# Down memory lane

*T. S. Sadasivan*

When S. Ramaseshan invited me to write an article for *Current Science* which would be a kind of reminiscence of my role in the growth of botany in this country, I accepted the invitation for one good reason that the present-day trends in botanical research had their dim beginnings in the thirties and forties, a period of flux as it were. Classical botany was slowly yielding place to experimental botany at that point of time. Plant physiology had started underlining the basic principles that made a study of the phenomenon of photosynthesis and respiration not only fashionable, but also one of exciting possibilities in understanding fundamental problems of form and function. It was difficult for a young research minded scientist to decide on what area of research he could choose. Plant pathology, during the period, had emerged as a subject where indepth studies could be made of the interaction between host and parasite brought about by an infective agent, be it a fungus, a bacterium or a virus in a disease-prone plant. In a sense, physiology of a plant under stress was considered a subject of absorbing interest as it involved biochemical changes in the plant as a result of pathogenesis. My choice of a subject for research got narrowed down to one of emphasis on the host and its deranged metabolism.

Returning to India in 1940 after an exposure in the United Kingdom into the complexities of plant virology, at a time when World War II was gathering momentum, it became obvious that it would be a long waiting period before a teaching-cum-research position would offer itself. With recommendatory letters to the Vice-President of the Imperial Council of Agricultural Research (now Indian Council of Agricultural Research) from the noted Agricultural Scientist E. John Russell and from my mentor Fred C. Bawden, from the Rothamsted Experimental Station, where I had worked for my doctorate, I met W. Burns, Head of the ICAR in New Delhi. In keeping with the dignity of his chair, he was sympathetic but had nothing specific to offer by way of placement. This was no jolt to my ambitions. It only made me decide to return to my *Alma Mater*, Lucknow University. My *Guru* Birbal Sahni welcomed the idea for he said in one of his letters that I should not rust at home in Madras. For one year I had a modest job as Demonstrator in Botany at Lucknow on a salary of rupees sixty per month. This assignment gave me much opportunity to organize and equip myself for the tasks ahead. It was a pleasure to work again with S. N. Das Gupta at Lucknow, my former teacher and well-known plant pathologist. From 1941 to 1944 I had a temporary war-time post of Microbiologist in the Punjab Agricultural College, Lyallpur. It was a frustrating experience. It was only in 1944 I was able to get a position of responsibility in the University Botany Laboratory, Madras and I could then see some light at the end of the tunnel. One of the most welcome letters came from none other than my teacher Birbal Sahni on assuming my post at Madras. He said among other things: 'Remember, it is not your own research contributions to your subject of choice, but those of your research students and associates that will bring you job satisfaction and laurels to your research school'. These words of wisdom and advice from a celebrated botanist of this country naturally made a great impact on me.

While I felt elated at getting a University position, which was one of my objectives all along, it brought in a sense of awe when I looked back at the achievements of the algal research school established in Madras by my teacher M. O. P. Iyengar. Instead of dampening my enthusiasm it undoubtedly acted as a spur and made me plunge into the task of organizing an active research group in plant pathology. To give effect to this resolve, however, there were many obstacles. The laboratory was reasonably well equipped for morphological work, but not for experimental botany. There were six university research stipends for deserving students with a glorious monthly remuneration of rupees sixty, a fact which may raise many eyebrows among academics today. To add to this modest infrastructure one has to realize that most departments of research at the Madras University were one-man departments with just one research assistant on a salary of rupees one hundred and fifty per month. The annual allotment for purchase of glassware and chemicals was hardly rupees eight thousand. Undeterred by these inadequacies in men and materials, one had to get along albeit keeping research ambitions at a low key. Independence to the nation in 1947 brought no message of optimism. It was not till early fifties that the Ministry of Education created a post of lecturership to be followed by sanction of a readership a couple of years later.

I have said enough to indicate the austerity conditions under which one had to develop a new subject of research. The silver lining was the fact that a large number of bright young women and men students joined the laboratory with the right motivation and they threw in their lot willingly. From my point of view, it seemed unwise to start developing plant virology (although I was trained in that discipline) as the infrastructure was totally inadequate for such a venture. We, therefore, chose long-term projects like soil conditions and plant disease. In this task we realized that we should choose model host-parasite systems and work at depth on all aspects of deranged host physiology, consequent on pathogenesis, especially of economically important plants. Looking back it is gratifying that it paid rich dividends. These kinds of intensive investigations in a highly circumscribed area of research meant the application of many experimental techniques which did not involve deployment of expensive sophisticated instruments as we did not have the wherewithal to procure them. During this period the most elegant technique of paper chromatography, thin layer chromatography, which was discovered in the late forties and early fifties and was extensively used in plant tissue analysis came in very handy. We were quick in realizing that ingenuity in application of experimental techniques was more important than pressing into service expensive instruments for analyses of plant tissues.

