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MEMOIR

Robert Simpson Loomis

October 11, 1928 –March 27, 2015

Professor Robert (Bob) S. Loomis, a world-renowned scientist, educator, and researcher, led highly active lives in all dimensions, including humanity, personal, family, social, and professional aspects. His broad scientific background in physics, biochemistry, botany, physiology, agronomy, and crop modeling led to a productive life that left a highly admired legacy to build upon by those whom he knew personally as well as those who read his writings that exceeded 130 publications and books. His publications covered both applied and basic plant sciences, ranging from theoretical developments in the biophysics and biochemistry of photosynthesis and growth at the subcellular level through to mass and energy cycling at the landscape scale.

Bob´s students, collaborators, and world scientists would agree that his analytical mind not only surpassed the norm but also transmitted its brilliance to others (Boote and Loomis 1991, Loomis and Connor 1992, Connor *et al.* 2011). To this day I recall his visionary words, while he was accompanying me along with Bill Williams to Sacramento airport in my return to Egypt: *"You are leaving your baby* (*meaning our cutting-edge discoveries at science frontiers in plant photosynthesis*) *unattended in the USA*!*"* Shortly, that position at Davis was refilled by the renowned plant physiologist from New Zealand, Dr. Keith J. McCree, who reached a distinguished career at Texas A&M University, where he was at the forefront of the quantum efficiency studies on leaf-scale photosynthesis (McCree 1972a,b, 1981) and the development of quantitative functional models of whole-plant respiration (McCree 1974). Indeed, Bob was a central catalyst of the key developments in the biochemical and physiological analysis and modeling of plant respiration during the 1960s and 1970s. As outlined by Amthor (2000), it was Bob, who first articulated the now widely used, biochemically based approach in calculating potential efficiency of plant growth from a unit of photosynthate (as developed fully by Penning de Vries *et al*. 1974); it was also the group of Bob, C.T. de Wit, and K.J. McCree who determined that plant respiration could be divided into "growth" and "maintenance" components within physiologically-based simulation models.

Roots, personality and family history

Bob was born in Ames, Iowa, USA, October 11, 1928, as the second child, after his brother, Walter David Loomis, who was later an accomplished plant biochemist at Oregon State University. His father, Prof. Walter Earl Loomis, was a man of great intellectual capacity who built a distinguished career in higher education and research in the fields of botany and plant biology/physiology, at Iowa State University, Ames, where a botany laboratory carries his name today. His wife, Helen Mary Parke Loomis, was a sharp-minded and critical English language editor of scientific papers.

Bob married Lois Ann Morris, a food scientist, in 1951, who had shared with him some undergraduate courses, and who was rooted in a well-established Iowa farm family. Both actively participated in her inherited agricultural enterprise. They enjoyed 58 fulfilling years of marriage (until Ann's death in 2010). Bob was devoted to his family and raised three professional daughters: Susan Loomis, Sarah Paul (Loomis), and Caroline Loomis. He had four grandchildren from Caroline.

The Loomis´ were socially active in the Davis academic community surrounded with and attending to so many friends and visitors. They loved traveling together attending scientific meetings worldwide, as well as sailing, camping, skiing, and inviting friends to pass time with them in their lovely cabin near Lake Tahoe.

I was fortunate to meet for the second time Bob´s father during his short visit to Egypt and Sudan, in 1967, at our research department, Ministry of Agriculture, Giza, where two senior researchers in plant physiology were his former graduate students at Iowa State University. My first encounter with Bob´s father was in 1966, at Davis, when he visited our plant physiology and gas-exchange laboratory. Walter Loomis trained many Egyptian young scientists, including one of my professors at the Faculty of Agriculture, Alexandria University, Dr. Mohammed Abul´ Ela, a crop physiologist/statistician. Thus, the Loomis´, the father and son, had contributed significantly to the building of scientific capacity and to the enhancement of agricultural research and development of Egypt early on.

Education

Bob received his pre-university education in Ames, and then attended Iowa State University there, where he earned a BSc in physics in 1949. This basic-science training gave him a solid background which strengthened his analytical approach to biological research later. At the University of Wisconsin, Madison, he obtained his MSc, in 1951, in botany with a research thesis on quantum efficiency of plant photosynthesis. After completing service in the U.S. Air Force, where he was engaged in atmospheric research at the A.F. Cambridge Research Center in Massachusetts, he returned to the University of Wisconsin for PhD studies in botany, which was completed in 1956, with a thesis on corn-stem borers discovering the importance of the antibiotic DIMBOA (a naturally occurring benzoxazinoid) in insect and disease resistances.

