



Local school children and UWA Vice-Chancellor Paul Johnson try their hand at propagating plants from cuttings during the Field Day at UWA's Future Farm in Pingelly.

UWA's Future Farm Field Day inspires all

Ms Uly Fritsch

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UWA's Future Farm 2050, located in Pingelly, opened its doors on 6th September to the community; showing local school children how fascinating the science behind farming can be and local farmers how UWA research can help them be more productive, profitable and sustainable.

Sixty children from Pingelly Primary School, Brookton District High School and Narrogin Senior High School spent a fun-filled morning studying soils, plants and bugs at UWA's 1600-hectare grain belt property. Besides exploring the world's biggest, bounciest inflatable plant cell (developed by UWA's Centre for Plant Energy Biology), they also learnt how to propagate plants from fresh cuttings by dipping the stems in honey and planting them in soil trays in a nearby farm work shed.

The farm's shearing shed provided a venue for the 150 visitors to listen to an inspirational talk by Winthrop Professor Graeme Martin, Deputy Director of UWA's Institute of Agriculture. Martin outlined the bold vision behind UWA's Future Farm 2050, to develop clean, green and ethical farm technologies and practices now to help feed the growing global population later, with minimum impact on the planet.

Visiting Oxford University Professor Marian Stamp Dawkins (cf page 4) addressed the question of whether more efficient food production is in conflict with animal welfare, and UWA Assistant Professor Marit Kragt discussed carbon farming options and economics.

The program also included afternoon tea, organised by the Pingelly Chaplaincy Group, followed by a bus tour of the property where visitors could view UWA Future Farm's hi-tech

farmhouse, paddock soils and a new Eureka Prize-winning saltbush that feeds sheep while reducing greenhouse gas emissions (see also page 5).

Vice-Chancellor Professor Paul Johnson thanked participants and invited local farmers and the industry to engage with UWA Future Farm 2050 as a local resource to meet the challenges of modern farming.

UWA Future Farm 2050 is a working farm and multi-disciplinary research facility based on world-class expertise in agricultural science, resource economics, architecture and landscape architecture, engineering, solar energy, wildlife ecology, and plant ecology.

For further details and photos visit www.ioa.uwa.edu.au/future-farm-2050/news-and-events/open-day-2013



Director's column

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In the Academic Ranking of World Universities published by China's Shanghai Jiao Tong University (www.shanghairanking.com/), UWA now occupies fourth place nationally and 91st place globally, with the disciplines of Life and Agricultural Sciences ranking 26th in the world. Another recognition of UWA as an outstanding university was announced in October, when UWA's global performance (ranking), based on the publication and impact of its scientific papers, climbed to rank 40 for agriculture, under the 2013 Performance Ranking of Scientific Papers for World Universities released by the National Taiwan University Ranking (<http://nturanking.lis.ntu.edu.tw/>).

UWA's strong performance in agriculture and related disciplines, was recognised at the UWA London Alumni Dinner in October this year (see page 9) as well as in many prestigious awards, and distinctions during 2013, including two international award-winning documentaries 'More than honey' (see IOA news April edition, page 5) and an ABC *Landline* program featuring GRDC Soil Biology Initiative's research on Soil Quality and Nitrogen (see page 7). Other awards include Emeritus Professor Alan Robson, who was made an Officer of the Order of Australia; Professor Phil Vercoe, who received the Caring for our Country Landcare Eureka Prize for Sustainable Agriculture (see page 5); Associate Professor Josh Mylne, who received Australia's highest award for young plant scientists, the Peter Goldacre Award (see IOA news April edition, page 6), and Emeritus Professor Bob Gilkes whose lifetime achievements and contributions to international agriculture training were honoured with the Crawford Fund medal 2013.

I was humbled to be the recipient for two awards: the Ag Institute Australia Fellow Award and the Dunhuang Award from China (see page 7) and would like to express a heart-felt gratitude to the selection committees for deeming me worthy of the above honours. Achievements such as these are also a reflection of the strong partnerships and drive for innovation: our strong international partnerships in China were highlighted this year with the launch (in May 2013), of the Centre for Dryland Agricultural Ecosystems, a joint endeavour between UWA, Lanzhou University and ICARDA (see IOA news, August issue, cover story); with the Three Brothers initiative (cf IOA August issue, page 4) which represents new agreement between UWA and long-time research partner Zhejiang University and new partner Tarim University. Our collaborations with India received a further boost with the new MoU between UWA and Kerala Veterinary & Animal Sciences University (see page 12), and 'chickpea genomics project' with Indian and Australian partners (see page 5).

Through our membership in the Worldwide Universities Network (WUN; we have advanced research on Adaptation to Climate Change and turned UWA's Future Farm 2050 into a research site of national and international significance (see also page 5). This year's UWA Future Farm Field Day in September (see also www.news.uwa.edu.au/201310186161/features/future-farm-inspires-future-farmers; and this issue cover page; IOA News, August issue, page 3) attracted considerable interest from the farming community and general public.

The importance of productive and sustainable agriculture was a central theme throughout the year, including the 2013 IOA Industry Forum 'Food 2050 – how to feed 9 billion people in 2050 without destroying the planet' and a high-profile series of public lectures 'Food 2050' (see also page 5).

2013 has also been characterised by many internal changes: former GRDC chairperson Dr Terry Enright has taken over from Mr Bruce Piper as the Chair of the IOA Industry Advisory Board, and I am grateful to both of them for their expert stewardship. I would like to thank Winthrop Professor Zed Rengel for his contributions as Leader of the Integrated Land and Water Management Program during the past six years. I welcome Professor Dan Murphy as Program Leader and Associate Professor Louise Barton as Deputy Leader of the above Program.

My sincere thanks also go to Mr Mike Perry for his excellent support as IOA Business Manager, a role from which he retired in October to pursue his personal interests.

I am fortunate to have had the support of such a dedicated team of colleagues, Executive Board and Industry Advisory Board throughout 2013.

I wish you all a wonderful festive season and look forward to a productive and rewarding 2014.

Soil Masterclass: 'Natural Capital' delivers ecosystem services

Emeritus Professor Lyn Abbott

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A Masterclass by Professor Brent Clothier, from the New Zealand Government's research company 'Plant and Food Research', was held for postgraduate students and staff, preceding the formal program of the UWA Future Farm Field Day on 6 September (see also cover story). The Masterclass was coordinated by UWA's Institute for Advanced Studies.

Clothier is an Adjunct Professor in UWA's School of Earth and Environment; at 'Plant & Food Research', he leads the Systems Modelling Group with expertise in modelling, biometrics and production footprints.

His research includes the movement and fate of water, carbon and chemicals in the rootzones of primary production systems, irrigation allocation and water management, plus sustainable vineyard and orchard practices for horticultural production, including adaptation strategies to climate change. He has also published on life-cycle assessment, carbon and water footprinting, environmental policy, investment into ecological infrastructure, plus natural capital quantification and the valuation of ecosystem services.

The focus of the Masterclass was soil's regulating ecosystem services. The Masterclass explored ways that have been used to assess the value of the soil's regulating services, and discussed the ways in which these values have been quantified and used.

He illustrated how investment of carbon into the soil's natural capital can provide valuable returns on investment. "Changes in the soil's carbon content can alter the manageable properties of the soil's natural capital, including its (macro)porosity, and water repellence, and these affect the nutrient, gaseous and water regulating services that flow from the soil's natural capital."



Brent Clothier.

Special journal issue honours the late Clive Francis

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Professor Clive Francis passed away on the 17th February 2012. An esteemed agricultural researcher, he contributed significantly to agricultural science and its application. In recognition of his career and award winning work on the improvement of grain and pastures crops, the WA Division of the Ag Institute Australia coordinated and produced a special issue of *Crop & Pasture Science*, the *Clive Francis Festschrift* (www.publish.csiro.au/nid/43/issue/6650.htm), to honour Prof Francis's outstanding lifetime achievements and legacy in this research discipline.

The special issue is a compilation of research papers written by leaders in the field of crop and pasture germplasm collection and its use in enhancing of genetic diversity and agricultural productivity.

Dr James Fisher (AIA), Hackett Professor Kadambot Siddique (UWA), Professor William Erskine (UWA), Adjunct Professor Michael Ewing (DAFWA) and Adjunct Dr Clinton Revell (DAFWA) from the IOA

have been part of the organizing committee to publish this tribute to a scholar and a long-standing member of the Ag Institute Australia, who was admired and respected widely among his academic colleagues and friends at home and overseas.

Fisher, former President of AIA's WA Division, presented copies of the Festschrift to an



Clive Francis's daughter Carlie Pollock receives a copy of the edition from James Fisher.

appreciative group of family, friends and (former) colleagues of Professor Francis during a Clive Francis Memorial Convocation, organised by the WA Division, Ag Institute Australia and held at UWA in October with the support of CSIRO Publishing, the UWA Institute of Agriculture and the AW Howard Memorial Trust.

Food Forensics – the latest tool to deliver safe foods

Winthrop Professor John Watling

Assistant Professor Christopher May

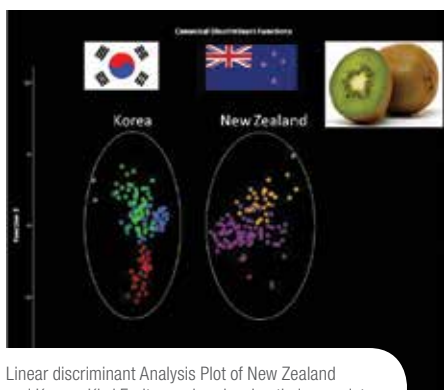
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The desire to deliver a secure supply of safe food to the world's population has fuelled a growing international trade in food and a food-based commodity which poses many challenges at almost every stage in this 'global food supermarket' supply chain.

The ability to rapidly trace where a food has originated is important from a food supply, bio-security and food safety (public health) perspective. Scientists from UWA's Centre of Forensic Science and TSW Analytical Pty Ltd have been working together with a variety of industries, including the agricultural sector, to develop traceability solutions that will address industry needs associated with the security of their current supply chains.

