

## Soil-plant-microbe interactions from microscopy to field practice

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Received: 22 July 2011 / Accepted: 16 August 2011 / Published online: 20 September 2011  
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A collection of papers dedicated to Professor Alan Robson

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Responsible Editor: Hans Lambers.

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This special issue recognizes the scientific contributions Professor Alan Robson has made to plant nutrition, plant-microbe interactions and soil science on the occasion of his retirement as Vice Chancellor of The University of Western Australia in December 2011. It comprises review articles and research papers on topics pertinent to the research interests of Alan Robson, including those of his postgraduate students, postdoctoral fellows, and colleagues.

Alan Robson was born in 1945 in Melbourne, Australia. He studied agriculture at The University of Melbourne where he was awarded a Bachelor in Agricultural Science in 1965. He attended The University of Melbourne with the support of a Wheat Research Scholarship, and received the W.H. Ferguson Memorial Prize (Agricultural Geology), the James Cuming Prize (Agricultural Chemistry), Exhibition (Agricultural Bacteriology) and an Arthur Sims Scholarship (Animal Husbandry). He received a CSIRO Research Studentship and a Federal Wheat Research Council Studentship (postgraduate) in 1966 to support his postgraduate studies at The University of Western Australia. He was awarded a PhD from The University of Western Australia in 1969.

Alan Robson's PhD thesis *Soil Factors Affecting the Distribution of Annual Medicago Species* was supervised by Professor JF Loneragan, Dr AJ Millington and Dr JS Gladstones. This laid the foundation for his career-long interest in soil-plant-microbe interactions, especially in an agricultural context. He spent a short period as an agronomist in the Victorian Department of Agriculture, and commenced a lecture-

ship in Soil Science and Plant Nutrition at The University of Western Australia in 1974. He was promoted to Professor (Soil Science) in 1984, and then appointed as Dean of Agriculture in 1991, Director of the Cooperative Research Centre for Legumes in Mediterranean Agriculture (CLIMA) in 1992, Deputy Vice Chancellor in 1993, Hackett Professor (Agriculture) in 2001, and Vice Chancellor of The University of Western Australia in 2004.

Alan Robson has made a significant contribution to research on soil-plant-microbe interactions and to the wider university sector. He is the author of four books, editor or co-editor of two books, and author or co-author of more than 200 papers in refereed international journals. His research findings have been well received internationally. Total citations of his journal publications since 1978 have exceeded 5,800 with an h-index of 42 and average citations per paper of 31 (Web of Knowledge). He has supervised many Australian and international postgraduate students at The University of Western Australia. Alan Robson has been a consulting editor of *Plant and Soil* (1987–1995) and an advisory committee member of *Australian Journal of Soil Research* (1986–92).

Alan Robson's research has bridged the disciplines of soil science, plant nutrition, plant-microbe interactions, and plant and microbial ecology. His acute scientific expertise stimulated research collaborations—from farmer's fields to the glasshouse, laboratory and microscope, illuminating both practical and theoretical problems. His enthusiasm for investigating the nutrition of agricultural plants in the highly weathered soils of south-west Western Australia led to the development of plant diagnostic tests for nutrient disorders (deficiency and toxicities) in cereals, and grain and pasture legumes. Always applying a critical scientific approach on a farm, in a mine-site undergoing rehabilitation, or in natural ecosystems, Alan Robson inspired students, researchers and farm advisors in cross-disciplinary themes. He was highly sought after as a supervisor by both undergraduate and postgraduate students. His expertise was also greatly valued by the farming community because of its direct relevance to understanding and ameliorating nutrient deficiencies and toxicities. His research commonly required knowledge in both plant and soil domains, as well as at the farming systems level.

Alan Robson was instrumental in developing a plant test for diagnosing Cu deficiency in wheat with

Jack Loneragan and John Gartrell (Western Australia Department of Agriculture). This new test involved analysing Cu in the youngest fully expanded leaf blade and laid the foundation for 'selective tissue analysis' as a superior tool for diagnosing nutritional stresses in plants in Australia. The test was first published in the *Journal of the Western Australia Department of Agriculture* to alert farmers. Jill Hill (a PhD student with Alan Robson and Jack Loneragan) confirmed the issues centred on Cu mobility and its redistribution in wheat.

Alan Robson's research with students and research staff demonstrated that in deficient-stressed plants, the mobility of some nutrients was restricted, indicating that analysing these nutrients in young tissues is the most sensitive procedure for diagnosing stress. His research with colleagues (including Nancy Longnecker and Doug Reuter) identified underlying physiological responses to mobility and absorption of nutrients in both cereals and legumes. He investigated these processes in response to soil stresses such as acidity, alkalinity, salinity and drought, and also considered complex interactions between nutrient disorders in his plant nutrition research.