Career and tenure professorship

Bob´s first appointment (in 1956) was as a sugar beet agronomist in the Department of Agronomy and Range Science of the newly developing campus at the University of California in Davis. With various colleagues, including the well-known plant nutritionist Dr. A. Ulrich, he sorted out the optimum plant nutrient inputs for maximizing sugar beet yield. This research emphasized the physiology of nutrient and water stress and its effect on crop growth and leaf photosynthesis. Later he turned to studies of growth and biomass partitioning among leaves and roots that led to the development of "ideotype concept for sugar beet". At Harvard University with J.G. Torrey in 1963–4, he elucidated hormonal controls over cambial activity in radish. Besides teaching crop ecology/physiology, he started in 1962 working with Prof. W. A. Williams, on maize crop growth dynamics in interaction with environments, particularly irradiance distribution and canopy structure, research that laid the basic foundations for crop modeling with W.G. (Bill) Duncan. He spent his entire academic career dedicated to his teaching, training, and research at Davis up to his formal retirement in 1991. Even after retirement he continued working and published several important papers and books.

The significance of research achievements in crops and agroecosystems improvements
Discovery of the C_4 grain amaranth

Bob was known for his ability to attract qualified graduate students, post-docs, and scientists because of his capacity as an educator, and analytically-oriented scientist. For instance, I recall his visit to Tucson, Arizona in March 1965. Along with Duncan, who piloted his small private plane, they visited John Hesketh´s photosynthesis laboratory at the University of Arizona to interview me for a fellowship two months before my PhD thesis examination on April 29, 1965. I was packing up personal belongings upon receipt of a ship ticket for my trip to Egypt in response to requirements of the Egyptian government that financed my postgraduate studies at the time (1960-1965). Bob, Hesketh, and Duncan were the driving force for me to move to Davis, with a project funded by a National Science Foundation grant (NSF-GB-4192). We studied patterns and characteristics of light interception/distribution, including light spectral analysis throughout maize crop profile, at different planting densities. Moreover, leaf development/configuration, leaf area, crop growth rate, dry matter partitioning, and total biomass and grain yield were investigated. These data were crucial for building the pioneering University of California photosynthesis/crop growth model (Duncan *et al.* 1967). Ground-breaking discoveries were also made in the field of plant C_3/C_4 photosynthesis (El-Sharkawy *et al.* 1967, 1968), which extended previous discoveries in various crop and weed species made at the University of Arizona, Tucson (El-Sharkawy and Hesketh 1965, 1986). Additional C_4 amaranths (red-root "pigweed", *Amaranthus retroflexus*, and the grain amaranth, *A. edulis*, recently renamed *A. caudatus* cv. *edulis*), were discovered. The first discovered C_4 dicot plant, made in 1964 in Arizona, was the weedy "plamer" amaranth, *A. palmeri* (El-Sharkawy and Hesketh 1965, 1986). These C_4 species were characterized by their high net photosynthetic rate, high optimum temperature, no light saturation, leaf Kranz anatomy, zero CO_2 compensation point,

absence of apparent releases of CO_2 in CO_2-free air in light, and complete recycling of internal CO_2 *via* their mesophyll (El-Sharkawy *et al.* 1967, 1968). These early discoveries facilitated sorting out the detailed photosynthetic pathway in C_4 systems (Hatch *et al.* 1967, Björkman 1968, Hatch and Slack 1970, Laetch 1974, Berry 2012, Lundgren *et al.* 2014).

Potential productivity of photosynthetic systems

A primary rationale for research on photosynthetic systems is to understand, and then to reduce the limitations on crop growth and productivity. A starting point for work in this area is to quantify—based on the most up-to-date knowledge available—the biophysical and biochemical limits on both gross and net primary production at the crop scale. Bob, working with Bill Williams, established the first major milestone in that field with his classic article "Maximum crop productivity: an estimate" (Loomis and Williams 1963). Although there were other estimates of potential photosynthetic productivity available at the time, this was the first robust treatment that considered whole plant communities within a realistic environmental context and that was therefore directly related to global food, feed, fiber, and biofuel production. The analysis laid bare the possibilities for improving crop production as well as the rather wide knowledge gaps concerning field-scale (and, indeed, leaf-scale) photosynthetic systems.