"Primary producers, food processors, distributors, wholesalers, retailers, consumers, regulators and other government agencies all have interests in food traceability," explains Winthrop Professor John Watling, "and it is essential that this traceability is accurate. With the possibility of fraudulent or misleading labelling of food it is also critical that any traceability be based on the food itself and not rely solely on paperwork."

With the generous assistance of Dr Soon Chye Tan (DAFWA) the scientists conducted a preliminary investigation, to assess the applicability of the traceability technology to food-based commodities such as mandarins, oranges and carrots.



Linear discriminant Analysis Plot of New Zealand and Korean Kiwi Fruit samples showing their complete chemical separation and country of origin identification.

The traceability technology is based upon the composition of trace elements in a commodity, and allows the development of an 'elemental profile.' "The elemental profile is a product of a variety of factors including the soil in which the commodity is grown, the water to which it is exposed, any fertilizer applied to the farm and, where applicable, any additional processing undertaken prior to distribution," explains Watling.

"Based upon these principles, we then carried out trace element analysis combined with multivariate statistical interpretation and were able to develop models which could be used to discriminate between the different sources/origins where the three commodities had been grown."

Given sufficient industry interest, additional research could be undertaken to determine the requirements that will enable industry to implement a customised traceability solution to add both security and value to its supply chain.

UWA PhD student claims best poster prize

Mr Federico Ribalta from UWA's School of Plant Biology, CLIMA and IOA was awarded the Best PhD Student Poster Prize in the Inaugural Pulse Breeding Australia (PBA) Conference held in Adelaide in October 2013. The poster titled "Accelerating the generation of homozygosity and genome fixation in field pea," describes his PhD research on the rapid generation advancement protocol development. Mr Ribalta's research is supported by a Grains Research & Development Corporation (GRDC) scholarship and supervised by Research Associate Professor Janine Croser (CLIMA & IOA), Professor William Erskine (CLIMA & IOA), Professor Patrick Finnegan (School of Plant Biology & IOA) and Dr Sergio Ochatt (INRA, France).



Face the challenge now to feed the world later

Dr Anke van Eekelen

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Future food security for an expanding world population is a timely issue in urgent need of attention. The prediction that in four decades from now the world will have 50 per cent more people to feed under increasingly challenging conditions, emphasises the need to plan ahead.

This challenge to meet dietary needs and ensure sufficient food supplies in the years to come was the core theme of the recent 2050 Food Lecture Series, organised by the Institute of Advanced Studies at UWA and the UWA Institute of Agriculture (IOA) and its Future Farm 2050 project. The free lectures attracted a large audience who came to hear the views of three leading academics in agriculture from across the world on key issues believed to influence the nature of our future food and the way it will be produced.

The first public lecture by Hackett Professor Kadambot Siddique, director of IOA, focused on the current and future contribution of Australian agriculture to a sustainable global food supply. In his view, the issue how and what to feed the world over time is inherently linked to the growing global demand for energy, the need to manage greenhouse gas emissions but preserve natural ecosystems and biodiversity.

"We can feed a hungry world by 2050 if we produce crops more efficiently with less input of scarce ground water supply and the same amount of land," he said. "Ranked as fourth largest exporter of agricultural products in the world, Australia indirectly helps to feed almost 500 million people in developing countries through research development and capacity building." To maintain the capacity to produce enough food in 2050, Australia needs to innovate and reform agricultural practices through strategic research, development



and implementation of knowledge and outcomes with impact. According to Siddique, this can only be successful if capacity building of agricultural institutions continues at the same time.

The second lecture by Professor Marian Stamp Dawkins from the University of Oxford, UK, considered the issue of a potential conflict between the necessity for more efficient food production and the ethical consideration of animal welfare. Her animal behaviour studies have already led to industry applications of innovative research outcomes to enhance animal welfare while meeting production targets of commercial poultry farms.

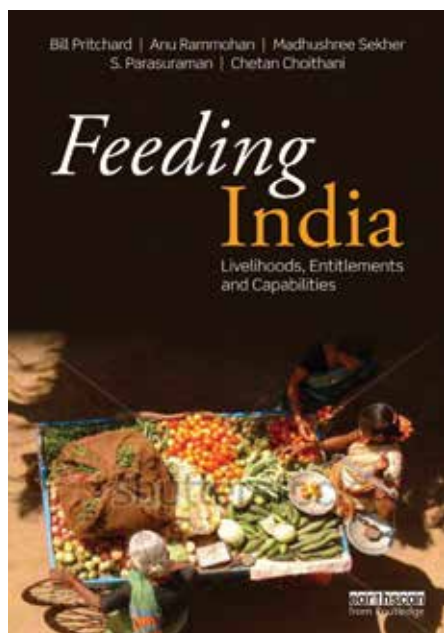
"The drive for greater efficiency in producing more meat or dairy products with less feed, less space and less water is going to be at the cost of animal welfare," she said. To make the importance of animal welfare heard she uses the argument that animals matter because they are useful – healthy animals have added value for our health, our environment and the quality of the food we eat. Her strategy to work with commercial farmers in the UK to deliver better animal welfare while efficiently producing profitable food demonstrates that there can be place for animal welfare within the push for a

more efficient way of food production in the future.

The final public lecture was presented by Regents Professor Emeritus Fred Allendorf from the University of Montana, USA, who has been a 2013 US Fulbright Senior Specialist at UWA. He discussed the impact of evolutionary effects of human activities, like commercial fishing pressure and hunting, on wild animal populations, and how this is likely to affect the possibilities of harvesting these populations in the future as part of the human diet.

"Hunting and fishing of animals from wild populations impose an exploitative form of selection that is likely to reduce the frequencies of those specific phenotypes," explained Allendorf. To survive fishing pressure, marine life has responded by becoming sexually mature at a younger age and this inherently means that "younger and smaller fish produce much lower quality eggs". The adoption of genetic considerations in current management plans seems indispensable to avoid further unnatural selection and allow for sustainable productivity of harvested fish and wild life stocks in the future.

This lecture series was recorded and can be accessed via www.ias.uwa.edu.au/lectures/2050-food



Feeding India: A new book showcases collaborative research

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A new book on food security and sustainability in India is the latest success story arising from a collaborative research initiative between Mumbai's Tata Institute of Social Sciences, The University of Sydney and The University of Western Australia with funding support from the Australian Research Council (ARC).

Co-written by five authors, including Professor Anu Rammohan, from UWA's School of Business and IOA, 'Feeding India: Livelihoods, entitlements and capabilities' approaches the issue of food security in India not in terms of how much food is produced, but rather, whether and how those in need gain access to that food. The book presents a compelling argument that in India access to

food is determined by a complex interplay of economic, social, political, environmental and cultural processes, which demands an integrated approach to address the issue of food (in)security successfully.

For more information visit www.news.uwa.edu.au/201310156131/international/timely-book-reveals-economic-growth-fails-end-indias-food-crisis

International symposium reveals innovations in farming systems



Participants at the 4th International Farming Systems Design Symposium, held from 19-22 August 2013 in Lanzhou, China.

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The latest research with a farming systems perspective was presented at the 4th International Farming Systems Design Symposium 2013, held late August in Lanzhou, China. Hackett Professor Kadambot Siddique from IOA joined an international audience of 300 participants from 16 countries, to participate in knowledge sharing across disciplines on farming system analysis, design and innovation. Siddique delivered a keynote presentation entitled "Climate change, water and soil conservation: opportunities for crop production in dryland environments".

During the conference aspects of innovations in farming system were considered in the many multidisciplinary discussions around questions related

to better participation by farmers in farming systems research, better nutrition as a research outcome and the need to target not only productivity but also reduced risk for farmers.

The large contingent of Chinese researchers and students at the meeting in their home country may have benefitted most from the exposure to such an integrative science way of thinking to solve specific problems in farming systems.

The meeting was concluded with a well received special session for Australian and Chinese farmers to exchange information on farming operations and to share experiences in dealing with climate risks, crop prices and farming yields.

Following the conference Professor Siddique visited Lanzhou University and held discussions with colleagues on various aspects of ongoing collaboration between UWA and Lanzhou University.

Sustainable grazing research scoops Eureka Prize

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This year's Australian Museum Caring for Our Country Landcare Eureka Prize for sustainable agriculture went to a team of researchers from UWA, CSIRO and the South Australian Research and Development Institute (SARDI) leading the Future Farm Industries CRC Enrich project on the benefits of native perennial shrubs as livestock feed to farmers, their animals and the environment.

Among them, Professor Phil Vercoe from UWA's School of Animal Biology and IOA has been nationally recognised for his research expertise in rumen fermentation and how plant chemistry influences digestion-related methane emission by livestock.

The Future Farm Industries CRC Enrich project represents a collaborative effort in which Vercoe works with researchers from other agencies, including CSIRO, SARDI, and NSW DPI, and land managers to investigate innovative grazing options for farmers with the aim of improving sustainability and profitability.

"Whole farm profit can increase by up to 15-20 per cent by including shrubs on about 10 per cent of a typical grain belt farm and have the potential to reduce the carbon footprint of the animals by decreasing methane emissions," says Vercoe.

At the award ceremony in Sydney, early September, Australian Museum Director Frank Howarth said: "The team has produced a practical recipe for helping to proof farms against climate change." Newly proposed sustainable grazing options have already been considered at various sites across Australia.



Phil Vercoe (right) with Enrich project collaborators Dean Revell (CSIRO), Jason Emms (SARDI) and NSW farmer Bruce Maynard at the shrub sites of the UWA Future Farm in Pingelly.

UWA Vice-Chancellor Professor Johnson commented that UWA's agricultural researchers are using innovative science to find new ways to farm sustainably while meeting the ever increasing demand for food in the future.

At Pingelly, UWA's Future Farm 2050 provides a real life laboratory for Vercoe and his colleagues at IOA, and Enrich project field trials include a shrub site at this WA grain belt location.

For further details visit www.news.uwa.edu.au/201309066039/awards-and-prizes/sustainable-agriculture-project-wins-eureka-award

UWA herbicide resistance scientist draws international attention



Stephen Powles on tour in the USA, examines a pigweed infestation in crop.

