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Adjunct Professor Dean Revell (formerly from CSIRO), Winthrop Professor Phil Vercoe, Minister for Agriculture, Food and Fisheries WA, Ken Baston and farmer Garry Page, at UWA Farm Ridgefield.

Minister's visit to UWA Farm Ridgefield

Ms Julia Berney
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One morning in May more than 10 key researchers, led by Winthrop Professor Kadambot Siddique, headed to UWA Farm Ridgefield where at midday they greeted the Hon Ken Baston, Minister for Agriculture, Food and Fisheries WA. The purpose of the visit was to update the Minister on the research being conducted on the farm.

Also attending the event was local farmer Garry Page who, after participating in a number of Farm Open Days, applied for a grant so that he could translate some of the research outcomes from experiments being conducted at UWA Farm Ridgefield into a real life situation on his own land. The researchers, led by Winthrop Professor Phil Vercoe (UWA School of Animal Biology and IOA) in collaboration with researchers from the CSIRO, have been studying how the native tar bush (*Eremophila glabra*), when eaten by sheep, reduces methane production in the rumen.

Methane gas produced by grazing animals accounts for over two-thirds of Australia's agriculture emissions. Research into finding out how these plants reduce methane production in the rumen is critical for improving sustainable farming practices to reduce greenhouse gases. Equally important is for researchers and farmers to engage in a two-way dialogue as we adapt to a changing climate.

The *Narrogin Times* reported the Minister as saying that it was important local growers and the wider community benefitted from UWA's investment in the region and had the opportunity to share knowledge with scientists, to ensure research stays relevant to the industry's needs.

"Additionally, what I heard from local farmers today, particularly in reference to fodder shrub research, is they were constrained because they simply did not have the time or money to push further," said the Minister in the *Narrogin Times* article by Lisa Morrison. "What UWA has been able to offer is the time and resources needed to extend research and help growers get results on the ground sooner."

The Minister visited the site of the tar bush experiment, as well as viewing the ecosystem restoration program and meeting community representatives from the Shire of Pingelly. The visitors also viewed the New Farm House, which was an initiative of UWA's Faculty of Architecture, Landscape and Visual Arts.

Following the visit the Minister wrote a letter acknowledging UWA's investment in the farm and complimenting ongoing research, teaching and community initiatives by the UWA farm project.

"I was impressed that UWA is taking a long term approach with the research and development being conducted at the property and conducting trials on a scale relevant to commercial farming operations," he wrote.

Further information about UWA Farm Ridgefield can be found on page 3.

Director's column

Hackett Professor Kadambot Siddique
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On campus in recent months the "public face" of UWA Institute of Agriculture (IOA) has come to the fore, firstly with the annual Postgraduate Showcase which was held in June (see page 5) and secondly, in July, with the IOA's eighth consecutive annual Industry Forum which was titled 'Potential for food production in northern Western Australia'.

The publication of the IOA's Annual Research Report 2013 in May was well received. The projects listed become ever more diverse each year yet continue to be of the highest relevance to critical challenges such as ensuring future global food and nutritional security while minimising agriculture's impact on the environment.

The Australia-Africa Universities Network relationship was further consolidated during a three-day meeting in April hosted by the University of Pretoria (see page 4). New ideas regarding education and the public sector forum were assessed and existing projects were reviewed in terms of their progress and future directions. UWA was well represented at the above meetings.

Still in the international arena, a UWA delegation visited Erbil in northern Iraq in April and discussions resulted in UWA being listed as one of the preferred universities for Iraqi scholarship holders seeking to undertake higher degrees overseas (see page 2). Then in May a Memorandum of Understanding was signed between UWA and the National University of Córdoba in Argentina (see page 6).

UWA Farm Ridgefield has received international recognition, having been accepted by the UN's FAO on to its directory of best practice models in grassland, rangeland and pastoral management (see page 3). The Farm is also a member of the Nutrient Network, a global research network assessing the ecological factors behind plant community dynamics in a range of different systems (see page 3).

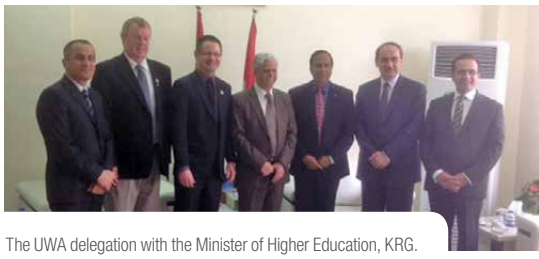
From a local perspective UWA Farm Ridgefield has established itself in the community base – with both Narrogin residents and farmers in the area – as well as with school students from as far away as Perth who have spent time there (see page 7). In May the Hon Ken Baston, Minister for Agriculture, Food and Fisheries WA, visited the Farm and commended its work (see cover story).

Dr Jose C Jimenez-Lopez, who has spent two years at the IOA and CSIRO as principal investigator of the 'Lupin challenge' project (see page 6), is returning to Spain to continue his research funded by the prestigious European Marie Curie research program. We thank him greatly for his contribution to research on lupin seed proteins.

We welcome three new staff members to the IOA: Bianca Tabbakh (Business Manager), Diana Jasudasen (Communications Officer), and Clive Dennis (Accounts Officer). Please "meet" them in more detail on page 17.

The second half of the IOA calendar is packed. Next month, UWA will host the World Universities Network 2 (WUN2) Workshop from 15 – 19 September. We look forward to welcoming delegates from 17 research-intensive institutions to build on our international research collaborations.

For more information on IOA and its activities, go to **ioa.uwa.edu.au**



The UWA delegation with the Minister of Higher Education, KRG.

Capacity building in Iraq

Hackett Professor Kadambot Siddique
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In April a UWA delegation consisting of Hackett Professor Kadambot Siddique (IOA), Mr Kelly Smith, Mr Paul Buist and Dr Oliver Charpenay (UWA International Centre) visited the Kurdish Regional Governorate (KRG) in Erbil, northern Iraq.

The aim of the visit was to meet with officials from various Ministries of KRG and Baghdad. The meetings and workshops took place in Erbil, Duhok and Shaqlawa with the help of the Australian Education Centre based in Erbil. UWA has an existing agreement with KRG to train fully funded Higher Degree by Research (HDR) and MSc (coursework) students from the region in various disciplines.

KRG Education Department showed interest in short- and long-term school teacher training. This includes short courses at UWA's Centre for English Language Teaching plus learning about education in WA through school visits, meetings with academics and so forth. They also showed interest in sending Master's students in Education to UWA.

KRG Ministry of Agriculture has some 100 Scholarships immediately available for HDR training their candidates in overseas universities. They are also looking for short-term programs for 20 to 25 students per course at four to five weeks. Areas of development needed include Geographic Information Systems as it relates to land tenure.

The UWA delegation also met with the KRG Minister for Higher Education, Vice President of Salahaddin University in Erbil, and Ministry of Higher Education Officials from Baghdad. KRG has a $100 million annual scholarship budget and 2000 scholarships per annum earmarked for training candidates in overseas universities. The Ministry of Higher Education in Baghdad is also offering a number of scholarships.

Meetings and discussions with higher officials have resulted in UWA being listed as one of the preferred universities for Iraqi scholarship holders to undertake their higher degree studies overseas. Following the above visit, large numbers of Iraqi candidates have applied for admission for their PhD studies at UWA in a range of areas.

FAO takes UWA Farm Ridgefield on board

Winthrop Professor Graeme Martin
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The UN's Food and Agriculture Organisation (FAO) has accepted UWA Farm Ridgefield into its directory of best practice models in grassland, rangeland and pastoral management. This enables our team to contribute to technical and policy guidelines for sustainable grassland management in a range of environments worldwide.

The focus on grasslands means a focus on production systems based on ruminant animals. Efficiency must be improved in ruminant production, not only to feed the increasing global human population but also to meet demand for more animal protein in developing nations and to compensate for pastoral land lost to urbanisation, biofuel production, climate change, water shortage and soil degradation.

Issues in the ruminant industries have been the subject of negative press, but the problems can be addressed. Foraging animals can, and should, eat foods which people cannot digest, and crop and livestock systems can complement each other. To achieve these goals, human food needs to be taken out of the livestock chain, livestock species and genotypes need to be suited to their local area, and animal health welfare and nutrition need to be improved so as to increase productivity and minimise the environmental footprint.

What the FAO found so attractive in UWA Farm Ridgefield was the intensive focus on novel grazing and foraging systems. The team led by Winthrop Professor Phil Vercoe and Adjunct Professor Dean Revell, winners of the 2013 Eureka Science Prize, is addressing a whole suite of issues. They are: self-medication for gastro-intestinal worms, reduced methane emissions, water table management, improved lamb survival (by providing "edible shelter"), the autumn feed gap and biodiversity.

When European farming systems commenced in Australia no thought was given to the potential worth of indigenous plants or animals. But Professors Vercoe and Revell have sparked interest in Australia's indigenous, deep-rooted perennial shrubs which are often better adapted to the local soils and climate.

Professors Vercoe and Revell are testing new grazing systems to rotate with food crops or be permanently established on farmland unsuitable for cropping. The permanent systems will likely be not monocultures but mixed grasses, legumes and shrubs. Offering a broader forage choice will increase the chances of animals instinctively selecting a nutritionally balanced diet.

It will also improve productivity on adjacent pasture by lowering saline groundwater levels, increasing soil carbon content and reducing wind speed, thereby lowering soil moisture loss through evaporation and providing shelter for soils, plants and livestock. Mixed forage species also improve natural resource management by creating a refuge for beneficial invertebrates and thus increasing biodiversity.

Winthrop Professor Phil Vercoe in the field at the UWA Farm Ridgefield. Image credit: Sefton & Associates.

The research by Professors Vercoe and Revell is built into one of the major enterprises at UWA Farm Ridgefield: 'Clean, Green and Ethical (CGE) Livestock Production', which promotes a combination of genetics and management to minimise dependency on drugs, chemicals and hormones, minimise the environmental impact and maximise animal welfare.