Bob maintained a keen interest in this critical topic and later refined his analysis from 1963 by accounting for new scientific insights and knowledge of both C_3 and C_4 systems (Loomis and Amthor 1996, 1999). Even nearly 20 years after his retirement, Bob continued contemplating the limits of crop-scale photosynthetic efficiency and productivity, though then he opted for a role of behind-the-scenes resource and sounding board rather than named author (Amthor 2010).

Crop simulation modeling

A powerful tool in understanding crop systems performance and in extrapolating basic knowledge of agronomy, biochemistry, and physiology to the scale of crops and landscapes is physiologically-based simulation modeling. These "explanatory" models are important both to students and advanced researchers; and Bob was a key player in the early development of such models as they were applied to crop systems (*e.g.*, Loomis *et al*. 1979). Indeed, a significant fraction of his national and international collaborative efforts were directly or indirectly related to advancing the rigor and usefulness of comprehensive/mechanistic simulation models, accounting for the most recent developments in processes ranging from the biophysics of photosynthesis to long-term, large-scale cycling of nutrients within and across landscapes. Many of his students and collaborators named in the following section made critical contributions to simulation modeling, and this was because of their interactions with Bob.

Bob's doctoral students, post-doctoral fellows, and visiting collaborators

One measure of the significance of Bob's contributions to research on photosynthesis and plant productivity is the list of internationally known scientists (doctoral students, post-doctoral fellows, senior researchers, and teachers) who spent time in Davis working with Bob on a wide array of experimental, theoretical, and modeling research projects. They include, up to the time of his retirement (in alphabetic order): S.S. Adams, J.S. Amthor, I. Baddila, J. Brickey, J.I. Burke, A. Clark, J.H. Cock, D.J. Connor, R.F. Denison, W.G. Duncan, M.A. El-Sharkawy, F. von Egmond, A. Enloe, S. Fukai, P.A. Gerakis, A.E. Hall, S.E. Hampson, W.F. Hunt, C. Itai, D. Johnson, P.L. Kooman, R.H. Lafitte, G. van Laar, J.H. Lemcoff, N. Lopez, Y. Luo, G. Malazian, K.J. McCree, D.K. McDermitt, P.A. Meyerhof, K. Mustafa, E. Ng, D.J. Nevins, K. Niste, R. Novoa, F.W.T. Penning de Vries, P. Pinto, R. Rabbinge, J.W. Radin, H.F. Rapoport, G. Ritenour, J. Rouanet, J. Talbott, J. Salisbury, C.B. Shah, R.M. Shibles, N.G. Seligman, J. Wallinga, I.J. Warrington, J. Wilson, and C.T. de Wit.

In total, Bob mentored 13 successful MS students and 19 PhD students. He sponsored 25 post-doctoral researchers and senior academic researchers.

Scientific societies, editorial boards, research committees, honorary awards, community services Science in services of society

Bob always maintained an unpretentious view of the place of scientific research within the larger human community, to which it should serve. During a 1991 trip through the mountains of eastern California, while passing a group of construction workers on the highway, he pointed out that it required the work of a rather large number of non-scientists to create the wealth and resources required for each and every research grant to the scientific community. We scientists should always remain grateful to society and do our best to warrant its support of our livelihood.

Among his many roles, Bob serviced as faculty athletic representative and chair of Intercollegiate Athletic Board, first director of the Institute of Environmental Studies, member of the policy committee of the University of California-University of Chile Convenio (in Spanish), and representative to the University-wide Assembly of the Academic Senate.

Scientific societies and editorial activities

Bob was the chair of the Western Section and secretary in the American Society of Plant Physiologists. He also served on various committees of the American Society of Agronomy (ASA) and Crop Science Society of America (CSSA) and as an editor of Crop Science, Advances in Bioclimatology, and Field Crops Research.

Honorary awards

Bob was an elected fellow of ASA, CSSA, and AAAS.

Selective publications and books

Publications

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Books

Crop Ecology: Productivity and Management in Agricultural Systems (authored by R. S. Loomis, D. J. Connor), published by Cambridge University Press in 1992, with translations in Japanese, Spanish, and Chinese. A second updated edition (authored by D. J. Connor, R.S. Loomis, K. G. Cassman) was published in 2011.

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