N8 AgriFood

ABSTRACTS

2017 INTERNATIONAL CONFERENCE

Food Production for the Future

Generating nutritious foods from resilient & sustainable agricultural systems

Durham University, UK 11th–13th July 2017

N8 AgriFood
Sustainable
Food Production

Precision agriculture, soil regeneration, resilient and productive crops and livestock, novel diagnostics, predictive modelling and 'omics' to promote resilient, sustainable food production.

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Speaker Abstracts

FOCUSING AGRICULTURAL RESEARCH AND INVESTMENT ON ACHIEVING SDGS 1 AND 2

***Philippe Ankers**, Senior Programme Advisor, Rural Poverty Reduction Programme,* **FAO, Rome**

The first Sustainable Development Goal calls for an end to extreme poverty, while Goal 2 aims to end hunger and malnutrition, all by 2030. The way in which we manage agriculture will be a major determinant of whether or not we reach these goals. Agricultural investments must now focus not just on increasing yields but also on a more complex set of objectives, including improving nutrition, preserving natural resources and adapting to climate change. Rural poverty reduction requires more than just investment in agriculture, including inclusive rural development policies, off–farm employment opportunities and effective social protection. Research, and improvements in the underlying data, are critical for developing an evidence base that highlights what interventions are most likely to be successful in achieving the SDGs in rural areas.

THE "CONTEXT" FOR SMALLHOLDER FARMING IS A POLITICAL ECOLOGY OF AGRARIAN CHANGE

***Simon Batterbury**, LEC,* **Lancaster University**

Keynote II argued that the "context" for smallholder farming has a significant effect on livelihood outcomes and the success of technological interventions. "Context" includes adaptive skill, and a wide set of constraints. African farmers are quite capable of managing their own genetic resources, innovating, finding markets and diversifying livelihood systems in the absence of severe structural constraints, as Paul Richards, Mike Mortimore, Robert Netting and others have argued. But the "constraints" operating in African and Asian farming systems have been magnified in recent decades by large scale land acquisitions, conflicts over land tenure, city growth, environmental challenges and displacement through civil war and rebel groups. Responding to these problems is a necessary precursor to achieving any widespread success through external technical interventions; food security and 'Climate Smart Agriculture' first involves recognising, understanding and tackling different forms of vulnerability, and the role of states, corporations and elites in creating it. I develop some ideas about how to do so, based on studies in Timor Leste, Niger and Burkina Faso.

DISSECTING THE CARBON FOOTPRINT OF A MAIZE DRY MILLING SUPPLY CHAIN

Lucas Borrás [1]*, Ignacio Greco* [2]*, Paco Martí* [3]*, Eamon Doherty* [4]*, Niall Daily* [4]*, and Haaye Boonstra* [4]

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Argentina is a traditional supplier of non–gmo hard endosperm maize to the European Union, averaging 350.000 metric tons per year during the last 10 years. We recently evaluated the carbon foot print of this supply chain. Our objective was to describe the sustainability of this special maize production system, and detect aspects for improvement. We used farmers real field crop yield, crop management and transportation data from the field to Liverpool (UK), where the largest EU maize dry milling factory is located, and calculated a carbon foot print using Cool Farm Tool. On average the central temperate region showed the foot print was 68 kg CO2 per maize ton. Maize was all rainfed, produced under no–till, with no post–harvest drying, and fertilizer levels averaging 70 and 15 kg. of N and P kg ha–1, respectively. From this description, transportation from Argentina to EU resulted negligible when compared to internal country transportation, or to different field management practices, like N fertilization rates. During the presentation action points will be discussed.

FEEDING TOMORROW: A NEW AGRICULTURE EXHIBITION AT THE SCIENCE MUSEUM, LONDON

***Mary Cavanagh**, Senior Content Developer, Contemporary Agriculture,* **Science Museum London**

The Science Museum in London is developing an exciting new exhibition asking how science and technology is helping us to find the balance between growing enough food and our growing concern for the planet's natural resources.

The impact of agriculture on the environment is increasingly in the public consciousness, and public engagement with this subject is more important than ever in the current political climate.

We will give an overview of our proposed exhibition, and share some preliminary research from our audience testing including our visitors' relationships with agriculture, and their perceptions of how science and technology are and should be involved with food production.

INDIVIDUAL DIFFERENCES IN STRESS RESPONSES AND THEIR SCALAR IMPACTS ON HIGHER LEVEL PRODUCTIVITY

***Lisa M Collins**, Faculty of Biological Sciences,* **University of Leeds**

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The propensity of individuals to show differential susceptibilities to stress and their subsequent variance in responding to those stressors and any treatment that may be applied to ameliorate the condition, is an emerging field of considerable interest within both human and non–human animal research. In this presentation, I will discuss how we are uncovering the nature and extent of individual differences to stress in a range of animal species, and what the consequences of this individuality are for efficiencies in recognising and treating problems, and ultimately for managing productivity on a commercial scale.