## A resume of three decades of work in plant pathology

I would now like to briefly summarize

the work done by our research school before continuing with my reminiscences in a general way. Our first long-range interest in soil-borne diseases of plants occupied much of our time as it included several aspects of colonization and survival of the soil inhabitant fungus *Fusarium vasinfectum* which caused widespread wilt disease of cotton in many cotton-growing areas in India and abroad. These studies helped in developing concepts such as competitive saprophytic ability, eventually leading to a better understanding of the 'inoculum potential' concept proposed by S. D. Garrett of the Botany School, Cambridge. We also studied the 'Rhizosphere effect', and in this, the role of root exudates in promoting the growth and survival of specific pathogens was adequately covered. It became clear that the root environment enriched by root exudates (containing exudates of vitamins and amino acids), enriched by sloughed-off root hairs could provide an ecological advantage to soil-borne pathogens to multiply and attack plant roots. A large team worked in this area spear-headed notably by C. B. Sulochana, V. Agnihothrudu and N. S. Subba Rao. We also turned our attention to trace element amendments to the soil that would alter the incidence of soil-borne disease caused by fungi promoting the growth of antagonistic microfloras. By close interaction between the Madras School and the Botany School, Cambridge, several ideas about soil microbiology, particularly soil mycoflora were developed by S. D. Garrett. In fact, he was deeply influenced by our contributions.

It was in the late fifties that the work of Flor on flax rust and the successful breeding of disease-resistant varieties of crop plants not only established the genetic basis of resistance to disease (gene to gene hypothesis) but also provided material to study differential response to pathogens (compatible and incompatible). It was realized, at that point of time, that 'pathogenesis in plants' is the result of active interaction between the host plant and the disease causing pathogenic organism and not solely the effect of the activity of invading microorganisms. Thus, the physiological activities of both the pathogen and the host had to be studied in understanding pathogenesis in plants. The science of physiological plant pathology had its birth in one or two centres in the world and also in our laboratory almost simultaneously. In short, plant disease studies were scaled down to laboratory investigations which permitted assessment of plant–pathogen interaction under controlled environment at the biochemical level. It was most gratifying to see the newly established Agricultural Universities in India, in the sixties, build sophisticated laboratories for the study of plant disease at the physiological and biochemical levels following our example at Madras.

Among the pathogenic factors, pectinolytic enzymes and toxins received comprehensive examination in several host–pathogen combinations. The first ever demonstration of the toxin fusaric acid in wilting cotton plants *in vivo* and designating it as a vivotoxin was by our group (D. Subramanian, K. Lakshminarayanan, N. S. Subba Rao). In fact, the adaptive nature of pectinolytic enzymes and the pattern of pectic enzyme secretion *in vivo* brought out the differential availability of the substrate in the host tissues (a genotypic difference). These studies were initiated by Subramanian and his collaborators.

Derangement in respiration, photosynthesis, carbon and nitrogen metabolism and growth substance balance in the *Cerospora* disease of groundnut were critically examined by R. Narayana Swamy and several of his collaborators. Of particular interest were the biochemical changes in a virus-infected legume which showed increased water loss by excessive transpiration, accumulation of iron, lower chlorophyll levels and carbohydrate contents in the infected plants.

Another model system of the widely spread rice disease, the 'rice blast' by the air-borne pathogen *Pyricularia oryzae* was experimented upon very thoroughly by S. Suryanarayanan and his colleagues and later by K. Manibhushan Rao and his associates over a period of two decades. Their contributions showed essentially a genotype-nyctotemperature interaction. Low night temperature was critical not only in host compatibility but also host range. Host-induced variability of the fungus was also demonstrated by these groups. Intensive studies were initiated on the toxin pyriculol produced by the blast fungus which included permeability changes brought about by the toxin in the host tissue. These alterations in permeability were shown to be due not only to toxins produced by the fungus but also by a $FeCl_3$ toxic host component. Furthermore, the toxins of the fungus were demonstrated, for the first time, to induce 'green islands' in rice leaf tissue. The role of Fe in the blast disease of rice was indicated by the importance of lipoxygenase in disease resistance.

