▼ LA - 058

## ANTIMICROBIAL PEPTIDES MEDIATE BACTEROID DIFFERENTIATION IN *MEDICAGO TRUNCATULA* NODULES

Peter Mergaert[1], Willem Van de Velde[1], Grigor Zehirov[2], Hironobu Ishihara[2], Agnes Szatmari[1], Katalin Mikulass[3], Monika Debreczeny[3], Attila Farkas[3], Andrea Nagy[3], Hilda Tiricz[3], Gergely Maroti[3], Attila Kereszt[3], Toshiki Uchiumi[2] & Eva Kondorosi[1,3]

[1]Institut des Sciences du Végétal, CNRS, Avenue de la Terrasse, Bâtiment 23, 91198 Gif-sur-Yvette Cedex, France peter.mergaert@isv.cnrs-gif.fr
[2]Department of Chemistry and Bioscience, Faculty of Science, Kagoshima University, 890 0065 Kagoshima, Japan
[3]Institute for Plant Genomics, Human Biotechnology and Bioenergy, Bay Zoltan Foundation For Applied Research, 6726 Szeged, Hungary

The symbiotic cells of legume nodules house large numbers of nitrogen-fixing, differentiated rhizobia, called bacteroids. In the legume *Medicago truncatula*, the symbiotic cells provoke terminal differentiation of bacteroids, which have altered membranes and are strongly enlarged due to genome endoreduplication and have lost the capacity for division. Intriguingly, the terminal bacteroid differentiation is typical for legumes of the IRL clade and not found in non-IRLC legumes (like *Lotus japonicus*). Transcriptome analysis in *M. truncatula* and *L. japonicus* nodules identified candidate genes coding for the plant factors involved in the terminal bacteroid differentiation. Expression of the candidate genes was restricted to infected cells in the nodules and homologous genes were absent in *L. japonicus*. These genes encoded several hundreds of different peptides resembling antimicrobial peptides. We postulated that intracellular rhizobia in the nodules of IRLC legumes are challenged with a battery of nodule-specific antimicrobial peptides (nsAMP) inducing the terminal bacteroid differentiation. The confirmation of this hypothesis relied on localizing the peptides in nodules, analyzing their *in vitro* activity on *Sinorhizobium meliloti*, the microsymbiont of *M. truncatula*, and their *in planta* activity in *L. japonicus* nodules. We speculate that terminal bacteroid differentiation enables the host plant to gain control over the microsymbionts. This might improve nitrogen fixation efficiency by redirecting the bacteroid's metabolism towards nitrogen-fixation or maximize the gain/cost balance of symbiosis by reallocating resources of bacteroids that are disintegrated during nodule senescence.

This work was supported by Agence Nationale de la Recherche grant N° ANR-05-BLAN-0129-01 and the Teller NAP-BIO program of NKTH.

### SESSION 19 (PARALLEL) IMRPOVING OLD AND DEVELOPING NEW LEGUME PRODUCTS FOR A CHANGING WORLD

*- Janet Sprent (University of Dundee, Scotland)*
*- Session Chair*

▼ LA - 059

## BURKHOLDERIA, METHYLOBACTERIA AND OTHER LESSER EXPLOITED RNB AS COMMERCIAL INOCULANTS IN TEMPERATE AGRICULTURE ON POOR SOILS

John G. Howieson[1,2], Graham O'Hara[1], Ron J. Yates[1,2], Giovanni Garau[3], Sunil Ratnayake[4], Julie Ardley[1], Ben-Erik van Wyk[5] & Ben Pariot[1]

[1]Centre for *Rhizobium* Studies, Murdoch University, Murdoch, Western Australia, 6150 [2]Department of Agriculture and Food Western Australia, 3 Baron-Hay Court, South Perth, Western Australia 6151 [3]Dipartimento di Scienze Ambientali Agrarie e Biotecnologie Agro-Alimentari (DiSAABA), University of Sassari, Italy [4]Department of Botany, Faculty of Science, University of Peradeniya, Sri Lanka [5]Department of Botany and Plant Biotechnology, University of Johannesburg, Johannesburg, RSA; j.howieson@murdoch.edu.au

One reaction from scientists to climate change predictions in Western Australia (WA) has been to re-assess the phenology of the plants we farm. Somewhat counter-intuitively, for regions where it is predicted that growing seasons will become shorter, hotter and dryer over the next 50 years, we have begun to evaluate the adaptation of perennial, herbaceous legumes (relative to the annual species currently in commerce). Since 2002 a global search has been underway for under-exploited legumes that might be adapted to acid soils and arid conditions. We have found that a great diversity of perennial species dominates arid ecological zones, such as in the Western Cape region of South Africa. Quite surprisingly, many of the perennial legumes we are examining from the Western Cape are nodulated by unfamiliar root-nodule bacteria (RNB) that are not commonly associated with nitrogen fixation. Hence we are investigating the roles these RNB might play in agricultural systems, particularly for the arid and acid soils that predominate in Western Australia.