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Science magazines's special issue on smarter pest control features a story on the war against weeds *Down Under* highlighting the significant contribution of Winthrop Professor Stephen Powles, director of the Australian Herbicide Resistance Initiative (AHRI) and his team at the School of Plant Biology and IOA, to the field of plant biochemistry and genetics and our general understanding of the adverse development of herbicide resistance.

Like no other, Powles and his team at AHRI have used science to investigate the mechanisms underpinning herbicide resistance, translating this knowledge into practical approaches to improve weed management in Australian broadacre cropping.

Powles stresses the need to preserve the herbicides we have and the only way to do that is to diversify the way we control weeds. To keep herbicides like glyphosate working it should be used as infrequently as possible and non-herbicide control measures should be applied at every opportunity.

According to Powles, the key to lowering the odds that resistance will evolve is mixing weed-seed capture with the use of herbicides and agronomic approaches. This is the message that he took on his recent six week tour through the United States.

"In the US, there has been a massive over-use of glyphosate and they are now confronting a major herbicide resistance problem," says Powles. To fight the battle against herbicide resistance Powles and colleagues provide good science coupled with sound agronomy, novel agricultural engineering, excellent extension and communication techniques which ultimately have led to dedicated farmers implementing a range of weed management practices. Successful examples of harvest weed seed management techniques are killing weed seeds by burning in windrows, using a chaff cart or the Harrington Seed Destructor during the harvest operation.

The Australian story on how ryegrass grew from an introduced grass to provide fodder for sheep to a problem weed for broadacre cropping has drawn international attention to the issue of herbicide resistance. Powles hopes to convince farmers beyond Australia to be proactive and diversify their management as he recommends Australian farmers to do.

For further information refer to "The war against weeds *Down Under*" by Erik Stokstad, *Science* 341 (2013), 734-736. www.sciencemag.org/content/341/6147/734

'Smart' potassium fertiliser application: a new tool to manage crop pests

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In the battle against crop pest infestations, researchers at UWA's Institute of Agriculture and School of Animal Biology have discovered that fertilisers can play a pivotal role in lowering the risk of pest damage to crops by boosting the health of the plants.

The preventative effect of fertilisers is reported in a recent publication by Associate Professor Christian Nansen and his colleagues in *Computers and Electronics in Agriculture* Journal. Their findings revealed that spider mites had a strong and persistent preference for crop leaves with low potassium levels.

"Potassium is a key element in standard crop fertilisers and plays an important role in growing plants. Potassium fertilisation leads to increased leaf thickness, stronger epidermal cells and decreases leaf nutrient concentrations of sugars and amino acids, so potassium can lower the suitability of crops as hosts for pests and can slow the development and spread of pests," said Nansen, whose position at UWA is funded by the Grains Research and Development Corporation (GRDC).

The study focused on only one type of pest in maize and corn plants but the findings may be relevant to crops in Australia, according to Nansen. Further experiments with both redlegged earth mites and different aphid species on canola support the published finding that pest preference can be "manipulated" based on potassium fertilisation.

The outcomes are quite consistent and encouraging – "fertilizer applications are clearly affecting the host choices by key canola pests, and we are very keen to explore how this can be used as part of an integrated pest management strategy," Nansen continues.

"Canola needs more potassium than wheat – especially after post-flowering which is when key canola pests become a problem – and many WA soils are deficient in potassium." To apply the right dose at the right time during crop development would add 'smart fertiliser applications' to such a strategy.

The study showed a strong link between 'spectral reflectance' of crop canopy, which can be measured with advanced imaging technology, and the attractiveness of these crop leaves to spider mites.

With crop attractiveness being related to potassium content, the researchers argue that it may be possible to develop remote sensing systems which collect 'spectral reflectance' data from crop leaves to continuously monitor their attractiveness during the growing season and apply fertiliser when there appears to be an increase in crop attractiveness to pests.

Nansen further pointed out that the use of the right amount of fertilisers to provide essential nutrients to plants to build up their defence against pests could also lead to less need and use of pesticides.



Honours student, Julius Wong, inspecting canola field plots for aphid infestations at UWA Shenton Park.

Australia and China pool expertise for better wheat

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In early September, the annual Australia-China Wheat Genetics and Breeding Workshop was held at UWA. This was the fourth such event since its inception in 2010, jointly organised by UWA's Institute of Agriculture (IOA) and the Chinese Academy of Science (CAS).

While Australia is a big player as the 8th largest wheat producing country world-wide, producing 20 to 25 million tonnes per annum (with an average annual gross value of \$6 billion), China, produces 4-5 times that amount of wheat annually which makes it one of the world's leading wheat producing countries.

A key strategy to sustain wheat production in the long term is the breeding of new cultivars resistant to biotic stresses (insects, diseases, etc.) and abiotic stresses (drought, heat, salinity, etc.) both of which adversely affect wheat production, causing significant fluctuations in global yield.

Since 2010, wheat researchers from Australia and China have come together once a year to pool their knowledge and resources to meet these challenges, and breeding superior wheat cultivars



Participants of the Fourth Australia-China Wheat Genetics and Breeding Workshop held at UWA on 5 September, 2013.

is well underway in both countries. "Australia has bred its own unique wheat germplasm suited to its harsh dry land environments while Chinese wheat breeding programs have been tailored to growing multiple crops per year (common in China)," explains Associate Professor Guijun Yan, (IOA and School of Plant Biology), who coordinated the series of workshops.

With the help of a leading Australian cereal breeding company, InterGrain, this fruitful collaboration was instrumental in importing 68 wheat lines created by Chinese researchers

which have been released from quarantine for genetic studies and breeding in Australia. "Most of the imports are wheat materials with alien/wild chromosome segments," says Yan, "and these segments have proven to be tolerant to several biotic and abiotic stresses, so they can be used to improve Australian wheat."

The joint workshops has also led to several recent joint grant applications – with one success already, and more collaborations are expected to follow, including joint training of young researchers and postgraduate students in wheat genetics and breeding.

WA farmers gain experience in Chinese farming systems

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A group of 23 WA broadacre farmers gained first-hand insight into Chinese farming systems during a recent Agricultural Study tour to the Agricultural University of Hebei (AUH) in Baoding, China.

The visit was facilitated by Associate Professor Guijun Yan (UWA's Institute of Agriculture and School of Plant Biology) and hosted by AUH's Vice President Professor Zhiying Ma.

Ma gave an overview of GM crops in China and discussed their food safety aspects and the visitors learned that cotton had been the most widely adopted and successfully integrated GM crop in China. GM cotton had improved farmer health and environmental safety as a result of the reduced use of pesticides in GM crops compared with traditional non-GM cotton.

"We were happy to hear that with China's increasing demand for quality food, Australian produce is highly sought after, particularly wheat, barley and canola," says tour leader Bill Crabtree.



WA farmers en route to the Agricultural University of Hebei, China, for their Agricultural Study tour.

The visitors also identified aspects of WA farming practices that could be of benefit to their Chinese counterparts: "We saw many fields that had been over-cultivated and had suffered structural decline as a result, so it seems Chinese farmers have yet to discover the full long-term benefits of no-tillage, conservation agriculture and improved soil health."

The tour was the second of its kind organised by Agricultural Consultant and UWA graduate Bill Crabtree in eight years. "It was a fantastic experience," says Bill. "You can really feel and see China growing, they are fast becoming an affluent society and we wish them all the best."

Multi-Peril Crop Insurance – when can we get it?

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Australian farmers can insure their crops against hail and fire damage but not against losses caused by drought and frost. This is despite the fact that variation in rainfall and frost are the largest causes of uncertainty in broadacre farming and may increase with future climate change.

This scenario prompted two researchers from UWA's Business School to undertake a feasibility study to try and determine, why insurance companies are currently not offering multi-peril crop insurance (MPCI) to Australian farmers, despite the evidence of a clear need for such an insurance.

Associate Professor Ernst Juerg Weber and Honours student Amy Khuu collaborated with grower groups to survey attitudes toward risk and risk management practices of farmers in the West Australian grain belt.

"Our findings indicate, that an increase in crop yield volatility of 20 per cent would raise the farmers' willingness to pay for crop insurance one-to-one, by 20 per cent," says Weber. At the same time, the study

highlights the interplay of 'private' or unknowable variables in determining individual farm risk.

"The hail risk is a given quantity that is based on historical observations, whereas the drought and frost risks change from one growing season to the next, depending on the El Niño cycle and other meteorological factors," explains Weber. "Insurance companies do not know how skilfully an individual farmer uses seasonal weather forecasts and meteorological information, if at all."

Furthermore, the research shows that without MPCI, farmers manage the risk of crop losses using seasonal weather forecasts at the time of the planting decision and through prudential farm management practices, including reducing the crop area if they



Amy Khuu and Juerg Weber.

expect unfavourable conditions during the growing season. As crop insurance shifts the risk of crop failure to the insurance company, the study concludes that the introduction of MPCI may change the risk management practices of farmers, as there would be less incentive for farmers to behave prudently, resulting in unexpected losses to the insurer.

Weber predicts that the introduction of MPCI will hinge on the development and availability of more sophisticated measurement tools and data that will enable insurance companies to determine individual farm risk.

The study was recently published in *Agricultural Finance Review*, 73(2), 2013, pp. 345-357.

Obituary Emeritus Professor Walter Ralph Stern

(3 September 1927 – 24 September 2013)

Hackett Professor Kadambot Siddique
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Emeritus Professor Walter Stern passed away peacefully on Tuesday 24 September at St John of God Hospital in Subiaco, Perth.

Walter Stern gained admission to the B. Sc. Agriculture course at The University of Sydney in 1945 under the legendary Professor R. D. Watt. After graduation in early 1949, Walter worked in the Bureau of Sugar Experiment Stations within the Queensland Department of Agriculture. In 1951 he joined CSIRO and moved to Katherine in the Northern Territory. Post-war, the Department of National Development had wished to explore the possibility of establishing permanent agriculture in the north and CSIRO was asked to investigate. Walter was among a group of multi-disciplinary scientists selected to conduct surveys in the region, which led to the establishment of the Katherine Research Station, and also the Kimberley Research Station (Ord River) in collaboration with the WA Department of Agriculture.

