

A doyen of Indian botanists: H. Y. Mohan Ram

Ramesh Maheshwari, K. R. Shivanna, R. Dore Swamy, K. Sankara Rao and Gita Mathur

Holenarasipur Yoganarasimham Mohan Ram, fondly referred to as HYM (Figure 1), belongs to the rare category of general botanists that is rapidly becoming extinct. He has completed 83 years. On this occasion, we offer this academic tribute, sautéed with personal anecdotes for transmitting to us his passion for plants in general, and of the flora of Amazon and of Malabar in Kerala, in particular. We briefly summarize his major research contributions on flower colour, sex expression in flowering plants, and *in vitro* culture of bamboo and aquatic angiosperms. Additionally, we sum up what each of us has learnt from him over informal meetings whenever he visits Bangalore and reflect on our perceptions of HYM as a general botanist and a humanist.

As general botanists do not come any more, it is of interest to know how HYM became one. Born in Karnataka, HYM obtained his early education in Mysore. After obtaining his Master's degree in botany, he went to Agra for research on the development of seeds under the guidance of P. Maheshwari (PM), who was then at Agra. Subsequently, when PM moved to University of Delhi, HYM was appointed a lecturer in Delhi University from where he retired as a professor. Currently, HYM is a research professor of the Indian National Science Academy, working at Shriram Institute for Industrial Research, Delhi. Knowing him since

the beginning of our own scientific careers, we suppose HYM would take umbrage at being labelled or categorized as a specialist. In his own words, he has been a teacher, researcher, naturalist, author, editor, reviewer, adviser, promoter and popularizer of science, traveller, photographer, lover of music and cricket and a tolerably good cook. He would always find the time to go out of the way to look up his former students or colleagues to popularize botany, especially economic botany of trees valued as sources of timber, gums and oils. For example, in a recent article on sandalwood he covers the use of the fragrant heartwood in carving, the use of its oil in perfumery and toiletry and in combating antibiotic-resistant bacteria, and points out the need for research on phytoplasma causing spike disease, micropropagation of sandalwood, and on the selection of diploid and triploid somatic embryos for establishing superior genotypes having higher quantity of heartwood.

At the time of writing this article, one of us (K.R.S.) was visiting California where, inspired by HYM's approach of learning based on personal observations of flora in nature, he visited the Pacific West Coast to see the endemic redwood trees, named for the colour of their bark and heartwood. One specimen of *Sequoiadendron giganteum* (Figure 2), named 'General Sherman', has a diameter 36.5 feet; circumference 103 feet; height 275

feet; age 2200 years; and weight 1256 metric tonnes. Seeing 'General Sherman', the questions that came to mind were the methods used to determine the weight of a living tree.

Making of a general botanist

After his postgraduate training under M. Anantaswamy Rau in Mysore, HYM was attracted to take up research on plant embryology, which had then begun to emerge as an important discipline due to publication in 1950 of a book titled *An Introduction to the Embryology of Angiosperms* by PM. HYM researched on the seed development in some plants belonging to the family Acanthaceae. After obtaining his Ph D, on PM's advice, HYM went to the laboratory of F. C. Steward (see Figure 1, centre) at Cornell University, who was attracting international attention for his contributions to the concept of totipotency. Using the tissue culture technique by which excised tissues are grown *in vitro* in artificial nutrient media, Steward, trained as a chemist, demonstrated that plant cells are totipotent—that is, each plant cell has the genetic information for developing into a complete plant. For example, cells from



Figure 1. H. Y. Mohan Ram (right side, photo by Gita Mathur) in group photo taken in Botany Department at Delhi University. This photograph taken during an International Symposium held in 1959 on Plant Tissue and Cell Culture shows, sitting from left to right: N. S. Rangaswamy (Convenor), B. M. Johri, J. Reinert, F. C. Steward, P. Maheshwari, J. Swarbrick, H. E. Street, J. P. Nitsch and B. Sen. H. Y. Mohan Ram is standing at the extreme left in the last row.