Three perennial legumes *Rhynchosia ferulifolia, Lebeckia sepiaria* and *Lebeckia ambigua* are nodulated by separate *Burkholderia* spp., and when effective strains are supplied these legumes fix N at a similar rate to lucerne (*Medicago sativa*). The *Burkholderia* spp. have been isolated from soils of pH($H_2O$) 5.5, which suggests that both micro- and macrosymbiont have an adaptation to acidity that might well be exploited. Another group of forage species that appear well adapted to infertility, drought and acidity in WA are the *Lotononis spp* from the Listia sub-section. In particular *L. listii, L. bainesii, L. angolensis* and interspecific hybrids of the latter two have produced abundant foliage over several harsh summers in WA. The RNB which nodulate *L. angolensis* are undescribed, however recent sequencing aligns strains closely to *Balneimonas, Chelatococcus* and *Bosea* (see Ardley et al this conference). The RNB that nodulate the other two *Lotononis spp* conform to the general description of *Methylobacterium*, however they do not metabolise C1 compounds. Whilst examining the field ecology of this range of unfamiliar RNB we see they are clearly adapted to recalcitrant soils and climates, and this may hence lead us to commercialise a new generation of legumes. We have also undertaken fermentation studies to assess the manufacturing characteristics of these RNB, and their survival in a range of inoculant carriers. These studies provide essential information if the unfamiliar RNB are to be successfully exploited in agriculture.



▼ LA - 060

## COWPEA SYMBIOSIS WITH ROOT NODULE BACTERIA IN AFRICA: NITROGEN CONTRIBUTION, PHOSPHORUS ACQUISITION, AND BIOFORTIFICATION OF DIETARILY IMPORTANT TRACE ELEMENTS

Felix D. Dakora

Chemistry Department, Tshwane University of Technology, 175 Nelson Mandela Drive, Private Bag X680, Pretoria 0001, South Africa; dakorafd@tut.ac.za

Cowpea (*Vigna unguiculata* L. Walp.) is the major food grain legume indigenous to Africa. Nutritionally, the grain contains 23% protein and 57% carbohydrate. The leaves contain about 35% protein and are eaten as a vegetable in Africa. Cowpea is highly adapted to a wide range of soil ecologies in Africa, and nodulates with both fast and slow-growing rhizobia. After insect pest and diseases, N and P nutrition constitute the next most important constraint to increased cowpea yields in Africa. Studies of $N_2$ fixation in 30 cowpea genotypes at Manga and Wa in Ghana, and 32 genotypes at Taung in South Africa showed different levels of N nutrition from symbiotic fixation, ranging from 8.0-60% N derived from fixation in 2005 to 57-89% in 2006 at the Manga site. In Botswana, N contribution by cowpea plants in farmers' fields ranged from 12.5-87.1 % in 2005 to 29.0-91.7% in 2006, while in Zambia the N derived from fixation in farmers' fields ranged from 58.5 to 59.6%. Assays of acid and alkaline phosphatase activity in rhizosphere soils of the different cowpea genotypes revealed significant variation in enzyme levels, indicating genotypic differences in P acquisition. Measurement of trace element density in edible grain and leaves of cowpea also showed marked differences among genotypes, with the leaves emerging as a richer source of dietary micronutrients compared with grain. These data suggest that both N and P nutrition, as well as trace element density in grain and leaves, are important traits to include when selecting cowpea genotypes for increased yields.

▼ LA - 061

## IMPROVING PRODUCTION OF GUM ARABIC FROM ACACIA SENEGAL

David W. Odee*

Marie Curie Fellow, Centre for Ecology and Hydrology, Bush Estate, Penicuik, Midlothian EH26 0QB, Scotland, UK. Tel. +44 (0)131 4454343, Fax +44 (0)131 4453943; daee@ceh.ac.uk

In the drylands of Africa, land degradation and soil fertility depletion are considered to be the major threats to natural resource conservation and food security. *Acacia senegal* is the world's major source of the internationally traded 'gum arabic', a natural plant exudate used as an emulsifier in confectionery and beverages, pharmaceutical and other industries. Its incorporation into farming systems will diversify agriculture, enhance food security and income generation, and also benefit the environment through soil fertility replenishment, biodiversity conservation and carbon sequestration. The key drivers for its adoption are gum production and quality, markets and fair prices for the small-scale producers, and adaptability to the rapidly changing climatic conditions. Enhancing $N_2$ fixation in gum arabic plantations ('gum gardens') is one of the key pathways to improving gum yield and quality. Early studies have shown that the species nodulates with a wide range of rhizobial partners and that inoculation with effective strains can enhance gum production. The symbiotic status and $N_2$-fixing potential of *Acacia senegal* is discussed in conjunction with ongoing research assessing the genetic basis for gum arabic production, and how it can be managed in a sustainable manner to improve livelihoods, food security and environment in the drylands of Africa.

This work is supported by the EC under Framework FP6 as part of the Marie Curie Fellowship "ASGEN" MIFI-CT-2006-039216

▼ LA - 062

## IMPROVING INPUTS OF NITROGEN FIXATION FROM TRADITIONAL GRAIN LEGUME CROPS

Abdullahi Bala[1] and Ken E. Giller[2]

[1]Department of Soil Science, Federal University of Technology, Minna, PMB 65, Minna, Nigeria; [2]Plant Production Systems, Wageningen University, P.O. Box 430, 6700 AK Wageningen, The Netherlands.

Agricultural production in most parts of sub-Saharan Africa is dominated by smallholder farming systems that are low resource-based and of low productivity. The ability to fix atmospheric nitrogen makes legumes excellent components within the various farming systems because they produce nitrogen-rich edible seeds, constituting the major source of protein in the diets of the poor; and provide residual nitrogen and reduce the needs for mineral nitrogen fertilizers by associated non-legumes. Residues of legumes also provide an excellent source of high quality feed to livestock especially during dry seasons when animal feeds are in short supply. Thus, appropriate integration of legumes in the farming systems could potentially improve system productivity in addition to their associated benefits in improved nutrition and enhanced incomes of rural households. In spite of this, however, often less than 10% of cultivated land is currently planted with field legumes. Maximal rates of biological nitrogen fixation (BNF) recorded in the tropics reach an astonishing 5 kg N $ha^{-1}$ $day^{-1}$ with the green