At Katherine Research Station Walter worked on both crop and pasture species. The principal crops being investigated were peanuts, cotton and sorghum, tobacco, millet and various fodder species. It was a great field experience and a thesis from this work earned Walter an M. Sc. Agr. from The University of Sydney.



In 1957, his passion to become highly qualified led him to enrol in a PhD program at the Waite Institute, The University of Adelaide, as the first PhD student under the supervision of famous Professor Colin M. Donald.

Upon completion of his PhD, Walter returned to tropical agriculture to continue his developing interest in crop-environment relationships. He joined CSIRO's Division of Land Research & Regional Survey, and divided his time between Katherine, the new Kimberley Research Station at Kununurra in WA, and Canberra. The work was initially focussed on cotton and safflower, major crops mooted for the Ord River Project. Walter undertook detailed study of the seasonal characteristics of the environment and microclimate within the crop.

In 1967 Walter was appointed as the inaugural Professor of Agronomy at the UWA Institute of Agriculture, where for the next 23 years he focused his energy on developing his new Department of Agronomy within UWA. This he did through a series of high-calibre academic appointments and the extension of his research interests in crop-environment relationships to wheat and other cereals in the semi-arid Western Australian grain belt. Many notable graduates and post-graduates from this period are now contributing to Australian and international agriculture. Following his retirement in 1990, Walter maintained his interest in agriculture and regularly participated in public lectures and seminars at the UWA Institute of Agriculture.

Walter also contributed significantly to agriculture at the international level. As one of three Australian consultants; he facilitated the design of (agricultural) courses, staff training and exchanges at the Universiti Pertanian (now Universiti Putra Malaysia), at Serdang, Malaysia.

He played a part in establishing the Australian Society of Agronomy and held many key positions during his career, including Secretary/Treasurer of the Queensland Branch of the Australian Institute of Agricultural Science (1949-51); ACT Branch Secretary in the mid-1960s; WA Branch President of AIAST in the 1980s and President of the highly successful 5th Agronomy Conference held in Perth in 1989-90.

Walter was honoured as a Fellow of the Australian Society of Agronomy in 2012.

UWA-CSIRO plant scientist wins secondment with leading international laboratory

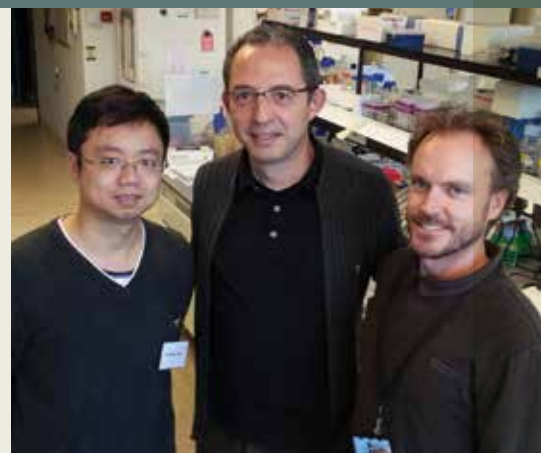
Assistant Professor Jonathan Anderson
Email: Jonathan.Anderson@csiro.au

Assistant Professor Jonathan Anderson, holder of a joint appointment between UWA IOA and CSIRO Plant Industry, has won a secondment with a leading international laboratory, The Sainsbury Laboratory in Norwich, England (www.tsl.ac.uk), under a Julius Caesar career award from CSIRO.

Anderson, who uses molecular biology to research plant defence against microbial pathogens and to improve disease resistance in a range of crops, selected the Sainsbury Laboratory for his secondment, because this has provided him with the opportunity to work with Professor Kamoun, one of the world leaders in molecular plant pathology and a specialist in understanding how pathogens are able to cause disease on plants.

"While here I am continuing my work on the root infecting fungal pathogen, *Rhizoctonia solani*, which notably causes bare patch in cereals, brassicas and legumes in Australia," says Anderson, "and I am excited that I am able to use the (new) *R. solani* AG8 genome sequencing and annotation data obtained recently in the joint UWA-CSIRO Molecular Plant Pathology and Crop Genomics group of Winthrop Professor Karam Singh in Perth, to progress the discovery of genes used by *R. solani* to cause disease."

The benefits of Anderson's secondment at Sainsbury Laboratory extend even further: "I have gained valuable experience in lab techniques to test the function of pathogenicity genes, and my visit has provided me with an excellent opportunity for discussions with many great minds and to see how science is done differently in different labs."



L-R: Jonathan Anderson (right) at Sainsbury laboratory with Sophien Kamoun, Head of Laboratory (centre) and fellow research scientist Suomeng Dong (left).

Anderson is keen to put his acquired knowledge and experience to good use on his return to Perth: "Having an understanding of how *R. solani* is able to cause disease on plants is a major step in developing strategies to enhance resistance in crop plants, and this secondment takes us a significant step closer to that goal."

Plant Science and food security on the menu at the 2013 UWA London Dinner

Winthrop Professor Tim Colmer
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"Food Security – The Role of Plant Science in Feeding the World" was the very appropriate topic of a presentation given by Professor Christopher Leaver at the UWA London Dinner in October 2013.

The UWA London Dinner is held each year to enable alumni and friends of UWA to gather and remain connected with the University and their Australian networks in London. This year's event was a special celebration of the University's Centenary, as well as the importance of Plant Science research (basic and applied) for crop improvement and agricultural sustainability to feed the world.

Leaver (CBE, Emeritus Professor at the University of Oxford, Visiting Professor at UWA) communicated to the dinner guests the looming issue of food security, and the importance of plant science to tackle challenges to current and future world food production.

He highlighted UWA's key strength in plant science and related areas of research and its impact both in terms of practical contributions to agriculture as well as in basic knowledge discoveries.

A key message was that scientific knowledge and its application is vital to secure a prosperous future for the world, and participants discussed the role of multidisciplinary collaborations, including international projects which build (human research and development) capacity.

UWA is a key collaborator in plant science and agricultural research with various universities and other organisations across the globe. Plant scientists from Oxford University, the John Innes Centre at Norwich, and Syngenta were also guests at the dinner. Three UWA-based plant scientists (Winthrop Professors Kadambot Siddique, Harvey Millar and Tim Colmer) visited Oxford and Norwich during the week, and also met with the Head of External Collaborations at Syngenta. Harvey Millar

delivered a seminar on protein turnover in leaves, using examples from experiments with Arabidopsis and barley to demonstrate the role of protein renewal in regulation of metabolism, the energy costs involved, and raising the possibility to modify these processes to improve plant performance.

An enjoyable week of scientific discussions concluded with a fine-dining experience at St John's College, Oxford University, kindly hosted by Leaver.



L-R: Harvey Millar, Chris Leaver, Kadambot Siddique, Lee Sweetlove, Tim Colmer and Andrew Smith at St John's College, Oxford University.

Lifting Africans out of poverty

Dr Anke van Eekelen

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An insight into a redefined strategy by the International Institute of Tropical Agriculture (IITA) to address the immense issues of poverty, undernutrition and untenable agricultural practices and use of natural resources in Africa was provided by its Deputy Director for Research and Development, Dr Ylva Hillbur, during her visit to the UWA Institute of Agriculture in August.

Hillbur's public lecture showcased how strengthening the presence of IITA, the leading international institute of agriculture in Africa, across the African continent and building stronger scientific research and development networks at national levels is already creating new opportunities for improved livelihoods in sustainable environments.

IITA operates from 18 research stations across four regional hubs in West, Central, East and Southern Africa; the hubs are managed from Nigeria, the Democratic Republic of Congo, Tanzania and Zambia respectively. Here, an international group of 120 scientists works on IITA's 'Research-for-Development' programs with an annual budget of 80 million US dollar, of which about 20 per cent comes from the Consultative Group on International Agricultural Research (CGIAR) Consortium. IITA, with its headquarters in Nigeria, is one of CGIAR's research institutes and the scientific focus of IITA's strategy for Africa overlaps with priorities across many of CGIAR's research programs (CRPs).

IITA works on a 'whole of society' approach to achieve its overarching goal of lifting 11 million Africans out of poverty and developing 7.5 million

hectares of land into sustainable use by 2020. Its success comes from quality research, translation of research and commercialisation of research outputs, but collaboration with national and local partners and serious efforts towards capacity development and gender equality are as important for long term progress to be made.

"From an agronomic perspective, we are challenged with low and further decreasing soil fertility, a high incidence of pests and pathogens and undiversified cropping systems, leaving the systems vulnerable and leading to undiversified diets," Hillbur explained.

IITA aims to generate impact by intensifying, diversifying and improving cropping systems of many essential staple crops and grain legumes. Encouraging outcomes have already been achieved with the development of pro-vitamin A enriched 'orange maize', striga resistant and drought tolerant maize varieties, the cassava transformation program in Nigeria and the GM banana transformation project in Uganda, to name a few.

Further attention to improve systems management, education and youth employment completes the holistic plan to combat the underlying issues of poverty in Africa.

Hillbur met Hackett Professor Kadambot Siddique, Director of IOA and a member of the CGIAR Grain Legumes Independent Advisory Committee, at the launch of the Grain Legumes CRP in India early this year. During her visit Hillbur discussed potential future areas of collaboration between IITA and UWA.

IITA: www.iita.org

IITA publication R4D: www.r4dreview.org



"Orange maize" enriched with Pro-vitamin A, and grown in Africa under the Harvest Plus Project on biofortified crops.



Researchers Bosede Lawal, Laura M. Boykin, Alice Maredza and Angela Eni during the Bill and Melinda Gates Foundation, Agricultural Connections Workshop, Naivsha, Kenya.

Whiteflies: a major threat to food

Dr Laura M. Boykin

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Expertise regarding whiteflies (*Bemisia tabaci*)

– a major insect pest threatening the food security in developing countries – has earned UWA computational biologist Dr Laura M. Boykin (ARC Centre of Excellence in Plant Energy Biology), a trip to Kenya with the support from the Bill and Melinda Gates Foundation.