UWA Farm Ridgefield joins global Nutrient Network

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Global data sets are highly regarded for their ability to generalise across ecological systems, and so increasingly they are becoming the dataset of choice for research scientists. The Nutrient Network or 'NutNet' is a global research network that aims to assess the ecological factors driving plant community dynamics in a variety of different systems. At last count NutNet included 54 experimental sites in 16 countries on six continents, operated by a group of scientists who are internationally recognised as being leaders in the field of ecology and ecosystem science. To date, the group has published two papers in *Nature*.

Research Assistant Professor Rachel Standish and Dr Jodi Price from the UWA School of Plant Biology were invited to participate in the network by contributing data from an experimental site in south-western Australia. They selected a site at UWA Farm Ridgefield, which offers a unique combination of climate, soils, plants and other ecological factors not currently represented in the network. The working hypothesis is that simulated global changes (e.g. nutrient addition) will enable exotic plants to out-compete native plants, with the final mix of species depending on the grazing impacts of kangaroos and rabbits, and land-use legacies (e.g. high soil phosphorus).

The researchers, ably assisted by Tim Morald, collected plants and soils in spring 2013 that will form the baseline data for the site. The first application of the experimental treatments occurred in April 2014, with data collection scheduled for spring of 2014 and annually thereafter. Ultimately the researchers will have data to address issues of global importance, including the impact of global change on the sustainable delivery of ecosystem services in agricultural landscapes. In doing so, this research will contribute to the overarching vision for UWA Farm Ridgefield.

Dr Jodi Price and Tim Morald sampling soil at the new 'NutNet' site at UWA Farm Ridgefield.

St John of God Health Care CEO Dr Michael Stanford with Professor Siddique at the Western Australian of the Year Gala dinner held on 30 May 2014.

IOA Director winner of esteemed Western Australian of the Year award 2014

Dr Anke van Eekelen
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Hackett Professor Kadambot Siddique was honoured with the Western Australian of the Year 2014 award under the Professions category. The announcement was made at the Gala Dinner on 30 May 2014 in recognition of Professor Siddique's leadership in agricultural education, research and development, capacity building and his passion and commitment towards global food security.

"I have no doubt that we can be a catalyst for lifting many of the world's estimated 1.4 billion poor out of poverty and malnutrition. To do so, we need more world-class scientists trained in agri-food production systems and related areas."

His research, education and training initiatives to enhance growth and development in agriculture span many countries, including Australia, Asia, Africa and the Middle East. They focus on preparing young scientists, agriculturalists and farmers – the people on whom the world will depend to solve the greatest challenge of human history – food security in the 21st century.

"I am humbled and honoured to receive this award and I acknowledge the support of my family, friends, colleagues, postgraduate students, UWA, international collaborators, funding bodies and the farmers of Western Australia," said Professor Siddique.

Well respected across the globe as a leader in crop science, dryland agriculture and food production systems, Professor Siddique has played a central role in the establishment of the pulse industry in Australia. Within and beyond Australia's borders, he has collaborated with many university research groups and governmental institutions. He is also highly regarded for his collaboration in agriculture in the USA, Canada, Europe, the Middle East and Asian countries including China and India.

"Globally the potential for agriculture education and research is enormous because we still have issues with food security and environmental sustainability," Professor Siddique said. "It is the perfect time for us to revitalise agricultural teaching, research and development. The most uplifting aspect of capacity building is that it empowers people and provides the opportunities that short term welfare opportunities can never match. With agricultural development will eventually come prosperity and prosperity is important for global peace," he added.

The Professions award celebrates excellence among individuals whose professional qualifications impact on social, scientific or economic aspects of life at a state, national or international level. The prize is proudly sponsored by St John of God Health Care and was awarded by CEO Dr Michael Stanford. It is one of seven annual awards that jointly acknowledge distinctions made in WA's people, lifestyle, culture and potential.

Revitalising Australia's Relationship with Africa through Collaboration in Education and Research

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A three-day Australia-Africa Universities Network International Africa Forum & Steering Group Meeting was hosted last April by the University of Pretoria in South Africa. The event brought together Australian and African researchers, policy-makers, officials, Vice-Chancellors and High Commissioners and Hackett Professor Kadambot Siddique represented UWA. The guests were warmly greeted to the campus at the welcome dinner on 4 April, during which the Australian High Commissioner to South Africa, HE Mr Graeme Wilson addressed the delegation.

The objectives of the Forum were: (i) to review progress and develop the next phase of projects already underway; (ii) to develop new project ideas, particularly in the streams of education and public sector reform; and (iii) to provide a forum for leading researchers and stakeholders from across both continents to network and collaborate.

The plenary session at the Forum focused on Australian-African education partnerships and policy options. Themes included *Perspectives on Africa's development – the role of universities, strategic education partnerships and the importance of the good governance & public sector institutions*.

Professor Siddique attended the Forum and Steering Group Meeting together with Winthrop Professor Andy Fourie from the School of Civil, Environmental and Mining Engineering and Assistant Professor Amin Mugera from the School of Agricultural and Resource Economics and IOA. Professor Siddique co-chaired and facilitated the Food Security workshop at the Forum.

Professor Siddique interacting with Forum participants at the social event.

Professors Siddique and Dolan with Dr Terry Enright and UWA's cream of the crop PhD students.

UWA's cream of the crop present at postgraduate showcase

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In June Hackett Professor Kadambot Siddique, welcomed guests to the IOA's eighth annual Postgraduate Showcase – an event that shines the spotlight on some of UWA's top PhD students. Nine students across a range of disciplines from UWA's Business School, School of Earth and Environment, Plant Biology, Animal Biology and Agricultural and Resource Economics spoke on their research relating to this year's topic 'Frontiers in Agriculture'.

The Hon Ken Baston, Minister for Agriculture, Food and Fisheries, gave the opening address after which Dr Terry Enright, Chair of the IOA's Industry Advisory Board, introduced Session One's presenters.

Delma Poniman's interest in her subject was sparked by two personal factors. Ever since childhood she has been passionate about food, later studying it in terms of health and nutrition – and as a Muslim she was keen to examine issues about the adoption of traceability systems in WA's Halal food supply chain. Delma is supervised by Professor Sharon Purchase and Professor Joanne Sneddon, both from the UWA Business School.

Anjani Weerasekara chose as her focus the processing of piggery waste and how removing excess phosphorus could create more stable phosphorus fertilisers. In the future she hopes to find sustainable solutions to other agricultural waste management problems. Anjani is supervised by Emeritus Professor Lyn Abbott, Dr Sasha Jenkins and Winthrop Professor Tony O'Donnell.

Bidhyut Banik's research involved the relationship between pasture plants and the levels of methane emissions in ruminants – methane being a significant component of greenhouse gases. He found that one pasture plant in particular, *Biserrula pelecinus*, was highly active in reducing methane production in sheep. Bidhyut is supervised by Professor William Erskine, Assistant Professor Zoey Durmic and Dr Clinton Revell (DAFWA).

Yiming Guo, who first came to UWA as a visiting student in 2009 while studying for her Master's Degree in China, returned to UWA to pursue her interest in the genetic diversity of rapeseed species and, in particular, *Brassica rapa* and its drought resistant qualities. Yiming is supervised by Winthrop Professor Wallace Cowling, Assistant Professor Shang Chen, Associate Professor Matthew Nelson and Winthrop Professor Neil Turner.

Isabel Arevalo-Vigne believes solving agricultural and environmental problems depends on communicating scientific knowledge in creative ways, so that all members of the community see that they can play a role in the solution. She chose Mediterranean fruit fly as her focus. Isabel is supervised by Professor Ben White, Professor Nancy Longnecker, Professor Ross Kingwell (UWA and DAFWA), and Assistant Professor Amin Mugera from UWA, and Professor Iain Walker from CSIRO.

Winthrop Professor Phil Dolan, Dean of UWA's Business School, introduced the Session Two presenters. Arif Watto, the first, discussed how groundwater depletion drives technology adoption and irrigation water use efficiency (for a report on his findings see page 9). Arif is supervised by Assistant Professor Amin Mugera and Professor Ross Kingwell.

Mike Ashworth spoke about whether control of wild radish, one of the most economically damaging weed species for agriculture, can be accomplished without producing herbicide resistance. With a WA family farm background Mike has witnessed how research improves farming practices and profitability. Mike is supervised by Winthrop Professor Stephen Powles, Associate Professor Michael Walsh and Dr Ken Fowler.

Louise Fisk also spent her childhood in the great outdoors – of New Zealand. While studying at university there she discovered "that you can actually study dirt"! This interest led to her recent research investigating nitrogen cycling and loss in semi-arid cropping soil. Louise is supervised by Professor Daniel Murphy, Associate Professor Louise Barton and Dr Linda Maccarone.

Lynne Johnston, the final presenter, examined the factors which determine who is chosen to sit on the Boards of organisations representing primary producers. Her long involvement in the agricultural industry, commercially and politically at state and federal levels, underpinned her interest in this subject. Lynne is supervised by Winthrop Professor Tim Mazzarol.

The presentations can be accessed at **www.ioa.uwa.edu.au/publications/showcase**

Dr Jose Jimenez-Lopez at CELS Floreat, CSIRO.

European funded 'Lupin Challenge' project finds momentum in WA

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I am a plant biochemist from Granada, Spain, and I have been working at IOA for the last two years as the principal investigator of the 'Lupin-challenge' project. I was fortunate to become a recipient of the prestigious European Marie Curie research program (FP7-2011-PEOPLE-IOF), which funds my research aimed at gaining insights into health promoting aspects of lupin seed proteins, with a particular focus on tackling diabetes and problems related to food allergy.

My time at UWA has been a greatly enriching working experience and IOA has provided an excellent environment for networking in a friendly but intellectually challenging atmosphere. I have been able to explore the substantial wealth of cutting-edge facilities and leading technological resources housed at UWA, which allowed me to accomplish the objectives of my project and obtain the relevant outcomes that support the potential of legumes (lupin) to improve our diet and be of substantial benefit to our health and well-being.

I will soon return to Europe to pursue the next stage of the 'Lupin-challenge' project, focusing on the molecular and cross-reactivity aspects of legumes allergy and this is made possible as a result of a collaborative endeavour between IOA/UWA and National Council for Scientific Research (CSIC), Spain.