When di-ammonium phosphate (DAP) was introduced into Western Australia as a replacement for fertilizers containing superphosphate, widespread

**Fig. 1** (A) Professor Alan Robson and the Hon Ernie Bridge OAM CitWA at the opening of CLIMA in 1992; (B) Past and present CLIMA directors: Mike Ewing, Alan Robson, John Hamblin, Kadambot Siddique and Neil Turner in 2006; Front covers of books of nutrient deficient symptoms of lupins (C), wheat and subterranean clover (D) and faba bean (E) published by Soil Science and Plant Nutrition, The University of Western Australia; (F) Kevan Snowball checking the temperature of water in controlled-temperature tanks in a glasshouse at The University of Western Australia; (G) subterranean clover root with community of arbuscular mycorrhizal fungi from field soil; (H) lupin root nodule initials; (I) a young lupin nodule (8 d after inoculation); (J) electron micrograph of a nodule cell of *Lupinus angustifolius* L.; (K) white lupin (*Lupinus albus* L.) grew poorly at soil pH above 8 (H<sub>2</sub>O) in the field at Goomalling Western Australia; (L) *Biserrula pelecinus*, a new forage legume, regenerating after canola; (M) response of a barley crop to 2.5 t lime ha<sup>-1</sup> applied 16 years previously to an acid soil at Wongan Hills Western Australia; (N) establishing a mycorrhizal field experiment at Badgingarra Western Australia in 1977 (Alan Robson second from left); (O) establishing a field experiment at Merredin, Western Australia (Alan Robson on left). Photos were provided by L Abbott (C, D, E, F, G, N and O), C Tang (H, I, J, K and M), N Turner (A, B) and J Howieson (L)



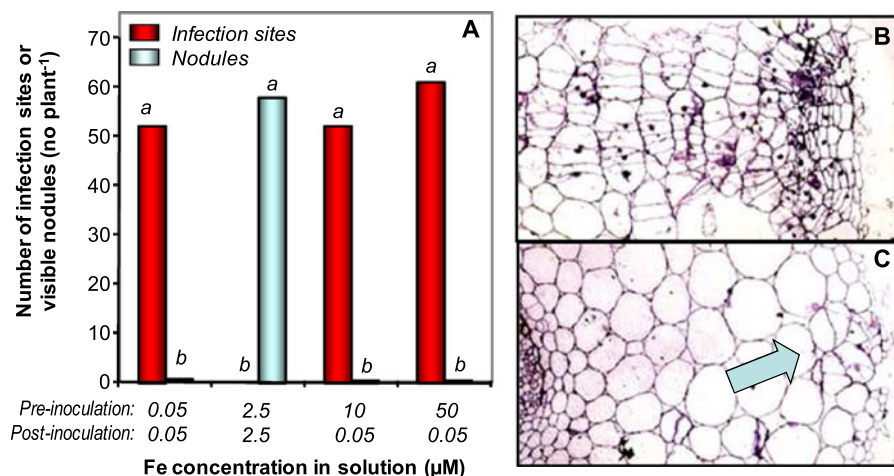
crop failure resulted. Encouraged by crop nutritionists in the Western Australian Department of Agriculture, Alan Robson investigated the cause with students, indicating the disorder was caused by zinc deficiency. Immediately, the Australian fertilizer industry began manufacturing and marketing Zn-enriched DAP. He co-supervised Ross Brennan's PhD research that developed plant and soil test for diagnosing Zn status in field crops grown in Western Australia.

Alan Robson chaired the organizing committee of the International Symposium on 'Zinc in Soil and Plants' held at The University of Western Australia in 1993 and was Editor of the publication 'Zinc in Soils and Plants' (Robson 1993). He also co-organised and co-edited the Golden Jubilee International Symposium on 'Copper in Soils and Plants' (Loneragan et al. 1981) held at Murdoch University in 1981 and prepared an overview chapter for the International Symposium on 'Manganese in Soils and Plants' held in Adelaide in 1988 (Robson 1988).

Alan Robson and Kevan Snowball published several monographs illustrating symptoms of nutrient deficiencies in important crop and pasture species (wheat, faba bean, field pea, lupin, and subterranean clover) (Fig. 1). This led to the definitive chapter on plant nutrient symptoms in *Plant Analysis: An Interpretation Manual* (Grundon et al. 1997).

