too late."[7,8]

The Ketshua Indians of Bolivia, descendants of the Inca, make ploughs from *Prosopis ferox* (Fabaceae). These trees are harvested only during the first waning moon after the start of spring, just before Easter celebrations.[1] According to recent ethnobotanical work in Kosrae (in the Federated States of Micronesia), elders have suggested that *Nypa fruticans* (Arecaceae) leaves should be harvested for roof thatch only after the full moon "until the moon is gone."[8] If harvested at the incorrect time, termites and other insects would reduce the life of the thatch from 6-10 years down to 2 years, a significant change in lifespan of building materials. This significant difference suggests that the chemistry and protective properties of *Nypa* may change drastically over the period of one month.

Folklore and traditional practices thus indicate that the cycle of the moon influences the trajectory of certain aspects of daily life, particularly involving plants and other living resources. They do not, however, demonstrate how these forces might be acting on biological organisms, and specifically how they impact the phytochemical profile of plants.

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Contemporary Studies

To aid in the development of high-quality plant-based medicines, research in plant rhythms should attempt to understand the forces acting on the plant, the mechanisms that yield changes in phytochemistry, and how these are affected by the natural rhythmic behavior of plants. Plant rhythms have fascinated scientists for over a century, not surprisingly due to the myriad legends and folklore about the moon from indigenous cultures going back through millennia. The earliest scientific studies attempted to understand the "sleeping" behavior of some plants whose leaves would fold flat against the stem at night and open during the day. All living organisms possess physiological processes and behaviors that follow rhythms involving a period of about 24 hours.[9,10] In humans and other mammals, an internal timing mechanism (often called the "biological clock," or central oscillator), imposes circadian rhythms on physiological, biochemical, and molecular events.[10] Plants, however, are unique, and their timing control mechanism is external, specifically the environment, i.e., the sum of all of the forces constantly acting upon the plant.

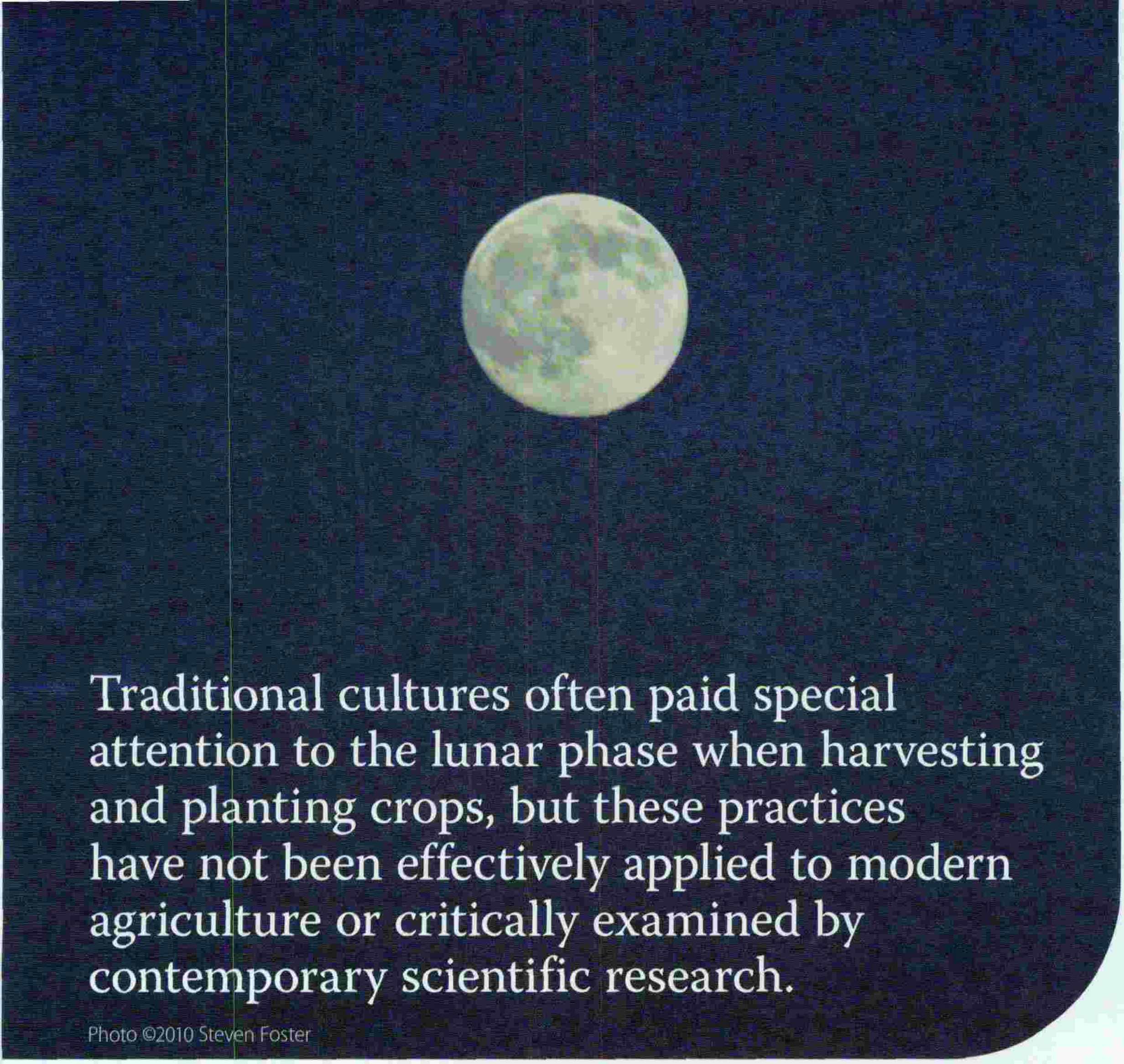
About 15 years ago, Gunter Klein first presented the hypothesis of an exogenous rhythm rather than the endogenous oscillator in humans and mammals, and he was preparing his manuscript when he died. From his experiments, he concluded that the rhythmic leaf movements of bean seedlings, grown in constant conditions, were regulated by the tidal forces of the changing position of the moon in relation to the Earth.[11] Barlow et al. (2008) analyzed Klein's work and found a correlation between leaf movements and tidal forces, and together with new repetitive studies, their data supported Klein's hypothesis.[12]