I look forward to extending my liaison with UWA beyond the duration of this project and hope that colleagues from UWA remain involved in the further development of my research career. I would like to express my sincere gratitude to Winthrop Professor Karam Singh at CSIRO/IOA and Winthrop Professor Kadambot Siddique at IOA for their support and mentoring during the development of the project, and thank UWA for being my host institution.

Argentinian researcher joins Rumen Microbiology Group

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During a visit to UWA last year, Florencia Garcia met Winthrop Professor Kadambot Siddique (IOA) to discuss the possibility of establishing an exchange agreement between UWA and her home institution, the National University of Córdoba in Argentina.

Since Australia and Argentina share many similarities in their agricultural systems and their commitment to sustainable production and management, it was considered timely for the two universities to forge collaboration. The result was a Memorandum of Understanding between UWA and the National University of Córdoba, which was signed in May this year.

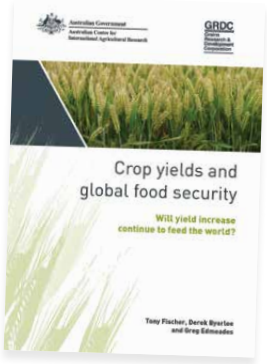
In the meantime Florencia has been awarded an Endeavour Research Fellowship sponsored by the Australian Department of Education, and she is currently in the middle of a six-month visit to UWA where she is undertaking a project with the Rumen Microbiology Group led by Winthrop Professor Phil Vercoe (School of Animal Biology and IOA).

Florencia is studying essential oils – extracted from plants by steam distillation – which could act as natural antibiotics and, when fed to sheep and cattle, reduce inefficient processes and microbes in their gut. This may result in methane reduction and improve ruminant meat and milk fat profile. During her stay, she will carry out several *in vitro* experiments, including the use of an 'artificial cow' where she will be testing Argentinian essential oils and Australian plant extracts. This research is complementary to the ongoing long-term studies which the group is undertaking.

"My project aims to discover alternative sources of feed additives, while combining green ethics with animal food product quality. The advantage of this work for farmers and consumers is that we may discover approaches that will decrease the greenhouse gases footprint, while obtaining healthier animal-derived food products," explains Florencia.

"This is an invaluable opportunity for me to accomplish part of my doctoral project at the National University of Cordoba with a widely recognised team of animal production researchers at UWA," she says. Florencia will be a member of the UWA family until October.

Ms Florencia Garcia enjoys her six month stay at UWA funded by an Endeavour Research Fellowship through the Australian Department of Education.



Global food security book presents realistic yet optimistic ideas

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The Australian Centre for International Agricultural Research (ACIAR) with support from the Grains Research and Development Corporation (GRDC) recently published '*Crop yields and global food security*' subtitled '*Will yield increase continue to feed the world?*' by Tony Fischer, Derek Byerlee and Greg Edmeades.

"In our book my colleagues and I delved into the influences upon the rate of growth of potential yields and farm yields for over 20 of the world's most important crops," says author Dr Tony Fischer, a former member of the IOA's Industry Advisory Board and currently an Honorary Research Fellow at CSIRO in Canberra.

"We investigated primarily breeding and agronomic sources of progress, but also climate change, resource use efficiency, cropping sustainability, environmental effects of intensified cropping, and key influences on farmer innovation such as rural socio-economics, institutions, infrastructure and policy."

The team found that, overall, the likelihood of increasing farm yields in the future via further lifting potential yields and closing yield gaps is promising through sustainable intensification of cropping, although a range of diverse challenges need to be addressed, primarily through larger investments in global research, development and extension as well as in rural infrastructure, institutions and policy in developing countries.

This most comprehensive book is an invaluable guide which offers proven lessons and encourages further research. Simple in presentation the text is aimed at – and accessible for – everyone from agricultural scientists, economists and decision makers in food production, to concerned citizens and tertiary students.

For further information visit
http://aciar.gov.au/publication/mn158

Master of Social Work students and the community of Pingelly

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In May Pingelly residents and staff from UWA joined 44 first-year UWA Masters of Social Work students to celebrate the end of a semester-long project in which the students undertook a profile designed to showcase Pingelly's community strengths.

The students developed a profile of the town, its activities, history and possibilities for the future, through interaction with key people and external research. They contacted groups such as the Community Resource Centre, Shire Council, Pingelly Aboriginal Progress Association (PAPA) and UWA Farm Ridgefield. The information they gathered contributed to the presentation of a '*Snapshot of a Connected Community*' booklet at the meeting, which was well attended and attracted much interest in what the students had observed about this vibrant community.

Among the projects of interest to the students were the community education links with schools as part of the 'UWA gives back' program in which schools in Pingelly, Brookton, Beverley and Narrogin visit UWA Farm Ridgefield.

Some students visited other sections of the community including the Men's Shed, the Craft Shop and the Shire's community development officer to help fill out the picture of Pingelly. All students agreed that, however brief their visits, nothing could have replaced the value of face-to-face contact.

During the semester the students gathered information remotely and in conversations with contacts in Pingelly. All this was consolidated into the booklet presented at the community meeting, during which the community centre was set up "market-style" to enable as much interaction as possible between students and residents. Spirited discussions continued through the morning and over lunch.

Part of the continuing engagement was to invite comments from the community about additional possibilities, and residents were encouraged to post suggestions on a board. General comments ranged from ways to attract more tourists, including day-trippers from Perth, to creating cheaper housing to attract low income families.

The comments relating to UWA Farm Ridgefield included having open days there, so that locals could see what was being demonstrated, and offering "indigenous experience" tours to international visitors to the Farm, who by taking up the tours would provide financial support for PAPA.

The booklet presented to the residents and attendees is available on the Social Work and Social Policy website at UWA. It is hoped that various interest groups, such as the Department of Agriculture and Food Western Australia (DAFWA) and UWA Farm Ridgefield, can continue to work with the students on future activities. A social work student is currently undertaking her first placement of three months in association with DAFWA and UWA Farm Ridgefield.

To return to the comments which Pingelly residents posted on the noticeboard, surely the most complimentary was the one which said: "Get the students to stay in town – 'to liven the place up'"!

Local school students enjoying a visit to UWA Farm Ridgefield.

Ms Eviness Nyalugwe checking ELISA plates to identify virus infected plant samples.

In-depth study of turnip mosaic virus resistance in Brassicas

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Two years into her PhD research on virus resistance in Brassicas, Malawian PhD student Eviness Nyalugwe at UWA's School of Plant Biology and IOA has produced intriguing and important findings recently published in the *European Journal of Plant Pathology*. She is studying a damaging mottle and stunting virus disease that causes economically important losses in oilseed, fodder and vegetable Brassica crops worldwide.

The pathogen responsible is turnip mosaic virus (TuMV) which is spread by common vector aphids. The resulting disease causes severe losses in crop seed yields by reducing numbers and sizes of seed pods, numbers of seeds and seed size.

Eviness's findings constitute the first study to demonstrate the widespread occurrence of virus resistance in lines of canola (*Brassica napus*) and Ethiopian mustard (*B. carinata*) belonging to germplasm collections originating from many parts of the world. The experimental plants were grown in aphid-proofed facilities at UWA and the Department of Agriculture and Food Western Australia (DAFWA).

The study highlights the range and occurrence of different TuMV resistance phenotypes available within a diverse selection of accessions, breeding lines and cultivars of these two species, mostly from Africa, China and the Indian subcontinent.

In canola, occurrence of necrotic resistance phenotypes involving localised or systemic necrosis reflects the presence of dominant TuMV resistance genes TURB01, TURB03, TURB04 or TURB05, alone or in combination, all of which are found on its A genome.

But since Ethiopian mustard lacks the A genome, the resistance phenotypes it contains indicate the presence of unknown TuMV resistance genes present in its B or C genomes. The study therefore also highlights the need to identify additional genes responsible for the different resistance and susceptibility reactions found in *B. carinata*.

The research demonstrates exciting opportunities to improve TuMV resistance in oilseed and forage Brassicas through crosses involving TuMV resistance sources in both species. However, Eviness's results also emphasise the risks associated with resistance screening procedures that only utilise a single TuMV pathotype and are not done at higher temperatures.

One canola and three Ethiopian mustard lines developed an extreme resistance phenotype as they never became infected with any TuMV pathotype, regardless of temperature, and they withstood graft-inoculation. These lines will be particularly valuable for developing future TuMV-resistant cultivars of oilseed and forage Brassicas.

"In Malawi nearly every meal has a vegetable component as relish, including several Brassica crops – mainly cabbage and other species in this family such as rape, Chinese cabbage and Indian mustard," says Eviness. "However, maximum productivity of these crops is not attained due to diseases such as turnip mosaic virus. Furthermore, there is an increase in demand for vegetable consumption due to population increase, hence the calls for increased production of Brassica crops."

When she returns to Malawi Eviness expects to undertake a similar study in order to identify potential cultivars that can be used for breeding cultivars resistant to TuMV. "I will also negotiate with the Ministry of Agriculture and Food in my country to import some of the potential resistant cultivars that have been identified elsewhere, for Malawi to evaluate and use them in breeding programs," she adds.

Plant Breeding for Drought Tolerance – a research symposium at Colorado State University

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Winthrop Professor Wallace Cowling visited Colorado State University (CSU), Fort Collins, Colorado USA in June this year to attend the "Plant Breeding for Drought Tolerance" symposium, hosted by CSU Professors Pat Byrne and John McKay.