One other problem studied, indepth, by T. S. Sadasivan, R. Kalyansundaram and L. Saraswathi Devi was the *in vivo* changes in the physiology of *Fusarium* wilted cotton plants. These studies were aimed at understanding the mechanisms of the disease syndrome. Wilt diseases show progressive loss of turgor in aerial parts of the infected plants, often accompanied by leaf vein-clearing, yellowing and dechlorophyllation of leaves. The *modus operandi* of these changes had been a subject of speculation and it appeared to be more a difference of opinion as to where to lay the emphasis. Wilting, due to an acute water deficit, was considered not only the aftermath of occlusion of vessels by the growth of the pathogen, resulting in a physical blockade, but also in the release of products of fungal metabolism and in the secretion of enzymes essential for their establishment *in vivo*. The role of toxins, however, remained a matter of conjecture until a newer concept of 'vivotoxin' was advanced to explain their *in vivo* complexity in pathogenesis. We, therefore, put forward definite evidence for the occurrence of fusaric acid *in vivo* in the cotton wilted plants and this necessitated a reorientation of our concept of wilt pathogenesis. As far as we could visualize, there seemed little damage to semi-permeability of the root of the infected plant. The stem damage appeared to be mechanical obstruction to uptake of solutes, and in the lamina ionic imbalance was largely in the form of excessive excretion of potassium and accumulation of divalent cations. The basic thing, of course, is that, in the cotton, the pattern of uptake of ions and the availability of the pectin substrate seem to be gene-controlled.

Studies initiated by P. N. Raju and his research associates on legume–rhizobia symbiosis, as part of a wide theme of host–parasite interaction, was to evaluate di-nitrogen fixing effectiveness of rhizobia isolated from the nodules of a variety of tropical legumes. Similar studies on di-nitrogen fixation were extended to symbiosis in virus-infected legumes where abnormal conditions developed resulting

in a nitrogen stress in the host. These investigations showed, for the first time, that the metabolic picture presented by the virus-infected legumes, when infected, by an effective strain of *Rhizobium*, was the result of the activity *in situ* of an agent causing nitrogen stress and one meeting this demand.

## Centre for Advanced Study in Physiological Plant Pathology

It is the kind of dedicated team work done by our researchers during the period 1944 to 1962 that paved the way for our laboratory to be named by the University Grants Commission (UGC) as a Centre for Advanced Study (CAS) in Botany with specialization in Physiological Plant Pathology. With this recognition came the necessary financial inputs for strengthening our efforts by adding many new analytical instruments. With expansion of the research staff we embarked on ambitious projects in our chosen field of research. All this was possible with the cooperation of two distinguished educationists: A. Lakshmanaswamy Mudaliar, Vice-Chancellor of the Madras University and D. S. Kothari, Chairman, University Grants Commission who was the architect of the concept of establishing Centres of Excellence in the Universities and build them round active schools of research. As a member of the UGC Committee for formation of these advanced centres, I recall with pleasure the enlightened thinking among the members of this committee, in particular, the progressive ideas of T. R. Seshadri in giving shape to the concept of Centres of Advanced Study.

The vitality of any research centre is to be judged by the attention given to it by leading scientists at home and abroad. The Madras group of physiological plant pathologists enjoyed this privilege. Notable among those that interacted with us were: Panchanan Maheshwari of the University of Delhi, P. Parija of the Utkal University, Shri Ranjan of the Allahabad University, S. D. Garrett, of the Botany School, Cambridge University, F. C. Bawden, Director Rothamsted Experimental Station and Vice-President of the Royal Society, R. K. S. Wood of the London University, James G. Horsfall and A. E. Dimond of the Connecticut Agricultural Experimental Station, W. C. Snyder of Berkeley, Kenneth V. Thimann of Santa Barbara, F. C. Steward of Cornell University, Academician N. A. Krassilnikov of Moscow University, Kurt Mothes of Halle-Saale and many other younger scientists from abroad.

Developing one's narrow research interests, in my view, do not contribute to the overall growth of the discipline of botany. We were, therefore, most anxious to advance the research interests of M. O. P. Iyengar in the field of algology. The opportunity presented itself when the Centre of Advanced Study was formed in 1963. The UGC was quick in appreciating this and accorded sanction for a chair in Algology which was held with distinction by T. V. Desikachary. Similarly, we were anxious to give fillip to the subject of mycology and this subject also had a chair in the scheme of expansion. This branch again was ably established by C. V. Subramanian and his group of mycologists. Our centre also gave all facilities and a Senior Research Fellowship to E. K. Janaki Ammal to continue her interests in cytogenetics.