Figure 2. 'General Sherman' (*Sequoiadendron giganteum*) growing in California is one of the largest known trees in the world. Photo by K. R. Shivanna.

the phloem tissue of carrot roots cultured in suitable sterile nutrient media differentiated into plantlets that could be transferred to soil and grown into complete plants, thereby demonstrating that each cell of the adult plant retains the genetic potential to regenerate an entire plant. HYM's exposure to tissue culture technology led him to initiate work in this field on his return to India. He guided his Ph D students to apply this technique to understand many aspects of plant growth development (Figure 3). With his training in systematic and experimental botany, his own curiosity and self-education through observations and enquiries, HYM established himself as an effective teacher and a researcher. Most importantly, his broad outlook on plants and his expertise in identifying them and pointing out their economic uses attracts both botanists and the laypersons. HYM has been a popular plant scientist; and is invited for giving lectures and as an expert in the selection and appointment of new cadres of staff and faculty in teaching and research institutions throughout India. From years of observations of plant diversity and their adaptation to habitats, he has become a natural authority, commanding the respect of people like only a few can. With his cool temperament and power of persuasion and the desire to help move the botanical research forward, HYM has been an automatic choice for presiding over national meetings, and in the process meeting people, and updating knowledge and expanding his influence on development of botanical science in India.

Highlights of some contributions

Insectivorous plant

An insect-feeding plant found floating in water bodies has fine thread-like leaves



Figure 3. Multiplication of banana by shoot tip culture. Photo by R. Dore Swamy.

and bladders with tiny hair-like projections at their opening. Commonly known as the bladderwort, its scientific name is *Utricularia*. The bladders trap tiny insects. As it generally grows in nitrogen-deficient habitat, it was thought that this plant depends on insect-derived nitrogen for its growth. One of us (R.D.S.) took up this problem for Ph D. By raising seed-cultures of *U. inflexa* in a synthetic nutrient medium containing only an inorganic nitrogen source, it was demonstrated that *Utricularia* can utilize inorganic nitrogen for its growth. However, the *in vitro* grown plants flowered only when the cultures incubated under short day conditions (20 cycles of 16 h dark and 8 h light). This was the first report of *in vitro* culture of an insectivorous plant. We became impressed with plant organ and tissue culture technique for demonstrating the regenerative power of plants. The technique allows plant cells and tissues to be indefinitely maintained in culture by their successive transfers to fresh medium at regular intervals of time and to study their physiological requirements for growth and reproduction.

Banana tissue culture

In 1958, HYM received a Fulbright scholarship for advanced research in Steward's laboratory at Cornell University. Steward was interested in the biochemistry of the banana plant. Sponsored by a research grant from the United Fruit Company, while in Steward's laboratory, HYM initiated work on tissue culture of the banana varieties for studying the differences in their response to nutrient media containing different plant growth regulators. The experiments on banana involved culturing the white mass of cells or a triploid edible tissue or the pulp which presumably is the endosperm and deriving a mass of callus cells that could be regenerated into plantlets by incorporating plant growth regulators, such 2,4-dichlorophenoxyacetic acid or 2,4-trichlorophenoxyacetic, or the supplementation of nutrient growth medium with coconut water that contains a complex of compounds. However, these were ineffective. The important finding was that tissue from unripe fruits could be induced to callus but which failed to differentiate into plantlets. Tissue from ripe fruits did not respond. However, today banana plants are being cloned from the

virus-free (bunchy top, bract mosaic, infectious chlorosis, streak) shoot tips through plant tissue culture and derived plantlets from meristem culture of the high-yielding varieties are mass propagated in the field (Figure 3). *In vitro* propagation of banana is the most successful commercial achievement in India.