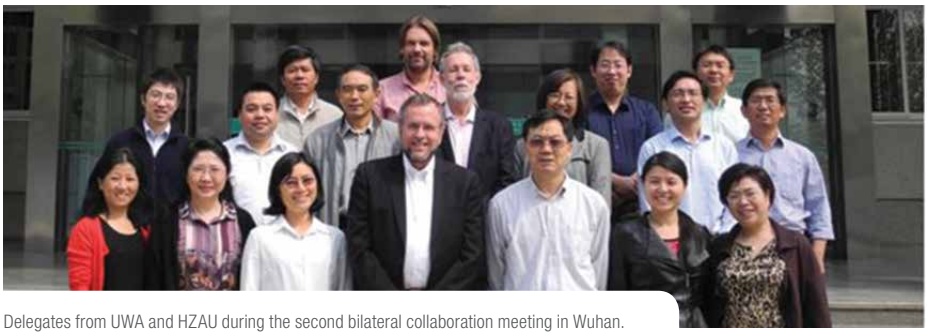
The symposium included young researchers and research leaders in crop drought tolerance, and covered many perspectives from molecular responses to drought in *Arabidopsis*, root and leaf responses in maize to drought, an evolutionary perspective of drought and heat responses in the grass *Brachypodium*, evolution of xylem function, and genetics and breeding of rice and Brassica species for drought tolerance. Professor Cowling's talk was titled "Breeding for drought and heat tolerance in canola – *Brassica rapa* as a model species."

The symposium followed a two-week intensive course in plant breeding for drought tolerance for national and international students, hosted by CSU and led by Professor Byrne.

The conference was a good point of contact for Professor Cowling to meet world leading researchers in drought tolerance in crop plants, and to report on research of PhD students Yiming Guo and Annisa in the School of Plant Biology and IOA.

W/Professor Wallace Cowling (right) with Mr Brian Campbell of Colorado State University.

UWA-Huazhong Agricultural University collaboration on track for research



Delegates from UWA and HZAU during the second bilateral collaboration meeting in Wuhan.

Assistant Professor Sheng Chen
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In order to further enhance the academic research collaboration between UWA and Huazhong Agricultural University (HZAU), the second workshop on "Plant Functional Genomics and Crop Genetic Improvement" was held at HZAU in April 2014. A delegation of eight researchers from UWA's Institute of Agriculture (IOA), School of Plant Biology and Centre of Plant Energy Biology attended this workshop.

HZAU is one of the top and key agricultural universities in China. Over its history of more than 100 years HZAU has made great achievements in the fields of many disciplines with creative teaching and research resources. Significant outcomes have been achieved in plant science research, such as hybrid canola, green super rice, high-quality citrus, potato micro-tuber and transgenic cotton.

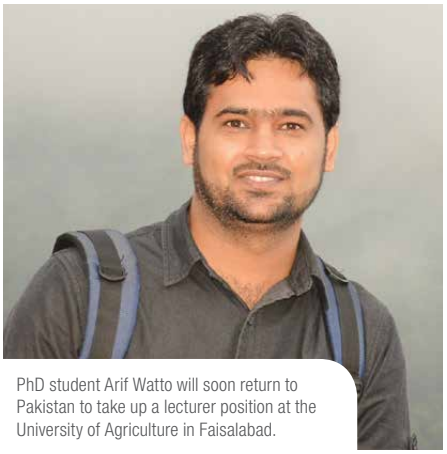
An agreement on establishing a Joint Centre for Plant Functional Genomics and Crop Genetic Improvement was signed by Professor Xianlong Zhang, HZAU vice-president, and Winthrop Professor Kadambot Siddique, Director of the IOA.

This Joint Centre agreement defined eight key areas to promote research and training collaboration between UWA and HZAU: (1) crop and model plant heterosis, especially in energy efficiency of protein metabolism; (2) crop biotic resistance including disease and pest resistance in wheat, rice and canola; (3) crop abiotic stress tolerance including drought, heat, salinity and flooding tolerance; (4) epigenomics of polyploidisation and hybrids in Brassica and cotton; (5) molecular mechanism of male sterility and fertility restoration; (6) crop nutrient use efficiency in wheat, rice and canola; (7) functional genomics of oil accumulation and flowering time genes conditioning adaptation in canola; and (8) training programs for postgraduates and early career researchers in the above areas.

During the wonderful two-day meeting, the UWA delegation was deeply impressed by the research achievements HZAU had made and the great facilities on campus. UWA and HZAU researchers had extensive discussion at six small group meetings on the first day, resulting in six researchers from each side presenting research of mutual interest and collaboration proposals at the workshop on the second day. A number of important and practical projects were identified and agreed by both sides at the final round table meeting.

"We look forward to many years of fruitful collaboration," said Professor Qifa Zhang, the director of the National Key Laboratory of Crop Genetic Improvement at HZAU. A third bilateral meeting has been proposed at UWA in 2016.

Better water efficiency for Pakistan's cotton growers



PhD student Arif Watto will soon return to Pakistan to take up a lecturer position at the University of Agriculture in Faisalabad.

Ms Julia Berney
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Research by PhD student Arif Watto could help achieve greater efficiency in the farming of cotton, Pakistan's most important agricultural commodity which accounts for 46% of the country's entire exports. Cotton production requires excessive water use, and in many regions of Pakistan the water tables are rapidly dropping due to over drafting of groundwater for irrigation. Arif conducted his research across 172 cotton growers in the Punjab province.

"The goal was to estimate the level of technical efficiency of groundwater-irrigated cotton farms and to examine the factors which affected that technical efficiency," he explains. "Research efforts aim to improve efficiency and productivity while making efficient use of the shrinking wate resources."

Most irrigation water is extracted from groundwater mainly through tube-wells operated by electricity or diesel. Tube-wells are costly to install where water tables are deep, and the costs are likely to increase as the water tables become lower. Cotton farmers without tube-wells – typically tenants or smallholders – engage in groundwater trading. However, since the agreements are informal, water buyers have equity concerns.

"Results of the data obtained from 92 growers who owned tube-wells and 80 who bought water indicate considerable technical inefficiencies, although generally the tube-well owners do better in this regard," says Arif.

"This may be because tube-well owners have more access to agricultural extension services and other information sources such as the radio, television and newspapers. Farmers who perceive the dangers of extracting too much groundwater are usually more efficient."

His study proposes that, on average, tube-well owners could increase cotton production by 19% and water buyers by 28%, without increasing their water use. This could be accomplished by using improved seed for new cotton varieties, having access to better extension services regarding production technology, receiving education about the actual crop water requirements and being made aware of the status of the water tables.

Arif, who is studying at UWA's School of Agricultural and Resource Economics and IOA, was born into a farming family in Pakistan. Although his family later gave up farming his interest remained strong. He earned his Master's with Honours in Agricultural Extension at the University of Agriculture in Faisalabad.

"However, in a country with limited water resources it is more important to examine the efficiency and productivity of irrigated agriculture and to guide farmers about efficient resource management," he says.

"That is why I decided to study agricultural economics when I joined UWA – because agricultural economics is about resource management. Given the importance of cotton to Pakistan's economy I wanted to examine resource use efficiency in cotton cultivation," concludes Arif.

Tight-knit 'CRC family' can strengthen plant biosecurity in Australia

Associate Professor Michael Renton
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In May this year the Plant Biosecurity Cooperative Research Centre (PBCRC) held its first Science Exchange (SX) at Twin Waters Resort, Sunshine Coast, Queensland.

UWA students Isabel Arevallo-Vigne and Papori Barusa at the Science Exchange conference dinner. Image Credit: Stefan Daniljchenko.

The PBCRC centrally coordinates plant biosecurity research across all Australian states and territories. It has an extensive collaborative network of researchers and educators from 27 participating organisations from both Australia and overseas, representing industry, universities, and state and federal government. The PBCRC was established in recognition of the need to strengthen the plant biosecurity scientific capacity of Australia, and started its six year term on 1 July 2012.

The SX is a conference that brings together the 'CRC family', with the PBCRC Board, staff, students, researchers, participants, industry representatives and other end-users gathering to learn about the CRC's research projects, explore new research opportunities, to develop collaborative relationships, and enhance delivery to end-users.

UWA researchers and students attending the SX included Professor Ben White, Associate Professor Michael Renton, Maggie Triska, Papori Barua, Morteza Chalak, Cheryl Day, and Isabel Arevalo-Vigne. UWA delegates presented their work on current PBCRC supported projects related to biosecurity economics, optimal surveillance, human-assisted spore dispersal and community-based fruit fly control.

Biosecurity has emerged as a major global issue. Harmful plant pests and diseases can impact on food safety, trade, market access, market development and, ultimately, the profitability and sustainability of plant industries.

Australia is relatively free from many of the plant pests and diseases which seriously impact on agricultural industries in other countries. Through the absence of many pests and diseases commonly found overseas, Australia's plant industries have a valuable competitive advantage through maintaining lower control and production costs and securing better market access.

If these pests found their way into Australia, the economic viability of Australia's plant industries (with a crop production value of $14 billion in exports and $8 billion in domestic markets) would be directly threatened. Even the perception of pests in Australian produce would have a rapid and negative impact on Australia's reputation as a producer of safe, quality food products.

The SX supports the CRC's overall mission to develop and deploy scientific knowledge, tools, resources and capacity to safeguard Australia, its plant industries and regional communities from the economic, environmental and social consequences of damaging invasive plant pests and diseases.

A key strength of the CRC, highlighted at the SX, is the involvement of the participants who are, in many cases, end-users of research results. This ensures maximum benefit and impact in the delivery of project outputs, development of new products and services and capture of intellectual property.

Horizon Scholarship winners off to a good career start in agriculture

Dr Anke van Eekelen
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Among 16 first year students across Australia awarded with a Horizon Scholarship from the Rural Industries Research and Development Corporation (RIRDC) were two UWA students this year: Cameron Broun and Alana Martin.

Alana Martin and Cameron Broun in the glass house at UWA.

They both study for a Bachelor of Science and at this stage of their tertiary education their scholarships, specifically sponsored by the Grains Research and Development Corporation and the Cotton Research and Development Corporation, could not come at a better time. A bursary during the further duration of their studies creates a financial incentive for the students to finish their degree while at the same time preparing for a future in the agricultural industry in partnership with the industry.

"The Horizon scholarship is amazing in that it stays with me throughout my university career and beyond. The scholarship offers work experience across Australia and networking opportunities at conferences throughout the scholarship duration. I will be able to learn about and experience the passion of people in agriculture from my first year at university onwards and stay connected to the amazing and passionate people I meet along the way, " says Alana Martin. She grew up in Perth and her interest in agriculture started with a love for food science and technology at school.