The highly invasive pests, collectively known as *Bemisia tabaci* species complex, have the most severe impact in sub-Saharan Africa, affecting vegetable, cassava and sweet potato production throughout the region and causing damage through both feeding and the transmission of viruses (including the devastating Cassava Mosaic Virus (CMV), Cassava Brown Streak Virus (CBSV), Tomato Yellow Leaf Curl Virus (TYLCV), and the Sweetpotato chlorotic stunt virus (SPCSV)).

Boykin's work involves species delimitation of the *Bemisia tabaci* species complex, which refers to the process of deciding how individuals and populations fit into natural groups.

"The problem is that the whitefly complex consists of many different *Bemisia tabaci* species which look alike but (can) have different crop preferences, and this affects how the virus is spread within the farm," explains Boykin. "Different species in the whitefly complex require different integrated pest management strategies and once we determine what whitefly species

Crawford Fund conference inspires UWA Ag Science students



WA scholars Liam Ryan (left), Melinda Judge and Simon Yeap (right) with Jen McComb and Terry Enright from the WA Committee of the Crawford Fund.

Two Agricultural Science Honours students from UWA won invitations to the Crawford Fund Conference 2013 Mining, Agriculture and Development, held at Perth's Novotel Hotel in August.

Melissa Judge and Liam Ryan were sponsored to attend the event as Crawford Scholars – a distinction they shared with only one other student in the state, Simon Yeap (Murdoch University).

The conference highlighted the issues and the need for fruitful partnerships between the mining and agriculture industries for global food security, with a focus on Africa.

Melissa Wood, Director of the Australian International Food Security Centre (AIFSC) spoke of the focus on food security across Africa and how smallholder farming, advances in research and evolving policy are required to meet the food requirements of the population. These themes were reiterated by David Shearer, of the Australian Centre for International Agricultural



Food security in Africa and beyond

is present in a crop, this allows us to tailor the response more effectively and thereby decrease the cost to the farmer and ultimately increase crop yield and quality.”

Thanks to the support of the Bill and Melinda Gates Foundation, Boykin was able to participate in the Agricultural Research Connections workshop on crop protection in Naivasha, Kenya and explore potential collaborations. The group developed grant proposals and also toured the various facilities in Kenya, including the Biosciences of East and Central Africa (BeCA) in Nairobi Kenya (<http://hub.africabiosciences.org>).

Negotiations are underway for future support in this important area of research which plays a critical role in governmental decisions regarding the flow of trade and biosecurity measures.

Boykin has since published a new paper on her research (doi:10.1186/1471-2148-13-228) and further information is available at:

www.publicaffairsbooks.com/publicaffairsbooks-cgi-bin/display?book=9781610390675

www.nesi.org.nz/case-study/high-performance-computings-role-in-biosecurity

www.biomedcentral.com/1471-2148/13/228/

Research (ACIAR), who stressed Australia’s strength in agricultural knowledge and ability to form partnerships aiming to reduce poverty through international agricultural research and development.

The conference was followed by the annual Crawford Student Research Day, featuring high quality presentations from students across many African countries and Australia on topics including; biomass assessment tools, grass cultivar productivity, human adoption of improved

Award-winning PhD students find new ways to (help) identify climate-ready crop species

Dr Anke van Eekelen

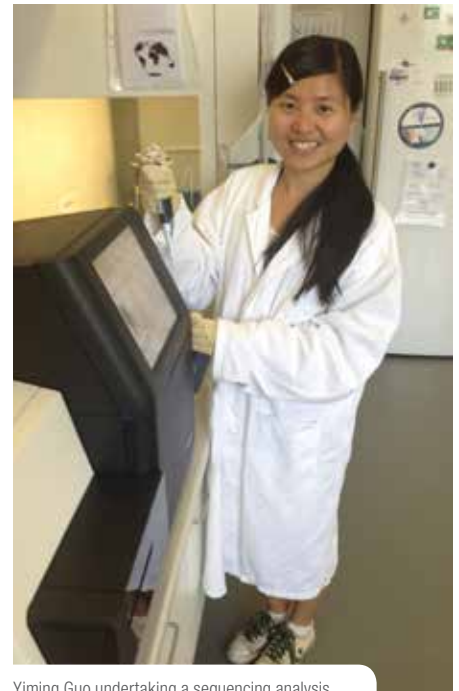
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In the face of hotter and drier conditions, plant breeders need to develop drought and heat resistant crops. Climate change and the ever-growing world population pose serious threats to the global food supply and the need for new varieties of crops with increased resilience against harsher environmental conditions is growing.

At UWA’s Institute of Agriculture (IOA), two PhD research projects are focussed on this issue, aimed at identifying Brassica plants that protect their flower parts from hot and dry conditions. The Brassica plant family is known for its diverse range of species and significance for mustard seed, canola oil and vegetable leaf production within the agriculture and food industry. For oil-producing Brassica crops, heat and drought tolerance during the flowering stage is essential for seed and oil production.

PhD student Yiming Guo (UWA School of Plant Biology and IOA) is currently pursuing her research on specific genetically-based mechanisms of tolerance against at the Justus Liebig University in Giessen, Germany. She has developed a new approach to assess drought stress in plants by measuring floral bud temperatures, and showed that some varieties were better capable of protecting their floral buds against water shortage than others by remaining cooler under drought conditions. Her findings were recently published in the journal *Functional Plant Biology*.

Ms Annisa, a fellow PhD-student at UWA’s School of Plant Biology and IOA and recipient of an Australian Development Scholarship Award, was the leading author of a recent paper in *The Journal of Agronomy and Crop Science*. She showed that heat tolerant *Brassica rapa* plants formed more seeds under heat stress than sensitive plants. A leafy vegetable type of *Brassica* from Indonesia appeared best equipped against heat stress during flowering and seed production, followed by an oilseed type from Pakistan.



Yiming Guo undertaking a sequencing analysis.

The above discoveries made in *Brassica rapa* may contribute to breeding of drought and heat-resistant canola in Australia to produce higher yield under high temperature and drought stress.

Both research initiatives are supported by an ARC Linkage grant with industry partners COGGO Ltd, a WA grower group, and NPZ Lembke, a German plant breeding company. Supervisors of the students include Winthrop Professors Wallace Cowling, Neil Turner, Associate Professor Matthew Nelson and Assistant Professor Prof Sheng Chen.

agriculture techniques, assessment of novel agricultural techniques, viral and insect crop pathogens, functional foods, soil quality, salinity tolerance and plant biosecurity.

Melinda and Ryan were excited at the opportunity to engage with leading government officials representing many African countries: “We talked to Sierra Leone’s Deputy Minister of Agriculture, Maria Jalloh, as well as to scholars and distinguished guests and many African students, and this was truly inspiring and has given us new

perspectives on international agricultural research as well as valuable contacts.”

Established in 1987, The Crawford Fund is a non-profit, non-government organisation, dedicated to raising awareness of the benefits to developing countries and to Australia of International agricultural research. It promotes and supports international Research and Development activities in which Australian research organisations and companies are active participants.

New collaboration advances Animal Production



L-R: Kadambot Siddique with delegates M.R. Saseendranath, S. Ramkumar and Iain Watt (Pro Vice Chancellor, International UWA) during their visit to UWA in October 2013.

Ms Uly Fritsch

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A recent visit to UWA by delegates from one of India's leading universities in the field of animal science has culminated in a new Memorandum of Understanding (MoU) between UWA and Kerala Veterinary & Animal Sciences University (KVASU).

Professor M.R. Saseendranath (KVASU Director of Academics and Research) and Professor S. Ramkumar (KVASU Director of Entrepreneurship) met with senior executives and key researchers at UWA and agreed on a five-year MoU aimed at developing future collaborations and new education programs and research in relevant areas of animal production.

The MoU will encourage academic and cultural interchange such as joint research activities, joint conferences, the exchange of academic materials and information, and will facilitate student and staff exchanges. The way for staff exchanges has already been paved through a recent visit, in September 2013, by three KVASU scientists to UWA, where they received hands-on training in the physiological and molecular aspects of heat stress impact in livestock. (For further details see www.news.uwa.edu.au/201309256084/climate-science/how-will-livestock-act-global-warming).

The new MoU was initiated by IOA Director Hackett Professor Kadambot Siddique; Winthrop Professor Graeme Martin points to Kerala's impressive track record of more than sixty years in Veterinary and Animal Sciences teaching and research: "Over the past two years, IOA has forged solid links with KVASU which the new MoU will advance even further. It represents a natural progression from UWA's MoU with Kerala Agricultural University (KAU), signed in 2008, which was specifically focused on the KAU Academy of Climate Change Education and Research. During 2010 KAU was divided and the disciplines of veterinary and animal sciences were shifted to the newly formed KVASU."

Since KVASU recently joined the World Universities Network (WUN) partnership (thanks to the efforts of Winthrop Professor Graeme Martin, IOA Deputy Director) – of which UWA is also a member – there is now an additional connection: "KVASU is keen to work with UWA's (WUN-supported) climate change adaptation research in animal production at UWA's Future Farm 2050 (see also article below, page 12), and I am confident the MoU will generate many new opportunities to share our knowledge and expertise for the benefit of all."

Animals take centre stage at international workshop

Winthrop Professor Graeme Martin

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As the human population is set to increase by 50% over the next three decades, a group of international scientists recently gathered in the United Kingdom, to examine the role of ruminant animals in meeting the needs for global food security.

Their forum was the second international workshop in the project 'Ensuring Sustainable and Responsible Production of Healthy Food from Healthy Animals', which is supported by the Worldwide Universities Network (WUN) and led by the University of Bristol in partnership with UWA, University of Leeds, Kerala Veterinary and Animal Science University (India), Penn State University and Zhejiang University.

The first workshop was held in Kerala in mid-2013 and the second took place from 17-20 July in Bristol. The third will be held at UWA in September 2014.

The participants are working on a position paper that sets out the role of ruminant animals in addressing the needs for global food security over the next three decades.