Sex expression in Cannabis

Cannabis sativa (hemp or marijuana) is dioecious, comprising male and female plants, but sex becomes distinguishable only when the flowers are formed. The term 'marijuana' refers to its medicinal, recreational or spiritual use involving the smoking of its flowers. Reportedly male and female flower buds vary in hallucinogenic effect. Smoking leaves are used for relaxation, stress relief, and for an overall sense of calm and serenity for body pain relief and in the treatment of insomnia. As female plants contain about 5–10% or more delta 9-tetrahydrocannabinol (THC), it was of significance that one of HYM's students, V. S. Jaiswal, could convert the male plants into females by spray application of ethephon (2-chloroethanephosphonic acid), a growth regulator. Stopping the application of ethephon caused the plants to revert to their original sex. They hypothesized that in *Cannabis*, gibberellic acid (GA) and ethylene act as male and female hormones respectively, and that the expression of sex is controlled by a balance between their endogenous levels. Abscisic acid (ABA) is able to overcome the GA-induced male flower formation. Reportedly, male or female plant flower buds vary in hallucinogenic effect. Fertile female flowers were induced in male plants by ethephon (2-chloroethanephosphonic acid) and NIA 10637 (ethylhydrogen-l-propylphosphonate).

Bamboo

On the basis of flowering, the bamboos have been categorized under three broad groups: (i) those that flower annually or nearly so (*Indocalamus wightianus*, *Bambusa atra*, *Ochlandra sivagiriana*), (ii) those that flower sporadically or irregularly (*Chimonobambusa* sp., *Arundinaria falcata*, *Dendrocalamus giganteus*, *D. hamiltonii*, *D. longispathus*), and (iii) those that flower gregariously once in their life in a synchronized manner

producing enormous amount of seeds and then die (monocarpic) (*Bambusa bambos*, *B. polymorpha*, *B. tuldatundra*, *Ochlandra travencorica*, *Dendrocalamus strictus*). The interval between flowering seasons of a species is highly variable. For example, *Phyllostachys bambusoides* takes 120 years to flower. A majority of bamboos belong to the third category. We know very little about how timing of flowering is programmed into a given species of bamboo. With the availability of large amount of nutritious seeds available in the flowering year, there is rise in the populations of squirrels, birds and rodents. After consuming the bonanza of bamboo seeds, the populations of rats turn to the standing crops and cause severe devastation, resulting in famine. In India, Mizoram has often experienced mass seeding of bamboos and resultant famines. Tribal lore and forest records indicate a regular flowering cycle of about 48 years for *Bambusa tulda* and *Melocanna baccifera* in Mizoram. Flowering of *M. baccifera* causes a famine called 'mautam' and that of *B. tulda*

brings about 'thingtam' famine. Conventional propagation of bamboos involves propagules such as rhizomes, suckers and culm cuttings. Because a large number of plants can be raised with minimum effort, propagation by seed is the most convenient method; but seeds are not available regularly. As tissue culture technology offers special advantages for bamboo propagation, HYM's group made the first successful report on somatic embryogenesis and plantlet regeneration from the seed cultures of *B. bambos* and *D. strictus* via a callus. Reproducible procedures for rhizome initiation and acclimation to potted conditions were developed. Over 10,000 plantlets raised by tissue culture have been introduced in various parts of India.

Post-pollination changes in flower colour

The newly opened flowers of *Lantana camara* are rich in β -carotene and are yellow-coloured. One of HYM's stu-

dents, Gita Mathur (GM) noted that their colour changes to orange, scarlet and magenta as the flowers age (Figure 4)¹. By suspending coloured sticking screens on lantana bushes, GM and HYM showed that thrips were attracted only to yellow colour. A methanol extract of *Lantana* pollen was also able to simulate the effect of pollination, suggesting the involvement of a pollen factor². The post-pollination shift in petal colouration is caused by the masking of carotenoids by differential amounts of anthocyanin. GM and HYM proposed that colour changes may play a role in conserving pollinator energy and on the production of nectar by the flowers.

Flora of Karnataka

HYM often spoke of India's rich floral wealth, its diversity and discussed critical issues related to conservation. He is also appreciative of any work on information building on India's flora. One of us (K.S.R.) is developing a database of about 4000 angiosperms and ferns from Karnataka based on the voucher specimens in the Herbarium JCB at the Centre for Ecological Sciences (CES), Indian Institute of Science, Bangalore to generate a readily accessible information system to help evolve strategies of effective conservation and sustainable utilization of plant resources in the state. Herbarium JCB was built by Cecil J. Saldanha and subsequently transferred to CES. It houses about 14,500 specimens belonging to more than 4000 species of angiosperms, ferns and lichens. The duplicates have been deposited with herbaria of Royal Botanic Gardens at Kew, England and the Smithsonian Institution, Washington DC, USA. The taxonomic data presented on each species in the database include information presented on the herbarium specimen label, namely species name, author citation, sub-species if any, variety if any, family, subfamily, collection number, location, date of collection, habitat and the collector's name. Scanned herbarium specimens and the image gallery ('synthetic flora') allow quick identification of species. Areas stripped-off their native plants can be restored by transplantation. The database could be a metric of the rate of loss of the species likely to go extinct. Figure 5 shows a scanned image of herbarium specimen of *Bruguiera gymnorrhiza* of