At a personal level, I had the good fortune of being associated with the Indian Academy of Sciences and its eminent President C. V. Raman. It was a rare privilege. Raman with his breadth of vision evinced keen interest in our work at Madras and gave our group the opportunity of organizing seminars during the Annual Meetings of the Academy. They were unforgettable moments in a scientist's career and our group used to look forward to these annual meetings of the Academy where our activities could be summarized. It is most appropriate to mention here that we considered it a matter of national pride to have published our scientific papers, over the decades, in the *Proceedings of the Indian Academy of Sciences (Sect. B)*, for which we were beholden to Raman.

My philosophy was, and is, to give the utmost academic freedom to young and bright scientists. I have had long arguments with peer groups about this and differed from some of them much to their chagrin. Simply stated, we should realize that a young scientist needs authorship on his own in his published papers for enthusing him to take to a scientific career. Funding research projects alone, or giving them awards of one kind or another is only one side of the coin and the other side should be academic freedom in its widest sense. Whether we like it or not, there is what I might call, 'Peer Patronage' in our higher institutions of learning. The sooner this goes the better it is for the young aspirants in our various schools of research. This will be in keeping with the highest traditions of our country as exemplified by our ancient gurukula system of learning where the teacher spared no pains to give the highest knowledge expecting nothing in return personally except that the pupil carries the torch of learning forward for the sake of humanity.

## Involvement in national work of academic importance

We had an invitation in the sixties, from the National Council for Education, Research and Training (NCERT) co-sponsored by the UGC to get together a number of university biologists and edit a series of Biology Textbooks addressed to age groups 10 to 16 in our schools. This was a very arduous task and we completed it in a few years. These books were tried in various schools in the country and the feedback showed that they were acceptable. I have always held the view that the integrated teaching of botany and zoology as biology both at School and College levels is the most logical thing to do. It is fortunate that this message of the sixties we gave to the NCERT is bearing fruit as many colleges and University Departments are opting for Biology Courses at the graduate level.

With a view to giving a boost to the study of problems in experimental botany, a number of proposals made by us were given effect to by many central agencies like the UGC, NCERT, etc., during the fifties and sixties. We organized a Summer School for Experimental Botany in 1965 with many participants drawn from university departments of botany and from affiliated colleges. They all expressed their shared concern in suitably aiding young researchers in the field. A number of important recommendations were made: (i) Establishment of a central agency for handling bulk import and distribution to researchers of fine chemicals and biochemicals, (ii) Creation of supernumerary positions in the universities and research institutes to attract young scientists from abroad, (iii) Give a fillip to

Indian industries for taking up manufacture of laboratory equipments, (iv) Liberal granting of funds for organizing workshop and glass blowing facilities in select educational and research centres in the country, (v) Create positions of laboratory technicians to assist scientists in the various research centres.

Our group also organized a workshop in research methodology in experimental botany for South East Asian Countries in 1970 sponsored by UNESCO. On similar lines we organized Summer Schools for School and College teachers and for talented students under the sponsorship of USAID, NCERT and UGC, all aimed at exposing the participants to techniques in research and teaching methodologies in modern biology within the reach of traditionally trained teachers of all categories.

Our Centre espoused the cause of young scientists for their placement and opportunities for attending scientific meetings at home and abroad and this philosophy found favourable response from aid-giving bodies like the UGC, INSA, CSIR, etc.

There were major review committees like the reviewing of the work of the Botanical and Zoological Surveys of India, reviewing the status of R & D in Tea and Coffee industries. Being on these committees was national work but it involved much travel and visits to laboratories, field stations, etc. The most arduous task, however, was report writing, as differing viewpoints, from among the members of the committee had to be narrowed down patiently. Whether the tardy implementation of the recommendations was commensurate with the time and energy spent is a moot point. Nevertheless, it was an education in itself. There were other demands on my time like the editing of botanical journals and being on the editorial boards of specialist international journals. They were pleasurable assignments and I, for one, looked forward to these assignments. Refereeing scientific articles has always posed problems. I recall what C. V. Raman had to say of this process in one of the Council Meetings of the Indian Academy of Sciences. A member of the committee was somewhat critical about the standards of refereeing in the Proceedings of the Academy and Raman was quick in saying: 'A scientist stands or falls by his own writings'. Left to himself he was not very particular on placing too much emphasis on refereeing. There was much wisdom in this observation. The Editorship of the *J. Indian Bot. Soc.*, was with me for over a decade and I thoroughly enjoyed this assignment as it gave me an insight into the many-sided developments in botany from plant taxonomy and anatomy through embryology to experimental disciplines like physiology, plant pathology and tissue culture. For nearly three decades I was on the editorial board of the international specialist journal *Phytopathologische Zeitschrift* which meant much work in screening all manuscripts submitted to the journal from India.

