

## The International Society for Plant Anaerobiosis: History and Activity

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The International Society for Plant Anaerobiosis (ISPA) was founded to promote and coordinate research on higher plant responses to hypoxic and anoxic stresses. The original goal of the Society was to organize regular meetings and discussions of scientists involved in this research and to encourage publication of monographs and papers in periodicals on plant life under low-oxygen stress conditions (Vartapetian BB, Crawford RMM 1997. *Russian Journal of Plant Physiology* **44**, № 6, p. 816; Vartapetian BB. 2003. *Russian Journal of Plant Physiology* **50**, № 6, p. 719)

The activities of ISPA members commenced immediately following the First International Symposium on Plant Anaerobiosis held within the framework of the XII International Botanical Congress in Leningrad (St. Petersburg) in 1975, although the ISPA itself was formally established somewhat later. In the 1970s, so few researchers were involved in studies on higher plant anaerobiosis that it was not easy to organize a special symposium dedicated to this specific topic. When a core of several key speakers was finally assembled, we met with the equally difficult task of persuading the principal organizers of the Congress to dedicate a special symposium to our subject. It was not easy for them to agree, because no previous international congresses on botany or biochemistry had paid particular attention to this topic and no special books on plant anaerobic stress had yet to be published. Thanks to academician A.L. Kursanov, a vice-president of the XII International Botanical Congress, who backed my appeal to the Congress, the symposium on anaerobiosis was finally added to the scientific programme of the Congress. As a result, several invited researchers in this field, including W. Armstrong and R.M.M. Crawford (United Kingdom), A. Pradet (France) and H. Tsuji (Japan) took part at the symposium. Later, these scientists were to do much to promote the development of research on plant hypoxic and anoxic stresses. Professor D.D. Hook (United States) who studied adaptation and flood tolerance of tree species, also participated in this symposium. His efforts were instrumental in publishing a monograph *Plant Life in Anaerobic Environments*, a collection of the papers read at the symposium edited by himself and Crawford and published in 1978 in the USA. The book met much interest from the scientific community, as reflected by

numerous reviews published in leading international journals, such as *Science*, *New Phytologist*, and *Journal of Applied Ecology*. The first edition of the book was soon sold out, and a second printing appeared in 1980.

The first symposium and the first book on plant anaerobiosis helped to unite the small group of researchers already active in this field to promote the development of new research groups and centres involved in the study of plant anaerobiosis. Efficient international contacts established between researchers resulted in joint studies and publications. In this way, the first symposium and the first book on plant anaerobic stress became the basis for establishing both a new scientific society and a new scientific discipline embracing plant life under hypoxic and anoxic conditions.

Several international symposia were subsequently initiated by ISPA members on a regular basis in various countries, sometimes under the aegis or financial support of UNESCO, NATO or Green Cross (Table 1). The level of participation in these meetings increased notably over time with the Second International Symposium on anaerobic stress (held in Moscow in 1985 and funded by UNESCO) attracting several times more researchers than did the first symposium in 1975. Subsequent ISPA conferences in Finland (1995), Netherlands (2001) and in Australia (2004) each brought together almost a hundred delegates from Europe, Asia, Australia, and North America. In addition to these international meetings, the many hundreds of scientific papers vividly illustrate the growing interest in the phenomenon of plant anaerobic stress and related topics connected with flooding and submergence. Thanks primarily to the efforts of ISPA members, numerous influential monographs or collections of papers have now been published on these topics (Table 2). The subject of plant anaerobiosis has been included in the scientific programmes of International Conference “Rice Production on Acid Soils of the Tropics” (1989, Sri\_Lanka), First International Crop Science Congress (1992, USA), International Botanical Congresses in Yokohama, Japan (1993) and St Louis, USA (1999), the 1995 annual meeting of the Society for Experimental Biology in St Andrews, Scotland and the 1998 Annual Meeting of the American Society of Agronomy/Crop Science/ Soil Science Crop Science held in Minneapolis, USA. ISPA members either organized these sessions or participated in them as invited speakers. A special chapter dedicated to plant anaerobiosis was included in volume 2 of *The Biochemistry of Plants* (Academic Press, 1980). A similar chapter appeared soon after in the *Encyclopedia of Plant Physiology* (Springer-Verlag, 1982). The importance of anaerobiosis and plant aeration was thus becoming recognized in basic plant biology and in applied agronomy and forestry with both economic and ecological dimensions of this problem being increasingly acknowledged.