Cameron Broun comes from the WA wheatbelt, where his family has farmed mixed grain and livestock for five generations. Both students aspire to work toward sustainable agricultural practices in the future. Cameron has a strong interest in the application of chemistry in agriculture to develop new ways of controlling disease, pest and invasive species, while Alana can see herself applying new technologies to farming and soil health problems as the population and issue of food inequality rise.

The Horizon program is a joint effort by the RIRDC and a diverse range of agricultural industries to support leadership development, provide work placements and create mentorship opportunities within the university or industry. It firmly believes that agriculture will become an increasingly valuable career pathway for young people with a high take up of new technology and innovation. This year's award ceremony was the fifth time the RIRDC reached out to the next generation of leaders in agricultural research and development with its Horizon Scholarship program.

Making apples even better for the benefit of our health

Dr Anke van Eekelen
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The spotlights are on apples like WA's Pink Lady™, flavonoid-rich sources of fruit at the heart of multidisciplinary research efforts to breed and commercialise more and even flavonoid-richer apples to benefit greater health outcomes.

With more than 5000 naturally-occurring flavonoids present in different plant foods and each flavonoid having a different effect on human biology, research into the potential of apples as functional food to naturally boost our well being is welcome.

Initial funding by the Australian Research Council (ARC) allowed Assistant Professor Michael Considine from the UWA's School of Plant Biology and IOA to collaborate with the UWA School of Medicine and Pharmacology and provide the scientific evidence for the claim that apples can positively impact on clinical indicators of the development of heart disease. Professor Considine was uniquely placed to initiate this network with the Department of Agriculture and Food WA's (DAFWA) apple breeding program, as he has a joint appointment between DAFWA and UWA.

Fortuitously, the DAFWA-bred Pink Lady™ was found to be richer in particular flavonoids than other varieties. Pink Lady was then used as the template for the ARC project. Continued research into the health benefits of apples is expected to further increase the value of the WA apple industry while contributing to improved human dietary health.

"The new project will further explore genetic variation and ways to speed up the breeding process by targeting certain traits." he said. The team acknowledges the challenge to understand the heritability of flavonoids and what breeding strategies will work best. But they are confident that the available expertise and capacity in targeted selective plant breeding within the national collaboration will warrant tangible outcomes.

At the same time, project leader Professor Considine and colleagues will focus on specific aspects of the market knowledge required to deliver a healthier apple to the consumer.

This research project is funded by DAFWA with support from local organisation Fruit West, and national bodies, Horticulture Australia and Apple and Pear Australia. It involves researchers from UWA's School of Plant Biology, IOA and School of Medicine and Pharmacology as well as plant breeders and geneticists from the department's Australian National Apple Breeding Program based in Manjimup.

Western Australia's Pink Lady™ apple is richer in the flavonoids that provide more cardiac health benefits than some other varieties.

Cabernet Sauvignon clone. Image Credit: DAFWA.

Raising the bar for red wines

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A new national project developed in WA is investigating how to create the next generation of fine red wines. Headed by Assistant Professor Michael Considine, a joint researcher at UWA and the Department of Agriculture and Food Western Australia (DAFWA), the project will hone in on the true identity of Cabernet Sauvignon 'clones', by exploiting the same sequencing technology which is being used in cutting edge medical science.

"The national project is using molecular profiling of 12 specific Cabernet Sauvignon clones, which are known to show different qualities such as distinct growth patterns or wine flavours," Professor Considine says.

"A clone is simply a plant that comes from a cutting, or vegetative propagation. This is how most of our fruit crops are planted, because the seed can be widely different from the parents. This allows us to use the same varieties that, for example, the Romans made wine from, but the reality is that small gene mutations do naturally occur," he explains.

"Over time, grape and fruit producers have then selected the best of the best, when planting out new vineyards and orchards. On the scale of grapes and other fruit industries, this creates valuable new sub-varieties (clones). The crux is that there are several ways the mutation might occur. This has not been studied anywhere in the world before."

DAFWA has been involved in vine selection research since the late 1960s, and vines of the original clones are still making distinctive, award-winning wines to this day. "But grapevines often spontaneously mutate, resulting in new clones with unique traits which lead to changes in the fruit and ultimately to the wine produced," explains Professor Considine.

The research aims to discover exactly what distinguishes one Cabernet Sauvignon from another. For many years the Australian wine industry has recognised the value of regional distinction. The clones currently in production under the project are being grown in WA's Great Southern and Margaret River regions and at Yalumba Nursery Coonawarra in South Australia, so that the effects of different sites, soils and climate can be assessed.

Running from this year to 2016 the project is receiving strong support from DAFWA, Yalumba, the Australian Wine Research Institute and the WA Vine Improvement Association, as part of an Australian Research Council Linkage Project.

Overcoming the challenge of mung bean production in Bangladesh

Professor William Erskine
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During the pre-monsoon season the Australian Centre for International Agricultural Research (ACIAR) funded project "Introduction of short duration pulses into rice-based cropping systems in western Bangladesh" is working to optimise the management package for mung bean (*Vigna radiata*) production in Bangladesh. Over the last three years, the project has recommended optimum cultivation technology to growers. In collaboration with the Bangladesh Agricultural Research Institute (BARI), the Department of Agriculture Extension (DAE) and an NGO named PROVA, advice on a new short-duration variety, line sowing, the need for sowing irrigation, timely weeding and the application of insecticides has been provided during on-farm demonstrations.

In western Bangladesh alone, more than 300 demonstrations in 10 districts reached out to approximately 450 farmers since the start of the initiative. They resulted in an average yield advantage of 31% and 22% in 2012 and 2013 compared to the harvest of neighbouring farmer-managed plots, which served as a control in the experimental set-up of the project. Demonstration plot yields of mung bean ranged from an average 1.3 to 1.5 t ha^{-1}.

Pest management was also part of the on-farm demonstrations. A clear change to practice was to control the major insect thrips (*Callothrips indicus*) with Imitaf insecticide to prevent an attack on the flower buds and potential destruction of an entire crop.

In specific regions of western Bangladesh where the cropping pattern has a fallow (March to June) there is limited scope for income generation at this time. Men migrate seasonally, but women often are unable to do so. A further introduction of mung bean cultivation in the fallow period has opened opportunities for employment in the area during the lean period. Women and youths are involved in mung bean pod harvest and can earn up to AUD$2.50 a day. They are also involved in the post-harvest preparation of the produce to be ready for the market. Such activities recommended by the project during the lean period have generated a social movement towards engagement in an extra crop production between rice crops.

Bangladeshi women harvesting mung bean pods.

Tran Sy Hieu assessing different field pea genotypes for their level of resistance to black spot disease.

At last an answer to pea black spot disease

Winthrop Professor Martin Barbetti
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Breakthrough research carried out by researchers at the School of Plant Biology and IOA has demonstrated why field pea breeding programs in Australia continue to struggle to develop field pea varieties with the level of effective resistance needed to manage pea black spot disease.

Pea black spot disease, caused by a complex of different fungal pathogens, is a devastating disease of field peas and is the major constraint to limiting yields and preventing crop expansion.

Surveys conducted across pea-growing regions of WA and associated studies, carried out by PhD student Tran Sy Hieu of UWA's School of Plant Biology and IOA have redefined the pathogens associated with the pea black spot complex in WA.

"From 1984 to 2012 four new pathogens were found associated with black spot symptoms on field peas. Among these pathogens, a major fungus *Phoma koolunga* was shown, for the first time, to occur on diseased peas in WA and to do so extensively," said Mr Tran.

"The black spot population of pathogens in WA is very dynamic with time and across location. This poses a huge challenge to developing effective resistance against the black spot complex, because breeding programs are focused almost exclusively on resistance to one pathogen, *Didymella pinodes*, rather than including all major pathogens involved," he added.

A paper on the research has been published in *Plant Disease*, a prestigious international journal on plant pathology. It is co-authored with Plant Pathologists W/Professor Martin Barbetti (project leader), Assist/Professor Ming Pei You and Plant Breeder Professor Tanveer Khan, all from UWA, and Agronomist Ian Pritchard from DAFWA.

"Deployment of host resistance or fungicides targeting only part of the pathogen complex simply shifts the make-up of the population toward pathogen species least challenged by the host resistance or fungicides", said Professor Barbetti. This creates an evolving black spot pathogen complex that remains ahead of breeding and explains the slow rate of breeding progress" he said.

Professor You explained that "Until now options have relied on delayed sowing along with fungicidal measures, resulting in severe yield penalty from delayed sowing or costly chemical applications."

"Providing pathogen populations are monitored, it should now be possible to identify varieties displaying high levels of resistance to prevailing pathogen populations," added Professor Khan.

The study was mainly funded by the School of Plant Biology at UWA with additional support from both DAFWA and from IOA.

Chinese agriculture borrows practices from WA farmers

Ms Jennifer Carson
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Agricultural innovations familiar to Western Australian farmers may assist farmers in China to store more organic carbon in their soils.

Professor Daniel Murphy, from UWA's Institute of Agriculture and School of Earth and Environment, has shown that stubble retention and no-tillage practices have the potential to increase the amount of organic carbon stored in agricultural soils in northern China over the next 90 years.

Prof Murphy and his colleagues from the Chinese Academy of Agricultural Sciences (CAAS) began by using a network of long-term trials in China to validate computer models for changes in climate and soil carbon. They then predicted how different management practices would affect organic carbon stores in soil until 2100.

Their modelling showed that if no fertilisers were added to soil, the amount of organic carbon stored in soil would actually decrease by 5 tonnes per hectare in the next 90 years. Adding only inorganic fertilisers (nitrogen, phosphorus and potassium) would increase organic carbon storage in soil by 5 tonnes per hectare over the same time period.

The greatest increase in the amount of organic carbon stored in soil was achieved by applying both inorganic fertilisers and manure. This resulted in organic carbon in soil increasing by 20 tonnes per hectare.

However, manure application in China is declining and is unlikely to increase in the future because inorganic fertilisers are widely available. Between 1949 and 2003 manure application to arable land decreased from 100% to 25%. Therefore, to increase stores of organic carbon in soil other practices must be found.