Their focus is on the major challenges and solutions in five areas:

- i. Animal health – the emphasis will be on 'One Health', in which human and livestock diseases are seen as a continuum, not separate spheres of activity;
- ii. Alternative feed sources – the view will be that human food should not be used for livestock, but livestock should be used to produce human food from resources that humans cannot digest or will not consume (eg, high-fibre forages, food waste, crop residue); at the same time, the best agricultural land will be restricted to grain production for humans, and grazing animals will be primarily restricted to 'un-croppable' areas;
- iii. Environmental footprint – this encompasses greenhouse gas emissions and nitrogen and phosphorus wastes in effluent;

- iv. Genetics – the concept of 'fit-for-purpose' will be applied to livestock species and forage species, and also to crop species (where crop residues are seen as a valuable feed resource); two new and exciting fields will have a major impact on thinking here – epigenetics ('programming' of the fetus for future productivity) and the 'pan-genome' concept (in which the ruminant animal genome and the rumen microbial 'genome' are considered as a single unit; an international research project led by UWA Professor Philip Vercoe);
- v. Livestock management – all of the above issues need to be incorporated into management packages that are specific to the major climatic and socio-economic environments; this is the point at which animal ethics and welfare is also included as a major factor in the quality of the livestock industry.

The position paper will be submitted to a leading journal as a guide to future research directions in the participating partner institutions, and provide clear avenues towards international collaboration.

The first workshop (India) has already led to a collaborative project on heat stress between UWA (Prof Shane Maloney) and two visitors to UWA from KVASU (www.news.uwa.edu.au/201309256084/climate-science/how-will-livestock-act-global-warming).

A major resource that will contribute to research towards the solutions will be the three 'farm platforms': UWA Future Farm, Silent Valley in Kerala, and the North Wyke Farm Platform that is run by Rothamsted Research in the UK.

UWA's contribution to the WUN Project is led by Winthrop Professor Graeme Martin, who is currently on sabbatical leave in Oxford, where he can work closely with the Bristol team (Prof Mark Eisler and Dr Michael Lee) in managing the workshop programs and the writing of the position paper.

A fresh approach to animal welfare

Ms Ully Fritsch

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A fresh approach to farm animal welfare was the topic of discussion at a recent talk given by Dr Pierre Le Neindre, an international authority on animal welfare, during his visit of the IOA Animal Production Systems team and their colleagues at CSIRO Division of Animal, Food & Health Sciences.

As a former chair of the Scientific Committee on Animal Welfare of the European Commission (1990-2000) and vice chair of the Scientific Committee of the European Food Safety Authority (EFSA) (2000-2009), Le Neindre acquired in-depth knowledge and understanding of the European approach to animal welfare.

"Assessment of animal welfare underwent a big shift in Europe, in the wake of the mad cow disease-crisis," says Le Neindre. "Animal welfare was (and remains) a big issue with political implications and subject to public scrutiny, and the mad cow disease crisis triggered a push for transparency and created a new field of research – animal welfare quality.



L-R: John Beesley (CSIRO) with workshop presenter Pierre Le Neindre and Phil Vercoe (UWA).

This led to big changes in the way animal welfare is assessed (in Europe): the assessment criteria now focus on the animal, rather than on resources or management practices; an obligation to make changes is determined by assessment results rather than means, and quantitative analysis of results has become mandatory."

These changes have placed more responsibility in the hands of livestock producers and industry in Europe. "The European Union provides a stable framework with a uniform code of practice

developed through discussion with and between stakeholders," says Le Neindre, "and this creates an opportunity for all key players to engage and contribute to informed and responsible policies and practices."

"There are a whole range of factors which must not be compromised in animal production, such as food safety, worker safety and animal welfare, and we need an integrated approach by well-informed, well-trained stakeholders, to balance and give due consideration to these factors," said Le Neindre.

Breeding flystrike-resistant sheep – can it be done?

Dr Anke van Eekelen

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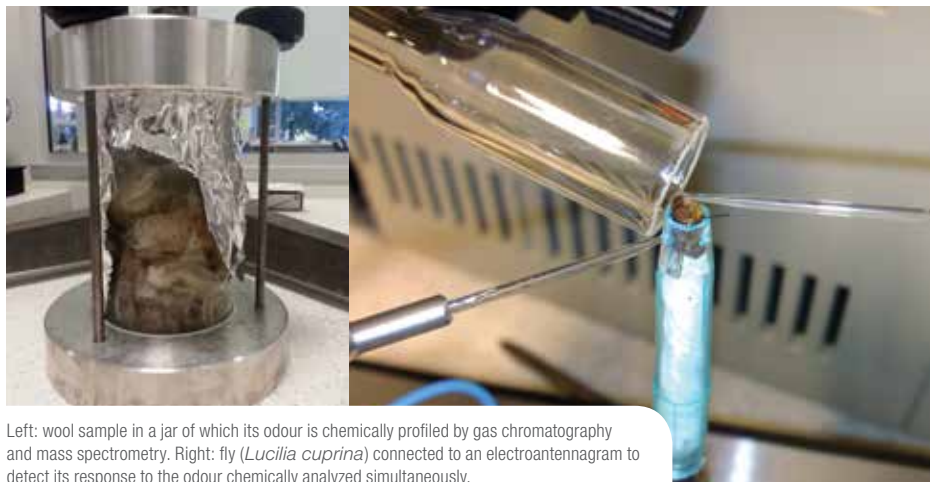
Driven by a change in consumer attitudes towards how food is produced, farmers now face the challenge, more than ever before, of how to manage breech flystrike ethically and cost-effectively

UWA School of Animal Biology and IOA PhD student Mr Joe Steer, has embarked upon a research project which may ultimately lead to a breeding strategy to create a flystrike resistant – or more specifically: a flystrike-repellent – flock, through harnessing the Australian Merino sheep's heritable odour traits.

"Some sheep are naturally resistant to breech flystrike while others are susceptible," explains Steer "Physical factors, like skin wrinkle and wool cover, only explain 25 per cent variation in breech flystrike resistance. For the 75 per cent left, we have no idea."

Previous research, (by collaborator Dr Johan Greeff from DAFWA), has shown that sniffer dogs can be trained to distinguish sheep susceptible to breech flystrike from those resistant to this health risk. The dog training program using wool samples from WA sheep showed 100 per cent efficacy.

Steer's aim is to locate the source of the odour-cue responsible for attracting or repelling flies and to identify the odour components which play a key role in preventing the potentially 'fatal attraction' between flies and sheep in the field.



Left: wool sample in a jar of which its odour is chemically profiled by gas chromatography and mass spectrometry. Right: fly (*Lucilia cuprina*) connected to an electroantennogram to detect its response to the odour chemically analyzed simultaneously.

His preliminary Honours project eliminated faeces as the prime source of smell attracting the flies. He now uses naturally odour-rich wool samples, which he analyses by gas chromatography and mass spectrometry to identify what chemicals make up the odour profile of each specific sample.

"Each individual breech strike resistant sheep is still slightly different and there is not yet one particular odour component in the wool that stands out. It is potentially a cocktail that is diminishing its attraction to flies."

Steer predicts that the selection of some powerful odour components among the many identified,

can serve as practical indicators to farmers to determine breeding strategies to create a resistant flock over time.

This joint research project is funded by Australian Wool Innovation, UWA's School of Animal Biology and RSPCA, and supervised by Professor Phil Vercoe (UWA School of Animal Biology and IOA), Dr Johan Greeff (DAFWA), with co-supervision by Dr David Cook (UWA Forensic Science) and Dr Gavin Flematti (UWA School of Chemistry and Biochemistry).

The study's contribution to animal welfare was recognised last year with an award from the RSPCA for humane animal production.

UWA scientists help revitalize agriculture in Iraq

Adjunct Professor Wal Anderson
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UWA, through its Institute of Agriculture (IOA) and with funding support from the Australian Centre for International Agricultural Research (ACIAR) and AusAID is playing an important role in the rehabilitation of agricultural sector in Iraq. Since 2005, IOA has participated in a project to assist the re-establishment of agriculture, and enhance cropping practices in the dryland areas of northern Iraq.

The work has involved various phases including crop variety development, field trials on tillage methods, in-country and overseas training and most recently the adoption of aspects of conservation cropping. Partners in the work, in addition to UWA, include the University of Mosul, the Iraqi Ministries, the International Centre for Agricultural Research in Dry Areas (ICARDA), the University of South Australia and the University of Adelaide. The UWA project team includes: Hackett Professor Kadambot Siddique, Adjunct Professor Wal Anderson, Dr Ken Flower, Assistant Professor Amin Muger, Ms Cara Alan and Dr Jens Berger (CSIRO/UWA).

During the first two phases of the project farmers in Ninevah Province in Iraq witnessed the project team using zero till seed drills and they were so impressed with the technology that they immediately began constructing and modifying their existing seeders. Farmers in northern Syria began the same process and zero tillage, the cornerstone of conservation agriculture (CA), has been eagerly adopted in both countries.



Project staff inspecting the field research site at Cunderdin in WA.

The current phase of the project is managed by UWA graduate and former member of the IOA Industry Advisory Board, Dr Stephen Loss employed at ICARDA in Amman.

Siddique, Anderson and Flower met with project partners in Amman in September 2013 for a review of last year's activities in Ninevah Province in Iraq, northern Syria and the establishment of new sites in Arbil in Iraqi Kurdistan and Jordan.

The project team also discussed and agreed on the manufacture and delivery of new and renovated zero tillage seeders for all the collaborators during the new season and has taken steps to introduce other components of conservation cropping, such as returning of crop residues to the soil each year and the use of diversified rotation crops (including legumes). The project team expressed the view that when CA is more fully implemented, this will lead to even greater benefits through improvement in soil fertility and grain yields.

As part of the project, the UWA team is currently investigating the impact of stubble retention and grazing on soils and on the levels of insects, diseases and weeds in cropping rotations in WA.

Loss also emphasised the training of Iraqi project participants as one of the project's key benefits to the recipient country and referred to the numerous training projects (past, present and planned) conducted by UWA for Iraqi students, professionals and government officials. (For further information refer to www.ioa.uwa.edu.au/__data/assets/pdf_file/0003/2152884/97454_IOA-News-No17-web.pdf)

The Iraqi collaborators recently announced that several new crop varieties of durum and bread wheat, barley, field pea and vetch have been selected, seed increased, and varieties formally registered and released to farmers in Iraq. Multiplication of these varieties will provide farmers with further options to improve their crop yields and diversify their rotations.