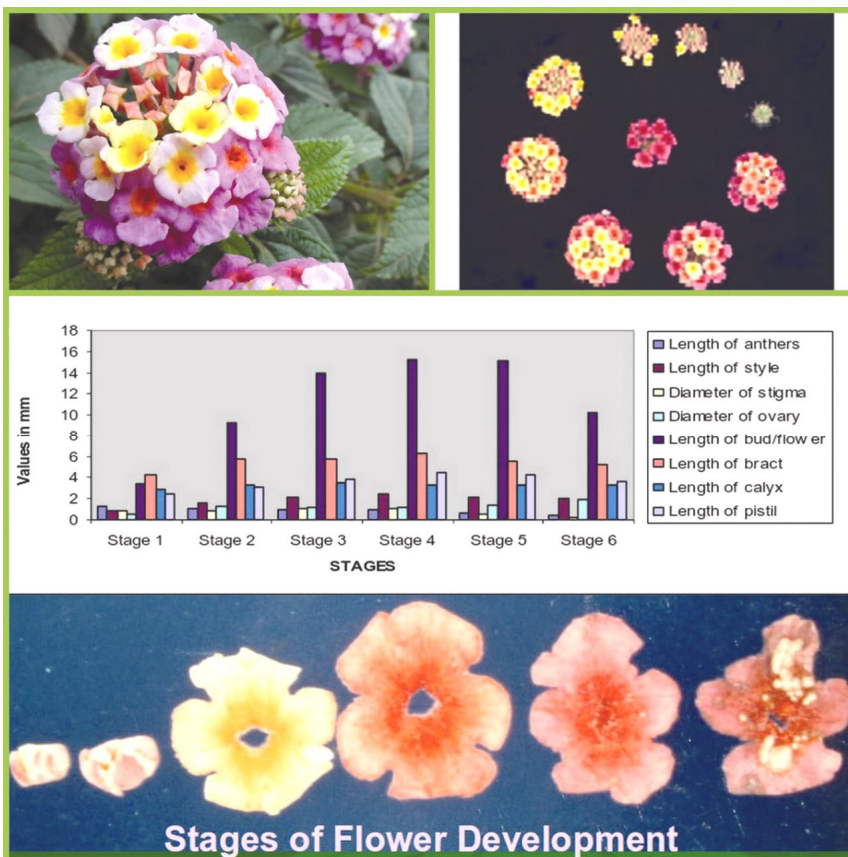


Figure 4. Colour change in flowers of *Lantana camara* following pollination. Flower development was divided into six stages. The data was statistically analysed and is graphically depicted. Photo by Gita Mathur.

Rhizophoraceae endemic to Karnataka. The flowers are solitary, axillary and pink in colour. The seed germinates while the fruit is still attached to the tree (vivipary).

Biology of Podostemaceae

The family Podostemaceae (riverweed family) is little studied. The aquatic plants are found in flowing waters adhering to rocks, although the mechanism of their adhesion in the water remains unknown. Three of HYM's Ph D students showed that adult plants are quite unlike the flowering plants, lacking clearly defined roots and stems with a thalloid plant body resembling an alga, lichen or a liverwort. Nonetheless, they are flowering plants (angiosperms) that form seeds. The plant body has been interpreted as root, stem or a combined shoot (leaf-stem) structure. This confusion has mainly arisen due to difficulty in studying the development of the seedling. HYM's group at the University of