One such practice may be retaining straw in paddocks after harvest. Retaining stubble has not been part of agricultural practice in northern China until recently. Crop straw was historically used as fuel, animal feed and bedding, or burnt directly within the field.

However, since the 1980s, straw return was popularised by government policy as a practice to improve soil fertility and decrease air pollution by not burning. Now, over a third of all straw in China is used to improve soil fertility. It is expected that the rate of straw retention in China could increase to 90%.

Prof Murphy and his colleagues found that a combination of inorganic fertilisers and straw return to soil could result in 17 tonnes of carbon per hectare being stored in the next 90 years.

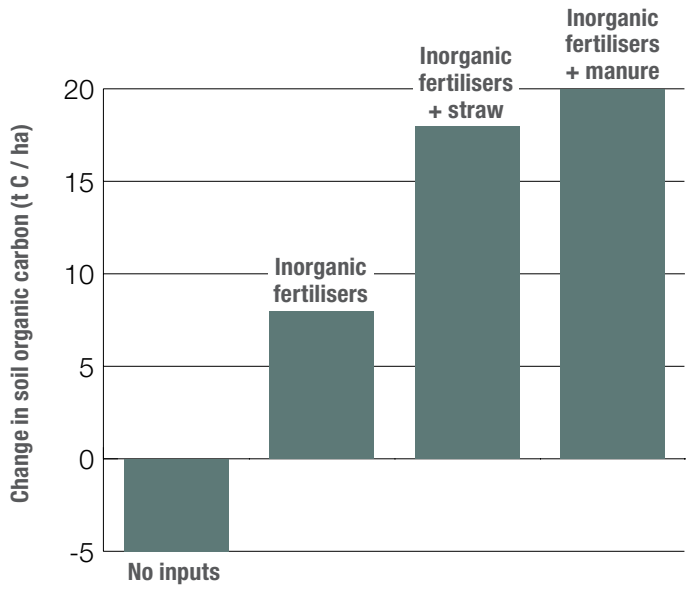
Another practice widespread in WA could further increase stores of organic carbon in Chinese agricultural soils. No-tillage practices could be extended to 50% of China's cropland by 2050.

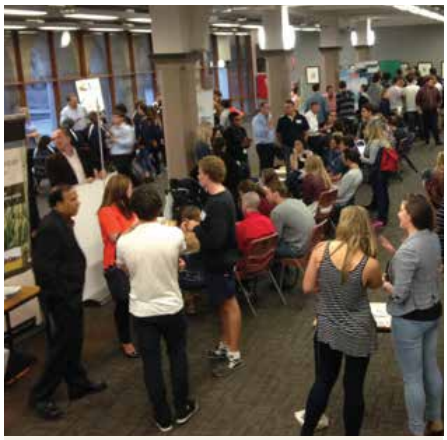
"A previous study estimated that converting soils in China to no-tillage could increase organic carbon storage in soil by 0.04 tonnes of carbon per hectare each year. This is equivalent to 3.6 tonnes per hectare over the next 90 years," says Prof Murphy.

"Our future collaboration will focus on determining how close agricultural soils in China are to their soil organic carbon saturation capacity. This will enable us to focus on the regions where we can make the greatest difference."

This research was supported by the National Science Foundation of China, the National Basic Research Program, the Australian Research Council Future Fellowship Scheme, and a Chinese High-End Foreign Experts Visiting Professorship.

The change in organic carbon storage in soils in northern China with different management practices over the next 90 years (from Jiang et al. 2014).





Agriculture Careers Evening at Winthrop Hall

The annual Agriculture Careers Evening organised by the WA Division of AgInstitute Australia was held in the Undercroft of Winthrop Hall on 27 May. Career opportunities in the agriculture sector were presented to students in the format of 'speed dating'. More than 100 students from UWA, Curtin University, Murdoch University and CY O'Connor Muresk attended to hear from 16 employer organisations. The UWA Institute of Agriculture was major sponsor of the event.

The Agriculture Careers Evening on 27 May 2014 was well attended.

Protecting traditional knowledge to prevent biopiracy

Winthrop Professor Michael Blakeney
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The knowledge of indigenous peoples and traditional communities to identify plants with agricultural or medical use is priceless. Examples close by are the highly nutritious Kakadu plum of northern Australia and some smokebush species containing active ingredients which can be used as an anti-retroviral. Both plants were identified by Aboriginal people as having useful applications.

Unfortunately, unauthorised outsiders frequently obtain global patent protection, thereby preventing the commercial application of those plants by the local communities. Referred to as "biopirates", they help themselves to useful biological materials and then patent the relevant bits of DNA. They generally target the biodiversity of the tropical regions. As a consequence there has been agitation by countries in the tropics to establish an international legal regime to deal with this issue.

The World Intellectual Property Organisation (WIPO), United Nation's specialised agency which deals with intellectual property, is considering the enactment of three international conventions dealing with genetic resources, traditional knowledge and traditional cultural expressions. The negotiations for these three conventions are currently underway for presentation to the General Assembly of WIPO in October, 2014.

Winthrop Professor Michael Blakeney of the UWA Faculty of Law and IOA has been recruited to assist the countries of the Association of South East Asian Nations (ASEAN) in defining their positions for the WIPO negotiations as part of the ASEAN-Australia-New Zealand Free Trade Area (AANZFTA) Economic Cooperation Work Program (ECWP).

Last June Professor Blakeney facilitated two negotiating workshops for ASEAN Member States

W/Professor Michael Blakeney shakes hands with a tribesman from West Papua.

at the Directorate General of Intellectual Property Rights (DGIPR) in Jakarta. He was assisted by a number of officials from the Australian patent office, as well a representative from WIPO. His focus was on the subject of national policy formulation for the purpose of implementing international treaty obligations in the fields of genetic resources and traditional knowledge.

As it turned out several of the workshop attendants, including the WIPO representative, were successful doctoral candidates supervised by Professor Blakeney, which strengthened the success of workshops. Professor Blakeney is now writing a policy framework document as the principal outcome of the project.

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The Morrison Featherflower (Verticordia nitens [Lindl.] Endl.) was one of the south-west species used in the study.

South-west plants share fungal symbiosis for nitrogen uptake

Aaron Bryans
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AN INVESTIGATION into nitrogen transfers between plants has found that different species can share nutrients through fungal interactions.

The study looked into numerous nutrient-acquisition strategies of plants to determine if nitrogen transfers between native plants exist in nutrient-poor soils in south-west Australia.

"We've had this question [of] how is it possible that our ecosystem has so many species when the soils are so poor?" co-author Professor Erik Veneklaas (UWA's School of Plant Biology and IOA) says.

"What we've shown here is that it is the balance between positive and negative interactions that could help species survive together and in a way collaborate whilst they also compete."

Lead author and UWA's Dr François Teste and his team found that plant species connected by both *arbuscular mycorrhizal* (AM) and *ectomycorrhizal* (EM) fungal interactions benefitted most from nitrogen transfer between plants. AM interactions penetrate plant roots allowing nutrient intake, whilst EM interactions form sheaths around the roots of plants rather than infiltrating them.

"My work highlights that these interactions might also be partly responsible for biodiversity; so nutrient retention and sharing can be part of the reason why so many species are interacting together," Dr Teste says.

Nitrogen is an essential nutrient for plants as it is a basic component of chlorophyll that is used to process sunlight into energy through photosynthesis. It also increases the strength and support of roots, allowing plants to take in more water and nutrients.

The transfer of nitrogen in various chemical forms between the atmosphere, the earth, plants and mammals is the nitrogen cycle and is essential for all forms of life.

Findings lend support for restoration efforts

The findings highlight the importance of plant diversity in ecosystems with Dr Teste hoping for improvements to restoration efforts.

"What I would wish is that in terms of restoration hopefully my work can highlight that assemblages and interactions are also part of the equation to successfully restoring areas that are having a hard time," Dr Teste says.

The exploration of fungal interactions between plants adds to prior knowledge of plants receiving and donating nitrogen through root transfers in addition to nitrogen obtained from the atmosphere as a result of post-lightning rain and nitrogen fixing bacteria.

Dr Teste and Professor Veneklaas are two of four WA scientists who conducted the study, the others being Professor Kingsley Dixon and Professor Hans Lambers.

This was first published online by ScienceNetworkWA **sciencewa.net.au**

Students help investigate soil quality in restoration of land at the UWA Farm Ridgefield

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City school students are planting trees on the UWA Farm Ridgefield. The 'City Kids to the Country' Program was initiated by Mr Bruce Ivers in association with students from three city schools (Applecross Senior High School, John Curtin College of the Arts and Ardross Primary School).

Mr Ivers is a private consultant to the schools in the program and a former farmer. He linked the school programs 'Seedlings for a Sustainable Future' and 'City Kids to the Country' to the restoration program on the UWA Farm Ridgefield. In 2012 and 2013 school students have propagated and planted thousand of trees on the farm. In 2014, the 'City Kids to the Country' has been incorporated into a Future Farm Research Project so that monitoring and evaluation will be ongoing.

International Master's student, Andrea Bravo is assessing soil quality in the areas where the trees have been planted so far by the city school students. Andrea, from Chile, is investigating whether there is a link between seedling establishment and soil properties. She is also assessing whether there is a relationship between the time and location of planting and the success in establishment of the trees.

First year Science students Alana Martin and Hope Leech volunteered to assist Andrea on a recent soil collection trip to the farm.

UWA students Hope Leech, Alana Martin and Andrea Bravo collecting soil near trees planted by city school students on the UWA Farm Ridgefield.

Professor John Hamblin inspecting progeny of new wheat crosses to be harvested for analysis in 2015.

Wheat yields boosted by blast from the past

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Young students, be prepared: ideas you entertain today could come back to haunt you – in the best possible way – half a century from now.

Adjunct Professor John Hamblin from IOA has a new reason for affectionately remembering his days as an undergraduate and, in particular, a period between 1965 and '66. "I was so enthusiastic," he laughs. "Back then, we all thought we were going to solve the problems of the world."