One of the important invitations came from the Ministry of Education in 1969 for taking over the Chairmanship of the Governing Body of the Birbal Sahni Institute of Palaeobotany, Lucknow. I was privileged to interact with this Institute for nearly a decade. The distinguished members of the Governing Body and the scientists of the Institute had very resilient minds and we got on well as a team. Our objective was to aid the Institute, in every way, to be on par with some of our national laboratories. I think we succeeded in doing so.

I was also invited by the CSIR to be their Consultant for three of their plant-based laboratories: The National Botanical Garden (now renamed as National Botanical Research Institute), The Central Institute of Medicinal and Aromatic Plants and the Regional Research Laboratory, Jammu and Kashmir. It was a tough assignment in many ways. All the three laboratories, at that point of time (1973–76), did not have full-fledged Directors. An interesting discussion took place in one of the Selection Committee meetings for selection of a Director for one of the plant-based laboratories. A member of the Selection Committee asked the acting Deputy Director, who was also an applicant, as to what was his special claim for the position of Director. He replied by saying that, after he took over the reins, the scientists of the laboratory, due to his administrative competence, were now on 'talking terms'. Is this not a major achievement he asked the committee member who posed the question.

Those three years of consultancy gave me much satisfaction as I could intimately interact with the scientists of the three laboratories and assist in shaping their research programmes.

After three decades of active research work at Madras, I have a feeling that botanical research in the Indian Universities should continue to concentrate on fundamental problems with relevance to national interests. Successive Governments should appreciate this role of the universities. There is so much to be done in the field and in the laboratory. To cite a few examples: Whoever thought that the lowly algae had such an important role in nitrogen fixation in rice fields and whoever imagined that fungal toxins had an adverse effect on human well-being. The root nodule bacteria and its relationships with its host is still an exciting area of basic research even after several decades of work—the world over. Problems of biotechnology and genetic engineering offer immense scope for work in the universities. One can go on listing priorities and frontier areas of basic research but I will be content leaving these thoughts here. In India, I get the feeling that, funding agencies do not seem to be enthusiastic when it comes to aiding basic research in the universities. Nevertheless, I do believe that it is a matter of national pride and prestige to make fundamental discoveries in the basic sciences.

I would like to mention here that, while we are bestowing adequate attention to growth of science education at the higher levels, our efforts at the grass roots level of teaching science have been woefully inadequate. I have taken this as a challenge and as a crusade in the past decade to use every forum to impress on aid-giving bodies to strengthen laboratories in our schools and encourage building the infrastructure for museums and hobby workshops in schools. It is there that the young aspirants for a science career could get practical experience in rigging up simple instruments and studying biological specimens in their natural habitat. Students must be encouraged to study the myriad microscopic forms of life, be they of planktonic or terrestrial origin. Every school should have an electronics and instrumentation laboratory and they should learn the art of glass blowing. The rural schools need urgent attention if science is to permeate into our villages. Independent India's first and great Prime Minister Pandit Jawaharlal Nehru wanted this to happen if our rural people are to live in harmony with the urban population and enjoy the fruits of modern amenities.

I would like to conclude with a brief

account of some events that brought much satisfaction to me. I felt honoured by the Board of Governors of three of International Botanical Congresses electing me to the prestigious Vice-Presidentship of their quinquennial Botanical Congresses held in Canada, the USA and in the United Kingdom. The first International Congress of Plant Pathology held in London, in the late sixties, also honoured me with a Vice-Presidentship. These recognitions were, in fact, a token of appreciation of the sustained efforts of many young research scholars who helped establish the Madras Centre for Advanced Study in the new and exciting field of Physiological Plant Pathology. To my mind, in a scientist's long career, the most important thing is to derive satisfaction from striving to be a dedicated teacher and a motivated research guide to the young researcher.

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