Delhi developed an *in vitro* technique to germinate the seeds of Podostemaceae in liquid medium, enabling a detailed histological study of the origin and development of the thallus and induction of flowering. They have also carried out field and laboratory studies to understand the structure of the thallus, floral biology, mechanism of pollination and seed production. In *Indotristicha ramosissima* (Tristichoideae), an ephemeral primary shoot axis is formed apically between the cotyledons. No tap root is formed, but two or three adventitious roots develop at the radicular pole, which become compressed and grow horizontally, adhering to the stones and form flowers and fruits on vertical shoots (Figure 6), which dehisce to liberate tiny seeds. The seeds lie on rocks until the next monsoon and germinate with the first showers. HYM's students have outlined the biological challenges that the Podostemaceae offer and hope that plant scientists would use them as experimental systems.

A feel for classical botany

We wish to touch upon an inspiring typical botanical excursion during the undergraduate years of one of us (R.M.) conducted jointly by HYM and N. S. Rangaswamy (NSR). It was an excursion to Pachmarhi (Madhya Pradesh). Dusk had befallen and several plant specimens that we had collected and saved in a vasculum during our trekking remained to be identified. With the *Floras* and a dissecting microscope unpacked, and all of us holding flashlights for additional illumination, HYM and NSR began dissecting the flowers from the specimens and identifying them based on floral characteristics. The work continued until late night, unmindful of the dinner. Our

treasure trove contained *Psilotum* (Figure 7) – a plant spotted between moist rocks. *Psilotum* is regarded as a primitive plant: it has dichotomous green branches, but lacks leaves, roots, flowers, fruits and seeds. The branches bear sporangia at their tips, and the plant reproduces by spores formed in the sporangia. *Psilotum* is reported to form a relationship with a fungus known as mycorrhiza in its environment. The fungal hyphae ramify in the environment, and absorb and transfer the mineral nutrients to the plant. Both *Psilotum* and the mycorrhiza survive in severe nutrient-limited conditions. We remember this excursion in particular as NSR, who has a knack for naming, dubbed the excursion as the 'Fresh and the best' after the name of the lodge where we were put up for the night. In this excursion it was firmly driven home that making keen observations in nature not only sharpens one's eyes to catch minute details, but also imparts intellectual thrill.

An example of HYM's feel and concern for plants and for classical botany is reflected in his writings. Until recently, when during one of his visits to Kerala he met K. S. Manilal³, HYM was not aware of his work. Devoting over 35 years of intense labour, Manilal has translated the entire text of *Hortus malabaricus* (*Malabar Garden*) running into 12 volumes – the most comprehensive printed work on plants of the Malabar coast that stretches about 900 km in length and varying from 74 to 200 km in width from Goa to Kanyakumari and published between 1678 and 1693 in Malayalam on palm leaf by Itty Achuden, a priest-physician. HYM writes, by translating and interpreting this valuable document in English, Manilal has contributed significantly towards the safeguarding of our natural plant wealth and



Figure 5. An image of a herbarium specimen of *Bruguiera gymnorhiza* (L.) Lam of Rhizophoraceae. It is a small-sized tree with tough leaves, stilt roots and endemic to Karnataka. The flowers are solitary, axillary and pink in colour. The seeds germinate while the fruits are still attached to the tree (viviparous germination). Based on some 4000 scanned images, database of the Flora of Karnataka is being developed. Photo by K. Sankara Rao.

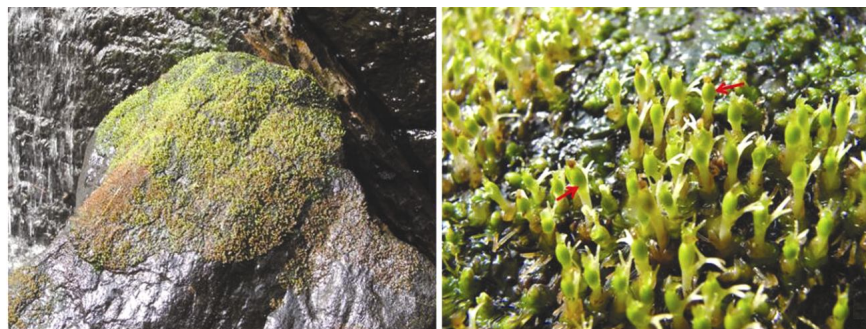


Figure 6. *Zeylanidium lichenoides*, a Podostemaceae growing on a rock in Kerala. Photo courtesy of Rajesh Tandon.