**Table 1.** International symposia and conferences organized by ISPA members

No.	Year	Country	Organizers
1	1975	USSR	B.B. Vartapetian
2	1985	USSR–UNESCO	B.B. Vartapetian
3	1985	United Kingdom	R.M.M. Crawford
4	1986	United States	D.D. Hook
5	1987	Switzerland	R. Brändle
6	1992	Iceland–UNESCO	B.E. Gudleifsson
7	1992	United Kingdom–NATO	M.B. Jackson, C.R. Black
8	1993	Japan (XV IBC)	M.B. Jackson
9	1994	United Kingdom	R.M.M. Crawford
10	1995	Finland	S. Pulli, B.V. Fagerstedt
11	1995	United Kingdom (SEB)	M.B. Jackson
12	1998	USA	T.T. VanToai
13	1999	USA (XVI IBC)	J.L. Seago, W. Armstrong
14	2001	The Netherlands (Green Cross)	L.A.C.J. Voesenek, E.J.W. Visser, M.B. Jackson, C.W.P.M. Blom
15	2004	Australia	T.D.Colmer, H.Greenway, T.L.Setter
16	2007	Japan (planned)	K. Ishizawa

**Table 2.** Monographs and collected papers on plant anaerobiosis, edited and published primarily by ISPA members

	Year	Title, publishing house	Editors
1	1978 1980	<i>Plant Life in Anaerobic Environments</i> , Ann Arbor, Michigan: Ann Arbor Science, 1st and 2nd editions	D.D. Hook, R.M.M. Crawford
2	1984	<i>Flooding and Plant Growth</i> , London: Academic Press	T.T. Kozlovski
3	1987	<i>Plant Life in Aquatic and Amphibious Habitats</i> , Oxford: Blackwell	R.M.M. Crawford
4	1988	<i>The Ecology and Management of Wetlands</i> , London: Croom Helm	D.D. Hook <i>et al.</i>
5	1991	<i>Plant Life under Oxygen Deprivation</i> , The Hague: SPB Academic	M.B. Jackson, D.D. Davies, H. Lambers
6	1993	<i>Interacting Stresses on Plants in a Changing Climate</i> , NATO ASI series, Berlin: Springer-Verlag	M.B. Jackson, C.R. Black
7	1994	<i>Oxygen and Environmental Stress in Plants</i> , Edinburgh: Proc. Royal Soc. Edinburgh Ser. B. vol. 102	R.M.M. Crawford, G.A.F. Hendry, B.A. Goodman
8	1994	Special Section of <i>Annals of Botany</i> , vol. 74	M.B. Jackson
9	1997	Special Issue of <i>Annals of Botany</i> , vol. 79	M.B. Jackson
10	2002	Special Section of <i>Annals of Botany</i> , vol. 90	N. Smirnoff
11	2003	Special Issue of <i>Annals of Botany</i> , vol. 91	E. Visser, L.A.C.J. Voeselek, M.B. Jackson
12	2003	Special Issue of <i>Russian Journal of Plant Physiology</i> , vol.50, № 6	B.B. Vartapetian

Today, a comparison of the 1978 Hook and Crawford monograph with papers from prominent research teams published in special issues of *Annals of Botany* (2003) and *Russian J. of Plant Physiology* (2003) gives a clear indication of the evolution and progress that has taken place in intervening 25-30 years. While earlier studies were focused on the ecological, physiological, and biochemical aspects of plant anaerobiosis, the current studies often involve molecular biology and molecular genetics. Such experimental studies actively exploit the already established idea of two major strategies of plant adaptation to anaerobic stress: adaptation at the molecular level, when in the case of the absence or deficiency of oxygen, cell metabolism is fundamentally rearranged, (*true* tolerance) and adaptation on the whole-plant level due to oxygen transport from the aerated parts into the organs (roots, rhizomes) localized in the anoxic medium, that is, the strategy of avoidance of the anaerobic conditions (*apparent* tolerance). Although most of biochemical processes are radically rearranged in response to hypoxia and anoxia, it is now widely accepted that energy metabolism, at metabolic adaptation, and oxygen translocation, at avoidance strategy, controlled and regulated at transcriptional, translational and post-translational levels resulting in selective synthesis of anaerobic stress