What Professor Hamblin recalls vividly is an experiment he conducted as part of his Honours project. At the time he never imagined that, 50 years on, he would revisit his hypothesis and that the results would have exciting implications for higher yields in crops. The experiment involved a specimen of *Arabidopsis* which Professor Hamblin plucked from the walls of the Oxford Botanic Garden. He bred this wild type with a variegated mutant from it, in order to test whether the impact of the different chlorophyll levels had any effect on the growth of the progeny.

"The growth of the F1 hybrid showed massive vigour, twice that of the better parent," Professor Hamblin says." The level of chlorophyll in the F1 leaves was evidently 'just right' for the relatively low light in the growth chamber, and that term 'just right' led me to explain the result as 'a Goldilocks effect' in my thesis."

In 2010 he was given a science journal by his colleague, Professor William Erskine, of Centre for Plant Genetics and Breeding and IOA. In it was an article which supported Professor Hamblin's hypothesis that reduced levels of chlorophyll might be a pathway to higher crop yields. Aware that he could now sort genetic material using tools which simply did not exist in his student days, Professor Hamblin decided to repeat his youthful experiment to analyse the chlorophyll per unit leaf area in a range of wheat varieties.

"There were two aims: to establish a system by which we could screen plants confidently, and to identify varieties that differ significantly and consistently. We succeeded far beyond our expectations." Two wheat genotypes were identified as having consistent and contrasting levels of leaf chlorophyll content: DBW10 with the highest and Transfer with the lowest amount.

Professor Hamblin is now growing the progeny of reciprocal crosses between DBW10 and Transfer produced for him by InterGrain Pty Ltd. He confidently expects true-breeding lines will be available for selection in 2015.

Those undergraduate dreams of solving the world's problems may have settled into perspective over a lifetime's career, but Professor Hamblin's experience shows that the seeds of hope in a keen young mind can germinate and mature decades later – when the conditions are, as fairy-tale heroine Goldilocks would say, 'just right'.

Clay added to biosolids does the trick

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Domestic wastewater treatment sludge can be recycled into a fertiliser that adds nutrients to soil, increases soil pH and overcomes severe water repellence according to research by UWA and the Water Corporation.

Every year Australia produces approximately 330,000 dry tonnes of biosolids, or treated sewage sludge. Biosolids are a rich source of organic matter, which improves soil fertility. They also contain significant amounts of the nutrients required by plants.

The Water Corporation already produces a product that contains biosolids mixed with lime. A new product, that also contains clay, was developed primarily for use on the Bassendean sands, initially in the Ellenbrook catchment.

These soils are prone to nutrient leaching that can result in eutrophication of the Swan-Canning Estuary System and potentially lead to algal blooms and fish deaths. The soils are also acidic and water repellent, and both these properties can decrease plant growth.

A mixture of clay, biosolids and lime improved the properties of a Bassendean sand from the Ellenbrook area.

The research, performed by UWA PhD student Sanjutha Shanmugam and Emeritus Professor Lyn Abbott from UWA Institute of Agriculture and School of Earth and Environment, found that adding clay to the mixture of biosolids and lime had two significant benefits for the properties of the Bassendean sands.

Firstly, adding clay to biosolids and lime eliminated the water repellence of the soil. The soil initially had a water repellence rating of "very severe". Applying the mixture of clay, biosolids and lime to the soil completely overcame the water repellence. However, the mixture of biosolids and lime without clay did not decrease the water repellence of the soil at all.

The second beneficial effect of adding clay to biosolids and lime was to increase the release of nitrate into soil. Adding the mixture of clay, biosolids and lime to soil resulted in approximately twice as much nitrate being released into soil over seven months compared to biosolids and lime without clay.

The research was conducted with financial support from the UWA Scholarship for International Research Fee and the Water Corporation of Western Australia.

Researchers of the "Global Farm Platforms for Optimisation of Ruminant Livestock" meet again

Associate Professor Dominique Blache
Email: dominique.blache@uwa.edu.au

Associate Professor Dominique Blache from UWA's School of Animal Biology and IOA was one of the group of international scientists from UK, USA, India, Canada, Uruguay and Australia to meet at the Instituto Nacional de Investigación Agropecuaria (INIA) Treinta y Tres Research Station, Uruguay last May. This gathering formed part of the Worldwide Universities Network (WUN) project "Global Farm Platforms for Optimisation of Grazing Livestock Production Systems".

The Global Farm Platform Network: 10 research farms distributed over six continents.

New participants from South America and Africa were invited to this workshop to consolidate the farm platform network. The network now consists of research farms located in six continents and illustrates different farming systems based on the existing natural resources (including pampas, pasture, grassland and feedlot), the climate (including tropical, Mediterranean, temperate, semi-arid) and the farm scale (ranging from small stakeholders to large enterprises). The network represents a unique opportunity for global projects to attract collaborators and students interested in comparative studies and unique educational experience.

The group formulated a Statement of Intent covering Community, Governance, Partners, Science and Education as five areas considered to be essential elements of Global Farm Platforms. The Statement of Intent is to be jointly signed by the participating institutions as a basis for moving forward with research and teaching projects.

The next meeting will be held mid September at UWA. The delegates will spend time at UWA Farm Ridgefield to develop the project and formulate the next round of funding applications to funding agencies targeting sustainable livestock production systems.

New staff

Mr Clive Dennis
Email: clive.dennis@uwa.edu.au

Clive Dennis has been appointed as Accounts Officer at IOA. Clive joins us from the Faculty of Engineering, Computing and Mathematics, where he was part of the Finance and Staff Resources team.

In his new role, Clive will be working on looking after the accounting needs of the UWA Institute of Agriculture, including UWA Farm Ridgefield.

Clive has worked full time for the University for the last 10 years, and has now decided to enter into a transition to retirement phase of his life.

Ms Diana Jasudasen
Email: diana.jasudasen@uwa.edu.au

Science Communicator Diana Jasudasen has joined The UWA Institute of Agriculture as their Communications Officer. Starting off as a biochemist, Diana quickly realised there was no point doing great research if it wasn't going to be communicated properly.

She recently completed a Master's of Science Communication here at UWA where she interviewed eminent Western Australian scientists on their attitudes towards communicating their research with society. Diana also tutored several science communication units to help undergraduate science students adapt complex scientific messages for varied audiences.

Diana brings her technical knowledge and keen understanding of the current academic structure to help the IOA and its members to communicate their research outcomes.

Ms Bianca Tabbakh
Email: bianca.tabbakh@uwa.edu.au

The UWA Institute of Agriculture would like to welcome Ms Bianca Tabbakh as its new business manager. Bianca started in her new role in May this year. Her main priority will be to manage the administration and the operations of the Institute, but she will also play a key role in promoting IOA within the broader university community to facilitate strategic liaison.

Bianca came well equipped to this new appointment at UWA. She graduated from Curtin University with a commerce degree in 2001, which included an overseas study experience at Southern Illinois University in the US. Further management studies were undertaken in 2011.

She gained invaluable professional experiences, skills and knowledge in management and marketing when leading the business for the Cottesloe Surf Life Saving Club (SLSC) until recently and managing the Student Service Centre division and the School of Public Health at Curtin University before that.

In her spare time, Bianca prefers the beach over UWA's campus during the surf season to volunteer as a life guard for the North Cottelsoe SLSC. But she can be spotted close by on firmer ground for a game of social tennis as well.

Staff awards and industry recognition

NAME	AWARD
W/Prof Kadambot Siddique	Winner of the Western Australian of the Year 2014 Professions Award (see also page 4) www.news.uwa.edu.au/201406026719/awards-and-prizes/uwa-people-honoured-western-australian-year-awards
Ms Brenda Coutts	Winner of the AUSVEG National Awards for Excellence 2014 Researcher of the Year www.news.uwa.edu.au/201407026802/awards-and-prizes/national-recognition-uwa-research-student
Prof Roger Jones	Fellow of the American Phytopathological Society, 2014
Asst/Prof Marit Kragt	Award for Excellence in Honours Supervision at the UWA Faculty of Science Teaching Awards

Visitors to Institute of Agriculture

VISITOR	VISITORS' ORGANISATION, COUNTRY	HOST DETAILS/PURPOSE	DATES
Prof Anlu Zhang	Head, College of Land Management, Huazhong Agricultural University, China.	Prof Michael Burton Asst/Prof Chunbo Ma	14 Apr – 9 May 2014
Qinsong Yang	Zhejiang University, China	Asst/Prof Michael Considine	6 Jul – 31 Aug 2014
Peipei Jiao	Visiting Research Associate, Tarim University, China	Asst/Prof Michael Considine	6 Jun 2014 - 31 May 2015
Zhu Li'ao	University of Science and Technology of China	Asst/Prof Michael Renton	7 July – 31 Aug 2014

New postgraduate research students

STUDENT NAME	TOPIC	SCHOOL	SUPERVISOR(S)	FUNDING BODY
Diana Prada	Market based instruments for conservation preferably in developing countries	Agricultural and Resource Economics and IOA	Asst/Prof Marit Kragt Prof Michael Burton	Australian Postgraduate Award UWA Safety Net Top-up Scholarship
David Rees	Farmers' engagement in the development of innovation	Agricultural and Resource Economics and IOA	Asst/Prof Ram Pandit Prof Ben White Asst/Prof Maksym Polyakov	Self-funded
Seyedehmahsa Mousaviderazmahalleh	Ancient polyploidy in the genus *Lupinus*	Plant Biology	Matthew Nelson & W/Prof William Erskine	Endeavour Postgraduate Scholarship

New research projects (since April 2014)