The extension of this work through demonstration sites in a further three provinces in Iraq will spread further the positive impact on agriculture in countries that sorely need a boost in their recent fortunes. The project team commended their Iraqi and ICARDA colleagues on their determination and success in seeing this work through despite security challenges that most of us can only imagine.

UWA-China collaboration on track for a bright future in crop genetics research

Assistant Professor Sheng Chen
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A recent visit by 11 scientists from China's prestigious Huazhong Agricultural University (HZAU) has laid the foundation for a Joint Centre for Plant Functional Genomics & Crop Genetic Improvement between HZAU and UWA.

The plan was developed during a workshop on plant functional genomics and crop genetic improvement which was held at UWA on 9-10 September 2013. The aim of the workshop was to strengthen scientific collaboration between UWA and HZAU in teaching and research in crop genetic improvement and plant functional genomics.

Hackett Professor Kadambot Siddique, Director of IOA, who had extended the invitation, explains the significance of this high-profile partnership: "HZAU is one of the leading agricultural universities in China and has achieved significant outcomes during its distinguished 100-year history, especially in plant science research, such as hybrid canola, green super rice, high-quality citrus, potato microtuber, and transgenic cotton."

At a meeting between the Vice Chancellor of UWA, Professor Paul Johnson, and the Vice President of HZAU, Professor Xianlong Zhang; HZAU and UWA agreed to focus the proposed centre's research on seven key topics:

1. Crop and model plant heterosis, especially in energy efficiency of protein metabolism;
2. Crop disease/pest resistance, in wheat, rice and canola;
3. Crop abiotic stress tolerance, including drought, heat, salinity and flooding tolerance;
4. Epigenomics of polyploidization and hybrids in crop plants, in Brassica and cotton;
5. Molecular mechanism of male sterility and fertility restoration;
6. Crop nutrient use efficiency, in wheat, rice and canola; and
7. Functional genomics of oil accumulation and flowering time genes conditioning adaptation in canola.

A box of tricks set to revolutionise soil-based salinity measurements



Nick Harris and Keith Smettem performing a real-time demonstration of chloride sensors mounted in a soil column.

Ms Uly Fritsch

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What do you get when you team up an electronics and electrical engineering wizard from the University of Southampton (UoS) with scientists from UWA.

Well, in the case of Dr Nick Harris (UoS), Winthrop Professor Keith Smettem and Professors Neil Coles, Ed Barrett-Lennard and Mark Rivers (all from UWA) you get a revolutionary sensor capable of measuring chloride in the soil and of linking up with other sensors to create a wireless network (of sensors) which can be used to collate and relay the measurement readings and to control the time intervals at which measurements are taken.

With financial support from the World University Network (WUN) and the Biotechnology and Biological Sciences Research Council (BBSRC), Harris elected to spend a sabbatical semester at UWA to work with Coles and Rivers, and developed a novel sensor which can be placed into the soil, to carry out non-destructive testing/measurements of sodium chloride levels (which make up a high proportion of the overall soil salinity).

This non-destructive form of soil-based testing and the use of sophisticated network technology (e.g. Bluetooth) to collate and transmit data, is likely to dramatically change the way (soil-based) research is conducted.

“Traditionally soil-based measurements involve taking samples and transporting them to the laboratory for analysis, which is very labour – and cost-intensive, and therefore it usually means spot checks only, with samples taken every 2-3 months,” explains Harris.

“The removal of a (soil) sample from its natural environment also means that the same sample can only be measured once, so the traditional (destructive) method is not suited to measure changes in a sample over a period of time.”

By contrast, Harris’ ‘box of tricks’ – the actual sensor connected to a small unit represents a device which you can almost plant and forget: the battery-powered unit can operate for (up to) two years and can either transmit data/information by short range radio, in this case Zigbee, to a laptop within 100 m range, or store the data on a memory card, to collect later. Many other options are possible, such as Bluetooth, or linking to the mobile phone network, or even satellite. However, the networking technology only allows information to be transmitted. The key to successful distributed

sensing is to have low-cost, reliable sensors, sensing the things that you want. In this case, the sensor itself consists of a ceramic tile covered by successive layers of glass, platinum, silver chloride and silver. Changes in the external sodium chloride level cause a change in the equilibrium of a well-known reaction between the silver and the silver chloride layers which manifests itself in a change in voltage, which can then be measured. The current device allows up to seven sensors to be connected at a time to a single transmitter, allowing simple multi-point measurements.

Harris expects soil-based sodium chloride sensors to be of benefit in a wide range of applications:

“At plant level, probes can be positioned at continuous levels of depth to determine, for example, the salt concentration to which roots are exposed and whether the concentration changes with the depth of the soil, or in different weather conditions; we could measure how well a plant performs at a particular concentration and change the salt content for a few days and observe the effects. On a bigger scale, sensors could be placed at different locations in a catchment field, to observe any changes in the level of salinity within a field over time, allowing hydrological models to be calibrated.”

“The (soil-based) chloride sensor represents a first step in integrating the science of networked information to provide us with perfect information on the things we want to measure at a low cost, over a long time.”

Harris, Rivers and Coles are co-authors in a recent paper published in *Computers and Electronics in Agriculture* www.sciencedirect.com/science/article/pii/S0168169913001063

In addition, the parties agreed that the directors of the joint centre will be Zhang (HZAU) and Siddique (UWA). Scientists from both sides will be involved in academic and scholarly links and collaborative projects of mutual interest.

Siddique summed up the likely benefits and impact of the proposed centre: “The joint centre will provide expertise and research groups and develop into a knowledge hub in which new research relationships will form. Collectively the scientists in the joint centre will be able to leverage significant external funding from a variety of sources to support sustained and high-impact crop research.”



Huazhong Agricultural University delegates with UWA executives during their visit to UWA.

Microbes share nitrogen winnings with wheat

Dr Jennifer Carson

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Soil bacteria take up organic forms of nitrogen far more rapidly than wheat, but much of this nitrogen is rapidly released back into soil as mineral nitrogen that is easier for crops to take up, according to researchers at UWA's School of Earth and Environment and IOA.

Plants need more nitrogen than any other nutrient, so a crop's ability to compete with soil microbes for nitrogen in soil is critical to their survival. The researchers, led by Professor Daniel Murphy, investigated how well wheat competes with soil bacteria for nitrogen in the form of small organic molecules.

When organic forms of nitrogen were added to the root zone of wheat, the plants took up very little of the nitrogen. Instead, most of the organic nitrogen was quickly taken up by bacteria.

However, bacteria gave the wheat a second chance to take up some of the nitrogen. The organic nitrogen taken up by the bacteria was rapidly converted to inorganic nitrogen in the form of ammonium. The bacteria released the ammonium back into soil, where it was available



L-R: Daniel Murphy, the national Advocate for Soil Health Michael Jeffery, Matt Kilburn and Chris Gazey (DAFWA) with the NanoSIMS at the UWA Centre for Microscopy, Characterisation and Analysis.

for the wheat to take up. Approximately half of the organic nitrogen taken up by bacteria was released back into soil in this way.

The cycling of nitrogen by bacteria occurred extremely rapidly after organic nitrogen was added to the soil. The bacteria took less than five minutes to begin taking up the organic nitrogen, converting it to ammonium and releasing ammonium back into soil.

Murphy says, "This research is unique because we were able to measure competition for nutrients between individual microbes and single plant cells in soil." This was possible because UWA has an instrument called a NanoSIMS (nano-scale secondary ion mass spectrometer), the only one in the southern hemisphere.

This research was part of an award-winning feature story on the ABC's *Landline* in November 2012 titled "Soil Secrets" (www.abc.net.au/landline/content/2012/s3630158.htm). The story's presenter, Prue Adams, was recently awarded second place in the International Federation of Agricultural Journalists–YARA Award for Sustainable Agriculture Reporting.

The research was funded by an ARC Future Fellowship and the GRDC's Soil Biology Initiative II and performed in collaboration with scientists from the UWA Centre for Microscopy, Characterisation and Analysis, University Wales, Bangor and Newcastle University, England.

Meeting marks milestones in joint India – Australia chickpea genomics project

Dr Anke van Eekelen

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Late August, UWA hosted the second bilateral talks between Indian and Australian researchers to monitor progress and discuss future plans for the "Genomic approaches for stress tolerant chickpea" project, funded by the Australia-India Strategic Research Fund (AISRF) under the Grand Challenge scheme.

Project coordinators Dr Rajeev Varshney from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and Dr Tim Sutton from the Australian Centre for Plant Functional Genomics (ACPGF), presented their respective overviews of research completed to date.

With project activities being on track, they led discussions on where to go from here.

The two-day meeting was attended by an Indian delegation representing ICRISAT, the Indian Agricultural Research Institute (IARI) and the National Institute of Plant Genetics Resources and research team members from ACPFG, the South Australian Research & Development Institute (SARDI), UWA, University of Queensland, University of Melbourne and the Royal Melbourne Institute of Technology (RMIT). The meeting was followed by trips to the experimental fields at Cunderdin, WA, and glasshouse experiments at UWA.

Varshney, who is an Adjunct Professor at UWA, also presented the Bayliss Seminar 2013 on



Participants of the second bilateral meeting of the project "Genomic approaches for stress tolerant chickpea," during their field trip to Cunderdin, WA.

"Genomics-assisted breeding of semi-arid tropic legume crops" and discussed ongoing collaborative work between ICRISAT and UWA with Hackett Professor Kadambot Siddique and Winthrop Professors Tim Colmer and Ian Small, director of the ARC Centre of Excellence in Plant Energy Biology.

The next bilateral meeting will be held at ICRISAT in India in February 2014.

New postgraduate students

STUDENT NAME	TOPIC	SCHOOL	SUPERVISOR(S)	FUNDING BODY
Ms Olive Onyemaobi	Molecular basis of drought tolerance in wheat	Plant Biology and IOA	Assoc/Prof Guijun Yan Dr Xuanlin Ma W/Prof Kadambot Siddique	Self-funded
Ms Gayle Somerville	Herbicide resistance modelling	Plant Biology and IOA	Assoc/Prof Michael Renton W/Prof Stephen Powles	APA

UWA Plant Breeding Expertise in high demand



L-R (back row): Wallace Cowling, Rale Gjuric and Tom Burns with Idy van Leeuwen (far right) and participants at the UC Davis Asian Plant Breeding Academy held in Bangkok.