proteins (mainly enzymes of glycolysis and related processes as well as of aerenchyma formation) have key role in plant adaptation to anaerobic stress. Biotechnologists attempt to create plants more tolerant to anaerobiosis by genetic engineering and clonal selection of tolerant cell lines *in vitro* in order to regenerate plants tolerant to soil anaerobiosis. Current studies of plant anaerobiosis employ the large inventory of modern physical and chemical methods and technologies. Members of ISPA who organized or participated actively during past decades both in regularly arranged symposia and conferences of Society and in publications of the papers in monographs and special issues of periodic journals, played important role in establishing and consolidating this branch of plant science.

As founder of the Society and its President until 2004, I feel it is appropriate to emphasize the exceptional activities and contributions of several key members of ISPA. Professor DD Hook should be mentioned first because of his role in organizing and co-editing the publication of the papers of the First International Symposium on Plant Anaerobiosis. In the Introduction to a later monograph, *Plant Life under Oxygen Deprivation* (1991), the book was described as “without doubt, a most influential publication and the inspiration for much subsequent research”. In addition, Hook organized in the United States a comprehensive symposium 'The Ecology and Management of Wetlands' in 1986 which resulted in two volume of collected papers he edited with others for the publisher Croom Helm (London). I should also like to highlight the role played by Professor R.M.M. Crawford, an active member of the ISPA since its inception. At the first symposium at the XII Botanical Congress in Leningrad (1975), Crawford was one of the invited speakers. Subsequently, he and Hook went on to edit the influential monograph, *Plant Life in Anaerobic Environments* mentioned above. Later, Crawford edited two further monographs, organized two symposia and, for many years, served as General Secretary of the ISPA while regularly compiling and distributing ISPA Newsletters. In 1995, a special session of that year's annual meeting of the Society for Experimental Biology was arranged at St Andrews, Scotland to mark Crawford's contribution to our subject. A similar meeting was held in 2001 and the papers published as a set in *Annals of Botany* (vol. 90, October 2002). Mention should also be made of the outstanding role and contributions of Professor M.B. Jackson. He has organized several international meetings on plant aeration, edited two excellent monographs and also three sets of papers on plant aeration stress in various issues of *Annals of Botany*. Very recently (2004) he has drew-up a new Society constitution that set out the aims of ISPA, created an international management structure and established a mechanism for its financing. Appropriately, at the 2004 meeting of ISPA in Perth, Australia he was elected to succeed me as ISPA President.

Thus, the labours and efforts of the older generation of researchers on plant anaerobiosis laid a solid basis for a new scientific discipline. The twenty-five years of activity of ISPA members have been instrumental in attracting the attention of the international scientific community to the issue of plant life under poorly aerated conditions. It is mainly thanks to ISPA activities that new laboratories and scientific centers became engaged in studies of the ecological, physiological, biochemical, molecular biological, and molecular genetic aspects of the phenomenon of plant anaerobiosis have sprung-up across the World. I feel justified in maintaining that, in addition to traditional branches of ecological physiology and biochemistry, embracing drought, cold and heat, and saline and biotic stress factors, a new independent avenue for study of plants under low-oxygen stress has appeared and won international recognition. An honourable task for the new generation of researchers of plant anaerobiosis is to receive the relay baton from the hands of their elders and move forward to clarify, the molecular mechanisms of plant damage and adaptation under hypoxic and anoxic conditions. The elucidation of basic processes underlying plant responses to anoxia, an issue currently involving research teams in many countries, will help take the next step of creating crop plants with the potential to tolerate to anaerobic stress and protect the environment.