Numerous studies have also shown seasonal variations, effects of harvest dates, and circadian effects on phytochemistry in some plant species that could help develop improved protocols for production practices, e.g., in growing raw materials for use in botanical supplements.

The phenomenon of seasonal variation is relatively well known for many crops, especially those whose value is derived from essential oils. Many species have shown a rhythmic increase in oil production throughout the growing season and then a steady decline towards the winter.[13,14,15] One study on blueberries (*Vaccinium angustifolium*, Ericaceae), harvested biweekly in Canada,[16] reported significant seasonal variation in the phenolics and anti-glycation effects. The authors recommended late summer as the optimal collection time with maximum bioactivity.

Research on St. John's wort (*Hypericum perforatum*, Hypericaceae) herb, one of the top ten herbal products in retail sales in the United States,[17] has shown seasonal variation and differences due to cultivation location. Levels of hypericin and pseudohypericin, the compounds to which commercial products are usually standardized, were found to vary from 100 ppm to 5000 ppm from winter to summer.[18] This remarkable quantitative difference in compounds could account for some of the differences in commercial products whose raw materials are usually from multiple sources. Additional studies with St. John's wort found significant variation among wild and cultivated plants sourced from around the world.[19] Although numerous environmental, genetic, and physiological factors contribute to the overall phytochemical profile of plants, the harvest time could be one of the more important considerations. Studies on peppermint (*Mentha* x *piperita*, Lamiaceae) herb growing in dry regions of California found that

Peppermint *Mentha* x *piperita*. Photo ©2010 Steven Foster



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the date of harvest was far more critical than the date of irrigation to overall quality and essential oil yield.[20]

A study of kudzu (*Pueraria lobata*, Fabaceae) root, a traditional Chinese medicine, revealed seasonal variation in overall isoflavonoid content, as well as variation among different compounds.[21] This is an exceedingly valuable finding if roots are being grown for individual compounds or if manufactured products are harvested at different times and standardized to a specific compound that varies from month to month, week to week, or even day to day.

Although these studies regarding seasonal variation do not necessarily indicate the moon as the driving force behind the oil production and phytochemical changes in plants, they do show the dynamic nature of plant chemistry as influenced by various environmental factors—of which the moon might play a part.

Aside from seasonal variations, daily changes have also been reported. Studies on *Virola surinamensis* (Myristicaceae), an endangered tree from South America that is valued for medicinal and economic purposes, showed daily circadian fluctuations in the constituents of essential oils distilled from leaves—specifically, levels of monoterpenes dropped by 50% from 6 a.m. to noon, and then increased to their original levels by 9 p.m.[22] Additionally, levels of the sesquiterpene caryophyllene in *Virola* doubled in samples taken in October versus those harvested in June. Daily fluctuations were also seen in the essential oil of wild basil herb, or *Ocimum gratissimum* (Lamiaceae), where levels of eugenol in the essential oil were observed to drop from 98% at 12 a.m. to 11% at 5 p.m.[23] In general, essential oils seem to accumulate throughout a growing season, but further research is needed to detect any lunar or circadian patterns to these studies.