Figure 7. *Psilotum*, an early (primitive) land plant transplanted in soil. Note sporangium at the axils of branches. Photo by K. Sankara Rao.

indigenous knowledge. We are impressed that during one of our meets, HYM emotionally briefed us on Manilal's collection and identification of 996 species of flowering plants belonging to 559 genera and 134 families. These included rare and endangered endemics, wild relatives of black pepper, cardamom, ginger and turmeric, the Malabar daffodil orchid (*Ipssea malabarica* discovered in 1850 and never seen again), 12 orchids that occur only in a pollution-free environment and 7 species new to science. Manilal and his associates have published over 40 research papers on their explorations in this region and a reference book, *Flora of Silent Valley Tropical Rain Forests of India*. Manilal's work sends a clear message to those scientists who tend to avoid research that demands rigorous and intensive labour. There is a general impression that meaningful long-term studies spanning several decades cannot be successfully undertaken by individuals. HYM writes, 'Even scientific institutions are reluctant to do so; that Manilal has accomplished this gigantic task with practically no financial support from any government or private agency deserves deep appreciation'. HYM concluded with the plea that the scientific communities recognize Manilal's scholarly and painstaking achievement at a time when citation indices and working in high-tech areas using modern tools appear to be the principal criteria for judging merit. Even if Manilal's volumes may not be in our reading or reference list, acquaintance with this work offers a

means of finding out what plant species have been lost in 300 years since van Rheedee and get some idea on their rate of extinction.

In the above paragraphs, we have reflected on our perceptions on how keen observations of plants and asking questions about their strategies of growth and survival have made HYM a general botanist rather than a specialist. Asked what his views are on classical botany being displaced by molecular botany, HYM referred us to his views⁴: 'There has been an over-emphasis on areas such as molecular biology, biotechnology and genetic engineering. To assume that these subjects would replace the other well-established branches of biology appears illogical as they are all interconnected. It has been said that even the most traditional branches of biology – systematic, anatomy, embryology and physiology – are still needed not just as data but also because all of them are endless unfinished frontiers and all of them are still needed to round our view of the living world. Each discipline seems to have a golden period, and many of them have several. But even after the law of diminishing returns has taken over, there is no justification for abolishing a discipline that has become "classical" '.

HYM is a botanist who has ploughed areas of enquiry untouched by others. In closing, one of us (GM) would like to dedicate this poem to her guru, HYM:

*My teacher, guide and supervisor
Are not sufficient when I think about you*

*You are my trainer and well wisher
And your polishing reflects in all I do.*

*I always think of you when I need
strength
Hearing your voice generates energy in
me
The feel your blessing hand on my head
Makes me think positively, whatever the
crisis is.*

*I thank you Guru for Your affection and
Your tireless hours of hard work
To make me the person I am today and
For giving vision to see brightness in the
dark.*

1. Mohan Ram, H. Y. and Sujata Varadarajan, *Resonance*, 2009, **14**, 1003–1017.
2. Mathur, G. and Mohan Ram, H. Y., *Phytomorphology*, 1986, **36**, 79–100.
3. Mohan Ram, H. Y., *Curr. Sci.*, 2005, **89**, 1672–1680.
4. Mohan Ram, H. Y., *J. Biosci.*, 2002, **27**, 651–664.

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RAMESH MAHESHWARI^{1,*}
K. R. SHIVANNA²
R. DORE SWAMY³
K. SANKARA RAO⁴
GITA MATHUR⁵

¹Formerly at Department of
Biochemistry,
Indian Institute of Science,
Bangalore 560 012, India

²Formerly at Department of Botany,
University of Delhi,
Delhi 110 007, India

³Formerly at Indian Institute of
Horticultural Research,
Bangalore 560 089, India

⁴Centre for Ecological Sciences,
Indian Institute of Science,
Bangalore 560 012, India

⁵Department of Botany,
Gargi College,
Delhi 110 049, India

*e-mail: ramesh.maheshwari01@
gmail.com