Winthrop Professor Wallace Cowling
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The third session of the University of California (UC) Davis Asian Plant Breeding Academy was held at Sirindhorn Science Home in Bangkok, Thailand, in July 2013. Participants were drawn from private plant breeding companies and government institutions in China, Philippines, Thailand, Malaysia, Vietnam and Taiwan, and Winthrop Professor Wallace Cowling from IOA was an invited lecturer at the event.

Cowling welcomed the opportunity to participate as guest lecturer: "UWA is becoming recognised as an institution with expertise in plant breeding and genetics education close to Asia through the International Centre for Plant Breeding Education and Research (ICPBER) within UWA's School of Plant Biology. This was a great opportunity for

UWA to be represented in Asia. UWA will continue to work with UC Davis to help lift plant breeding education opportunities in Asia in the future."

The Seed Biotechnology Center at UC Davis established the Plant Breeding Academy in 2006 to teach the principles of plant breeding to seed industry personnel. Its courses address the shortage of formal training opportunities in plant breeding worldwide, now recognised as a serious concern for the international agriculture field. Plant Breeding Academy participants meet for six sessions over a period of two years.

The UC Davis Asian Plant Breeding Academy has received strong support from the Asia and Pacific Seed Association (APSA). Dr Tom Burns, Director of APSA, said: "The lack of advanced training for plant breeders is becoming a serious issue in Asia and the UC Davis Asian Plant

Breeding Academy is an international leading program to help address this issue."

Other lecturers in the July session of the Asian Plant Breeding Academy were Dr Rale Gjuric, Director of the UC Davis Plant Breeding Academy, and Dr Idy van Leeuwen, a plant breeding and seed industry training consultant from the Netherlands.

Cowling delivered lectures in hybrid breeding and evaluation, as well as methods for sustainable plant breeding. Discussions focussed on how to expand the genetic diversity and rate of genetic improvement in crops bred by the participants, which ranged from rice, hot peppers, bitter melon, oil palm, watermelon, cucumber, maize and Chinese cabbage. Cowling and the UC Davies team also discussed areas of potential future collaboration between UWA and UC.

Current and upcoming visitors to IOA

VISITOR	VISITORS' ORGANISATION, COUNTRY	HOST DETAILS/PURPOSE	DATES
Ms Kasia Wyrwa	Polish Academy of Sciences (Institute for Plant Genetics), Poznan, Poland, visiting PhD student	Assoc/Prof Matthew Nelson	Jan-Jun 2014
Dr Shyam Sundar Dey	Indian Agricultural Research Institute, Brassica geneticist and breeder, visiting under an Indo-Australia Science and Technology Visiting Fellowship	W/Prof Wallace Cowling Assist Prof Sheng Chen	Oct 2013-Mar 2014

Research and industry recognition

STUDENT NAME	AWARD
W/Prof Kadambot Siddique	Dunhuang Award, from China's Gansu Provincial Government; for his outstanding contribution to research and leadership with within Gansu Province, especially Lanzhou University. Media release: www.news.uwa.edu.au/201309246081/awards-and-prizes/agriculture-expert-wins-top-chinese-award
Prof Phil Vercoe	Caring for our Country Landcare Eureka Prize for Sustainable Agriculture; for a sustainable grazing system using native perennial shrubs to feed livestock, developed under the collaborative Enrich project. Media release: www.news.uwa.edu.au/201309066039/awards-and-prizes/sustainable-agriculture-project-wins-eureka-award
W/Prof Stephen Powles	Finalist for Scientist of the Year in the 2013 Western Australian Science Awards
W/Prof David Pannell	Finalist for Science Ambassador of the Year in the 2013 Western Australian Science Awards
E/Prof Bob Gilkes	Crawford Fund Medal; for his lifetime contribution to improvement in agricultural production in emerging countries, and his research supervision and mentoring of overseas students. Media release: www.news.uwa.edu.au/201311216268/awards-and-prizes/recognition-lifetime-contribution-capacity-building-and-food-security

New research projects

TITLE	FUNDING PERIOD	FUNDING BODY	SUPERVISORS
Provision of Services Specialist Independent Peer Reviewer and Advisor – Water Resources	2013	Buru Energy Ltd	Prof Neil Coles
Innovative Livestock Systems to Adapt to Climate Change and Reduce Emissions	2013-2015	DAFF Carbon Farming Futures Filling the Research Gap	Prof Phil Vercoe
International Coordination of the Ruminant Pangenome Project	2013-2015	DAFF Carbon Farming Futures Filling the Research Gap	Prof Phil Vercoe
Western Node of the National Brassica Genetic Improvement Program – (NBGIP-2) Heat Tolerance Research	2013	NSW Dept of Primary Industries ex GRDC	Asst/Prof Sheng Chen, W/Prof Kadambot Siddique W/Prof Wallace Cowling
Model Upgrade and Development of Input Data Generating Tool for DAMCAT5 and RAIN-TANK2	2013	WA Dept of Water	Prof Neil Coles
National Pathogen Management Modelling & Delivery of Decision Support	2013-2018	GRDC	Assoc/Prof Michael Renton W/Prof Martin Barbetti Prof Roger Jones
With the Benefit of Hindsight – A Bioeconomic Analysis of Past Pest Incursions	2013-2016	CRC Plant Biosecurity	W/Prof Ben White Assoc/Prof Michael Renton
Insecticide Resistance & Alternative Chemistries for Mite Control	2013	CSIRO ex GRDC	Assoc/Prof Michael Renton
Management of Insecticide Resistance in RLEM and Screening New MoA Chemistry	2013-14	University of Melbourne ex GRDC	Assoc/Prof Christian Nansen
Information Management and Regional Development Partnership	2013	Wheatbelt Development Commission	Prof Matthew Tonts Prof Paul Plummer
Separating the Adverse Neurodevelopmental Consequences of Mechanical Ventilation and Postnatal Steroids in Preterm Lambs	2014-2017	National Health and Medical Research Council (NHMRC)	Prof Jane Pillow Assoc/Prof Dominique Blache Prof Kurt Albertine Dr Peter Noble Assoc/Prof Andrew Gill Assoc/Prof Mary Black Dr Jonas Rubenson
Floor Laying in Duck Farming	2013-2016	Poultry CRC	Assoc/Prof Dominique Blache Assoc/Prof Irek Malecki
Brain Regulation of Reproduction – Challenging the KNDy Hypothesis	2014-2017	ARC	W/Prof Graeme Martin Dr Jeremy Smith Prof Michael Lehman
Can frost tolerance be induced in wheat plants? A 100 million dollar question	2014	UWA UQ Bilateral Research Collaboration Award	W/Prof Stephen Powles Asst/Prof Roberto Busi Prof John Christopher

UWA IOA Publications 2013 (August–November)

Refereed journals

- Al Daini H, Norman HC, Young P and Barrett-Lennard EG (2013). The source of nitrogen (NH_4^+ or NO_3^-) affects the concentration of oxalate in the shoots and the growth of oldman saltbush (*Atriplex nummularia* Lindl.). *Functional Plant Biology* **40**: 1057–1064.
- Alamri S, Teakle NL, Barrett-Lennard EG and Colmer TD (2013) Improvement of salt and waterlogging tolerance in wheat: comparative physiology of *Hordeum marinum*-*Triticum aestivum* amphiploids with their *H. marinum* and wheat parents. *Functional Plant Biology* DOI: 10.1071/FP12385.
- Aryamanesh N, Zheng Y, Byrne O, Hardie DC, Al-Subhu AM, Khan T, Siddique KHM and Yan G (2013). Identification of genome regions controlling cotyledon, pod wall/seed coat and pod wall resistance to pea weevil through QTL mapping. *Theoretical and Applied Genetics* DOI: 10.1007/s00122-013-2234-2.
- Aziz T, Finnegan P, Lambers H and Jost R (2013). Organ-specific phosphorus-allocation patterns and transcript profiles linked to phosphorus efficiency in two contrasting wheat genotypes. *Plant, Cell and Environment* DOI: 10.1111/pce.12210.
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- Banik BK, Durmic Z, Erskine W, Nichols P, Ghamkhar K and Vercoe P (2013). In vitro ruminal fermentation and methane production vary in selected key pasture species in Australia. *Crop and Pasture Science* DOI: 10.1071/CP13149.
- Barrett-Lennard EG and Shabala SN (2013). The waterlogging/salinity interaction in higher plants revisited – focusing on the hypoxia-induced disturbance to K^+ homeostasis. *Functional Plant Biology* **40**: 872–882.
- Barrett-Lennard EG, Bennett SJ and Altman M (2013). Survival and growth of perennial halophytes on saltland in a Mediterranean environment is affected by depth to water table in summer as well as subsoil salinity. *Crop and Pasture Science* **64**: 123–136.
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- Berger JD, Clements JC, Nelson MN, Kamphuis LG, Singh KB and Buirchell B (2013). The essential role of genetic resources in narrow-leaved lupin improvement. *Crop and Pasture Science* **64**: 361–373.
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- Busi R and Powles SB (2013). Cross-resistance to proflurocarb and triallate in pyroxasulfone-resistant *Lolium rigidum*. wileyonlinelibrary.com DOI 10.1002/ps.3516.
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- Fogarty J and Muger A (2013). Local government efficiency: evidence from Western Australia. *The Australian Economic Review* **46**: 300–311.
- Gunasinghe N, You MP, Lanoiselet V, Eyres N and Barbetti MJ (2013). First report of Powdery Mildew caused by *Erysiphe cruciferarum* on *Brassica campestris* var. *Pekinensis*, *B. Carinata*, *Eruca sativa*, *E. Vesicaria* in Australia and on *B. Rapa* and *B. oleracea* var. *capitata* in Western Australia. *Plant Disease* **97**: 1256.
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Books

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To advance research, education, training and communication in agriculture and resource management, for the benefit of mankind.

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