Circadian rhythms are also known to control stomatal opening, gene expression, transcription, timing of photoperiodism, and to drive growth and development, although the control mechanisms remain unknown.[24] Studies have found that disruption of normal circadian function in *Arabidopsis thaliana* (Brassicaceae) has led to reduced leaf chlorophyll levels, reduced growth, and increased mortality.[25] Kiota et al. (2006) found that antioxidant levels in the algae *Euglena gracilis* (Euglenaceae) and spinach (*Spinacia oleracea*, Amaranthaceae) also followed circadian rhythms, peaking at midday when solar energy is most powerful, protecting the organisms from photooxidation.[26] Many of the important compounds in medicinal plants are secondary metabolites and believed to be a result of environmental stimuli, such as pathogens and changing environmental conditions.[27] Commercial cultivation of such plants would benefit from optimizing their management practices to correlate with such rhythms.

In some cases, the moon has been specifically implicated for its potential effects on plants. Zürcher observed the rhythmic variations in *Maesopsis eminii* (Rhamnaceae), a major tree species in Rwanda, and found that seed germination rates in *M. eminii* showed significant differences in seeds planted during the full

Blueberry *Vaccinium angustifolium*. Photo ©2010 Steven Foster

moon or during the new moon.[1] His study also found that speed of germination, rate of germination, and average height and growth rate of seedlings showed better results and larger seedlings if the seeds were sown before the full moon. The phenomenon of lunar effect on patterns of seed germination and initial growth rate has been documented for numerous species.[28] However, these effects have not been fully understood for medicinal plants or been incorporated into modern harvest practices.

Studies have revealed that some trees shrink and swell with the tides.[29] The physicist Gerard Dorda used a modified version of the Quantum-Hall-Effect (work on the QHE was awarded the Nobel Prize for Physics in 1985 and 1998) to calculate the effects of gravity from the moon on the water in living organisms and found a regular, reversible, rhythmic pattern of water in cells. This pattern showed the greatest amount of change during the new moon.[30] Interpretation of these effects can be difficult, according to Dr. Dorda: "I think that this effect is not easy to understand for students of botany" (e-mail to I. Cole, February 11, 2009).

Rather than struggling to understand the complex physics behind this phenomenon, a better strategy could be to try and identify the phytochemical constituents and bioactivity that change in response to lunar rhythms. A recent study on spruce trees (*Picea abies*, Pinaceae) found that the overall measured volume remained constant, but a rhythmic, reversible flow between the cell contents and cell wall was causing the shrink and swell. Even in the short-term, this would mean additional water accumulating in the cell walls at certain times of the month and could have implications for food crops and in lumber technology, as this "bound water" can affect the quality of the building product. In wood technology, studies often focus on the relationship between wood and water and the felling date and drying process, all of which impact the quality and durability of the final product.[31] Further studies with lumber found variations in wood density after the drying process that could be correlated to the lunar phase.[19] Interestingly, these variations were more noticeable for the outer sapwood, usually consisting of phloem and metabolically active parenchyma cells, rather than the inner heartwood, which is usually dead at maturity.

A plant is a sessile organism that adapts to changes in its environment through changes in its chemistry. The forces acting on a plant are numerous and constantly changing, and dynamic changes in biochemistry are required for survival. Observing limited scientific studies or ethnobotanical accounts alone will not shed light on the complex chemical changes that take place within the organism. Comprehensive chemical profiling is needed to observe and understand possible effects of harvest practices and environmental cues. Findings such as these, together with comprehensive chemical profiling, could be beneficial to modern production practices by helping to understand the best time to plant and harvest for healthy, vigorous crops rich in medicinal constituents.

Based on our review of the literature, the authors of this article have undertaken work to test the hypothesis that the lunar phase can influence levels of bioactivity, presumably via changes in levels of chemical compounds. Working with a tropical plant species, preliminary data from bioassays have shown changes in bioactivity that correlates with particular lunar phases. We are currently repeating the experiments with a sample of plants collected in different locations.

Conclusion

Through many generations, traditional cultures have learned that harvest practices, specifically the time of harvest, can greatly impact the characteristics and qualities of plant products. Wood is harvested at different times depending on if it is a "soft" or "hard" wood, and depending on if it is destined to become a chimney, cheese box, or a load-bearing beam for a building. Similarly, farmers have reported the best times to plant seeds, weed gardens, and harvest crops. These practices increase the quality of products and increase the efficiency of farming and management practices.

In the modern world of botanical products research and the quest to develop and improve plant-based medicines, numerous challenges exist. Inconsistent phytochemical profiles and commercial agriculture-based management practices of botanicals can sometimes make it difficult to prove efficacy in clinical trials and develop new commercial products. Traditional cultures often paid special attention to the lunar phase when harvesting and planting crops, but these practices have not been effectively applied to modern agriculture or critically examined by contemporary scientific research. With modern chemical tools and guidance from ancient wisdom, researchers could examine and optimize harvest practices for high quality botanical products. HG

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