TITLE	FUNDING PERIOD	FUNDING BODY	SUPERVISORS
Climate change in the media	2013	Worldwide Universities Network WUN	Assoc/Prof Meng Ji
Review Animal Welfare QA System in Europe	2013	Meat and Livestock Australia	W/Prof Graeme Martin
Pre Breeding in Annual Legumes	2013–2017	Department of Agriculture and Food WA (DAFWA) ex-Meat & Livestock Australia (MLA)	Prof William Erskine, Asst/Prof Janine Croser, Dr Parwinder Kaur
Quantitative detection of *C. difficile* in piggery effluent treated in covered and uncovered anaerobic ponds and prevalence in biosolid byproducts (including land application and compost)	2014	Australian Pork Limited	Prof Thomas Riley
Design and evaluation of biosecurity surveillance systems	2014–2016	CRC Plant Biosecurity	Assoc/Prof Michael Renton, Prof Ben White, Dr Jacky Edwards, Dr John Wainer, Maggie Triska, John Botha, Dr Kevin Powell, Dr Cassandra Collins, Prof Roger Jones
Tolerance of wheat genotypes to ion toxicities	2014–2015	GRDC	W/Prof Zed Rengel
Smart use of fertilizers to minimize and manage the risk of pest infestations in growing canola	2014–2016	GRDC	Assoc/Prof Christian Nansen
The Critical Zone Concept in the southern hemisphere – an international workshop		University of Sheffield, Pennsylvania State University	Asst/Prof Matthias Leopold

TITLE	FUNDING PERIOD	FUNDING BODY	SUPERVISORS
Biofuel and high value green chemicals from agricultural and silviculture non fodder residues	2014–2016	Queensland University of Technology (ex DIISR AISRF Grand Challenge Fund	Prof William Doherty, Dr Philip Hobson, Prof Sagadevan Mundree, Dr Victoria Haritos, Assoc/Prof Vishnu Pareek, Dr Tony Vancov, W/Prof Dongke Zhang
Visit to duck farms in Netherlands that use vencomatic nesting system	2014	Poultry CRC Ltd	Assoc/Prof Ireneusz Malecki
Modelling the spread of Skeletal Weed in WA	2014	DAFWA	Assoc/Prof Michael Renton
Safeguarding Honeybees – increasing parasite effectiveness using nano technology	2014–2017	Australian Research Council (ARC) Linkage Projects	Prof Boris Baer, Dr Iyer Swaminatha, Dr L Killugudi, Dr William Bosch
Gene identification & functional characterization for metabolism based herbicide resistance in lolium rigidum	2014–2017	ARC Linkage Projects	W/Prof Stephen Powles, Assoc/Prof Qin Yu, Dr Roland Beffa
Characterisation of soil microbial interactions for increased efficacy of herbicides using novel fertiliser management practices	2014–2017	ARC Linkage Projects	W/Prof Andrew Whiteley, E/Prof Lyn Abbott, Dr Abul Hashem, Mr Paul Storer

IOA Publications 2014 (April – July)

Refereed journals

Ashworth MB, Walsh MJ, Flower KC and Powles SB (2014). Identification of the first glyphosate-resistant wild radish (*Raphanus raphanistrum L.*) populations. *Pest Manag Sci* **70** (9): 1432-1436

Awasthi R, Kaushal N, Vade V, Turner NC, Berger J, Siddique KHM and Nayyar H (2014). Individual and combined effects of transient drought and heat stress on carbon assimilation and seed filling in chickpea. *Functional Plant Biology* http://dx.doi.org/10.1071/FP13340

Aziz T, Finnegan PM, Lambers H and Jost R (2014). Organ-specific phosphorus-allocation patterns and transcript profiles linked to phosphorus efficiency in two contrasting wheat genotypes. *Plant, Cell and Environment* **37**: 943-960.

Barbetti MJ, Banga SK, Fu TD, Li YC, Singh D, Liu Sy, Ge XT and Banga SS (2014). Comparative genotype reactions to *Sclerotinia sclerotiorum* within breeding populations of *Brassica napus* and *B. juncea* from India and China. Euphytica **197**: 47–59.

Barton L, Thamo T, Engelbrecht D and Biswas W (2014). Does growing grain legumes or applying lime cost effectively lower greenhouse gas emissions from wheat production in a semi-arid climate? *Journal of Cleaner Production* DOI: 10.1016/j.jclepro.2014.07.020

Chai Q, Ga Y, Turner NC, Zhang RZ, Yang Y, Niu Y and Siddique KHM (2014). Water-saving innovations in Chinese agriculture. *Advances in Agronomy* **126**: 149-201

Chen YL, Palta J, Clements J, Buirchell B, Siddique KHM and Rengel Z (2014). Root architecture alteration of narrow-leafed lupin and wheat in response to soil compaction. *Field Crops Research* **165**: 61-70

Farooq M and Nawaz A (2014). Weed dynamics and productivity of wheat in conventional and conservation rice-based cropping systems. *Soil & Tillage Research* **141**:1-9.

Farooq M, Hussain M and Siddique KHM (2014). Drought stress in wheat during flowering and grain-filling periods. *Critical Reviews in Plant Sciences*, **33**:331-349.

Guo Y, Chen S, Li Z and Cowling WA (2014). Center of Origin and Centers of Diversity in an Ancient Crop, *Brassica rapa* (Turnip Rape). *Journal of Heredity* **105** (4): 555-565.

Hamblin J, Stefanova K and Angessa TT (2014). Variation in Chlorophyll Content per Unit Leaf Area in Spring Wheat and Implications for Selection in Segregating Material. *PLOS ONE* **9** (3): e92529.

Hane JK, Anderson JP, Williams AH, Sperschneider J and Singh KB (2014). Genome Sequencing and Comparative Genomics of the Broad Host-Range Pathogen Rhizoctonia solani AG8. *PLOS Genetics* **10** (5): e1004281

Jaafar NM, Clode PL and Abbott LK (2014). Microscopy observations of habitable space in biochar for colonization by fungal hyphae from soil. *Journal of Integrative Agriculture* 13(3):483-490

Jiang G, Xu M, He X, Zhang W, Huang S, Yang X, Liu H, Peng C, Shirato Y, Iizumi T, Wang J and Murphy D (2014). Soil organic carbon sequestration in upland soils of northern China under variable fertilizer management and climate change scenarios. *Global Biogeochemical Cycles* **28**:1-15

Jones RAC (2014). Plant virus ecology and epidemiology: historical perspectives, recent progress and future prospects. *Ann Appl Biol* **164**: 320–347

Jones RAC (2014). Trends in plant virus epidemiology: Opportunities from new or improved technologies. *Virus Research* **186**: 3-19.

Kamphuis LG, Hane JK, Nelson MN, Gao L, Atkins CA and Singh KB (2014). Transcriptome sequencing of different narrow-leafed lupin tissue types provides a comprehensive uni-gene assembly and extensive gene-based molecular markers. *Plant Biotechnology Journal* 1-12

Kehoe MA, Coutts BA, Buirchell BJ and Jones RAC (2014). Hardenbergia mosaic virus: Crossing the barrier between native and introduced plant species *Virus Research* **184**: 87-92

Kehoe MA, Buirchell BJ, Coutts BA and Jones RAC (2014).Black Pod Syndrome of *Lupinus angustifolius* Is Caused by Late Infection with *Bean yellow mosaic virus*. *Plant Disease* http://dx.doi.org/10.1094/PDIS-11-13-1144-RE

Mason AS, Nelson MN, Takahira J, Cowling WA, Moreira Alves G, Chaudhuri A, Chen N, Ragu ME, Dalton-Morgan J, Coriton O, Huteau V, Eber F, Chèvre AM and Batley J (2014). The Fate of Chromosomes and Alleles in an Allohexaploid Brassica Population. *Genetics* **197**: 273–283

Nansen C and Meikle WG (2014). Journal impact factors and the influence of age and number of citations. *Molecular Plant Pathology* **15** (3): 223–225.

Nyalugwe EP, Barbetti MJ and Jones RAC (2014). Preliminary studies on resistance phenotypes to Turnip mosaic virus in Brassica napus and B. carinata from different continents and effects of temperature on their expression. *European Journal of Plant Pathology* DOI 10.1007/s10658-014-0423-8

Owen MJ, Martinez NJ and Powles SB (2014). Multiple herbicide-resistant Lolium rigidum (annual ryegrass) now dominates across the Western Australian grain belt. European Weed Research Society **54**: 314-324

Pauli N, Donough C, Oberthür T, Cock J, Verdooren R, Rahmadsyah, Abdurrohim G, Indrasuara K, Lubis A, Dolong T and Pasuquin JM (2014). Changes in soil quality indicators under oil palm plantations following application of 'best management practices' in a four-year field trial. Agriculture, *Ecosystems and Environment* **195**: 98-111.

Rahman MM, Erskine W, Materne MA, McMurray, Thavarajah P, Thavarajah D and Siddique KHM (2014). Enhancing Selenium concentration in lentil (*Lens culinaris* subsp. *culinaris*) through foliar application. *Journal of Agricultural Science* DOI: 10.1017/S0021859614000495.

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Watto MA and Mugera A (2014). Measuring effciency of cotton cultivation in Pakistan: a restricted production frontier study. J Sci Food Agric; DOI 10.1002/jsfa.6652

Yan C, He W, Turner NC, Liu E, Liu Q and Liu S (2014). Plastic-film mulch in Chinese agriculture: Importance and problems. World Agriculture **4** (2): 32-36

Zheng Z, Kilian A, Yan G and Liu C (2014). QTL Conferring Fusarium Crown Rot Resistance in the Elite Bread Wheat Variety EGA Wylie. PLOS ONE **9** (4): e96011

Book Chapters

Farooq M, Wahid A and Siddique KHM (2014). Physiology of grain development in cereals. In: Pessarakli M (ed) *Handbook of Plant and Crop Physiology*. Third Edition. Taylor and Francis Group, LLC 6000 Broken Sound Parkway, Suite 300, Boca Raton, FL 33487 USA. pp: 301-308.

Hussain SS, Siddique KHM and Lopato S (2014). Towards integration of bacterial genomics in plants for enhanced abiotic stress tolerance: Cluse from transgenics. *In*: J.A Daniels (ed.) 'Advances in Environmental Research'. Volume 33. Nova Publishers Inc., New York. pp: 65-121.

Wahid A, Farooq M and Siddique KHM (2014). Implications of oxidative stress for plant growth and productivity. In: Pessarakli M (ed) *Handbook of Plant and Crop Physiology*. Third Edition. Taylor and Francis Group, LLC 6000 Broken Sound Parkway, Suite 300, Boca Raton, FL 33487 USA. pp: 549-556.

Books

Hans Lambers (2014). Plant Life on the sandplains in Southwest Australia. A global biodiversity hotspot.

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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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