Alan Robson's ongoing interest in the legume symbiosis commenced with his PhD studies. He had a special talent for explaining interactions between nutrients, including their involvement in symbiotic nitrogen fixation, and his reviews entitled 'Mineral nutrition' (Robson 1983) and 'Interaction between nutrients in higher plants' (Robson and Pitman 1983) are testimony to this. His research on legumes explored effects of soil acidity on components of the legume symbiosis, separating direct and indirect effects on components of the symbiosis. His research underpinned the innovative research of Mike Ewing and John Howieson in overcoming a legume-gap in pastures associated with soil pH in Western Australian farming systems. Other collaborations in legume research (including those with David Chatel, Michael Dilworth and Caixian Tang) involved investigations of interactions between plant nutrition and symbiotic nitrogen fixation, and identified specific roles of nutrients such as Co, Cu, Fe, Mo and P in the nodulation of crop and pasture legumes, including pin-pointing the stage in nodule formation and function which was most sensitive to the deficiency of these elements. For example, it was established that Fe deficiency limits nodule initiation but not infection in *Lupinus angustifolius* L. (Tang et al. 1992) (Fig. 2).

Alan Robson's interest in soil, plant and microbial interactions stimulated productive collaborations



**Fig. 2** **a** Effect of Fe supply to plants before or after bradyrhizobial inoculation on number of aborted infection sites and visible nodules in *Lupinus angustifolius*, **b** a nodule initial in the plant grown at 2.5 μM Fe and **c** an aborted infection site at 0.05 μM Fe (C Tang and AD Robson, unpublished). The data with the same letter are not different at  $P \leq 0.05$ . **a** Three-day-

old seedlings were grown in nutrient solution with pre-inoculation treatments of Fe for 6 d. After growing in Fe-free solution for 20 h, plants were then transferred to post-inoculation treatments of Fe, and inoculated for 4 d with *Bradyrhizobium* sp. (*Lupinus*). Measurements were taken 12 d after inoculation

which drew especially upon his expertise in plant nutrition. His multi-disciplinary perspective brought depth and rigour to this inter-disciplinary experimental research. His leadership was responsible for the establishment of the CLIMA, a Cooperative Research Centre funded by the Australian Government in 1992 (Fig. 1). Since its inception, CLIMA has continued to excel in legume research and development internationally. Under the leadership of the current Director of CLIMA, Professor Willie Erskine, Adjunct Professor Harry Nesbitt and Professor Kadambot Siddique, CLIMA is co-ordinating the Australian-funded activities of the ‘Seeds of Life’ project, to improve crops and cropping systems in Timor Leste. This ambitious program is funded by the East Timor Ministry of Agriculture and Fisheries and the Australian Government, through the Australian Agency for International Development (AusAID) and the Australian Centre for International Agricultural Research (ACIAR).

Alan Robson’s research on arbuscular mycorrhizas (including collaborations with Lynette Abbott and David Jasper) has focused on soil and plant processes influencing with their distribution and function in agricultural and disturbed natural ecosystems. In particular, he applied his expertise in plant and soil science to critically evaluate paradigms of P x mycorrhizal interactions. With students and colleagues from disciplines of plant science, soil science and microbiology, he rigorously applied plant nutrition principles to investigations of these ubiquitous plant-microbe associations to understand their complex interactions in space and time. The approach is summarized in reviews (e.g. Abbott and Robson 1984) and in the proceedings of an international conference on management of mycorrhizas in agriculture, horticulture and forestry held at The University of Western Australia in 1992 (Robson et al. 1994).

Alan Robson has been awarded many distinctions, including a Fellowship of the Australian Academy of Technological Sciences and Engineering (FTSE) in 1987, the Australian Medal of Agricultural Science in 1989, a Fellowship of the Australian Institute of Agricultural Science and Technology (FAIAST) in 1992, and a Distinguished Alumni Award from The University of Melbourne in 1993. He became the Hackett Professor of Agriculture at The University of Western Australia in 2001, and a Member of the Order of Australia (AM) in 2003. His Fellowship of the Australian College of Education recognizes the sustained contribution he has made to university

education, both as a captivating teacher, and for his dedication to excellence in teaching and learning across the university sector.

Alan Robson’s other distinguished contributions to agriculture include his leadership during the restructuring of Australia’s agricultural research and development programs as Chair of the Grain Legume Research and Development Corporation (the pre-cursor to Grains Research and Development Corporation). He has been an invited member or chair of more than 50 State, National, and international committees.

**Acknowledgements** We thank all who submitted manuscripts to this Special Issue. Due to the page limit, publication deadline and peer-review process, we were unable to accommodate all the submissions. We also thank the section editors and anonymous reviewers for their contributions to improving the quality of this special issue of Plant and Soil dedicated to Professor Alan Robson.

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