Understanding how individual differences impact productivity at a local commercial scale only tells us part of the story. We measure animal health and performance at a range of scales; from individuals presenting with clinical disease, to problems across a pen/flock, batch, region, country or continent that can add up to billions of animals worldwide. At each level of measurement, there are complexities of appropriate biomarkers, their sensitivity, specificity and reliability across different or dynamic contexts. Understanding the scalar properties of our commonly used biomarkers and utilising advances in big data analytics will allow us to identify the key scalar differences in our recording of disease within commercial, local, national and international databases health records, and if carefully applied, could also allow us a clearer view on the complexities of the individual within the wider population.

HERITABILITY ANALYSIS OF DIETARY FLAVONOIDS IN APPLES

Michael J Considine [1 2 3]*, Wallace Cowling* [2]*, Matt N Nelson* [2 4]*, Catherine Bondonno* [5]*, Nicola Bondonno* [5]*, Kevin Croft* [5]*, Jonathon Hodgson* [2 6]*, Kevin Lacey* [3]*, Steele Jacob* [3]

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Apples are rich in dietary flavonoids, particularly concentrated in the skin. We've previously shown acute improvement in a number of cardiovascular functions, resulting from a flavonoid rich apple meal. Recent changes to the Australian and New Zealand Health Claims legislation make higher–level claims more achievable for horticultural products. Data presented here show >10–fold range in several dietary flavonoids in fruit from 91 genotypes from the Australian National Apple Breeding Program. The genotypes span six generations of crosses and represent commercial varieties as well as advanced breeding selections, which have passed selection criteria based on quality. Heritability analysis demonstrates high narrow–sense heritability of epicatechin, phloridzin and anthocyanin, and high breeding value of Cripps Pink for quercetin glycosides. Hence this represents a considerable potential to breed varieties with elite levels of dietary flavonoids without detriment to other consumer qualities. Current research to identify cisgenic alleles for marker selection and accelerated breeding will be discussed.

PROPOSED INDICATOR OF FOOD SYSTEM SUSTAINABILITY: THE TEMPORARY LEY INDEX (TLI)

***Julia Cooper**, Crop and Soil Sciences Research Group, Agriculture, Food & Rural Development,* **Newcastle University,**
Paul Muto, Senior Specialist Grassland Agronomy, **Natural England**

It is widely accepted that maintenance of good soil quality is the foundation of a sustainable food production system. Although not always readily visible, there is evidence of soil degradation in the UK, linked to the "yield plateau" in wheat, soil compaction and declines in soil organic matter. Causes of soil degradation in the UK are not clear, but reductions in proportions of crop land under legume and/or grass leys may be a factor, due to the decoupling of ruminant livestock and crop production systems. While a standardised system for measurement of soil quality is problematic, we propose that a useful indirect measure of soil quality and food system sustainability is the Temporary Ley Index (TLI), calculated as the percentage of crop land in temporary ley at any given time. The indicator would need to be validated against real data on soil quality and economic and environmental performance of food systems. Minimum threshold values could be calculated and appropriate scales for assessment of food system sustainability determined. If this was done, agricultural data routinely collected by Defra could be used to calculate the TLI and indirectly assess soil quality and the sustainability of the food system on an annual basis.

MANIPULATION OF THE SOIL NITROGEN CYCLE BY BARLEY ROOT EXUDATES

Tim Daniell [1 2]*, Adrian Langarica–Fuentes* [2]*, Maddy Giles* [2]*, Susan Mitchell* [2]*, Marta Manrubia Freixa* [2 3]*, Anna Taylor* [2]*, Liz Baggs* [4] *and Duncan Cameron* [1]

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Agriculture represents both a dominant and recalcitrant source of the potent greenhouse gas nitrous oxide and a source of pollution through leaching of nitrate and other nutrient. This is largely due to the conversion of added nitrogen based fertiliser through the action of the microbial nitrogen cycle in soil. Denitrification represents a dominant source of nitrous oxide (N2O) and is carbon driven, as it maintains respiration under low oxygen conditions with nitrogen oxides acting as alternative electron acceptors. Screening of barley (Hordeum vulgare) cultivars indicated significant variation in N2O emission from soil in different lines. Further experimentation using a limited range of contrasting cultivars has demonstrated that these effects are connected to root exudation differences rather than direct interaction or litter effects and that both exudate composition and quantity are important. This effect may be mediated through manipulation of soil microbial community dynamics as a combination of exudate effects and soil physical characteristics. Further work is underway to dissect the role of exudation quality and composition, the interaction between soil aerobic status and flux through denitrification and the role soil community dynamics plays in driving alteration in nitrogen cycle flux and the end product of denitrification.

NOVEL–STRESS ASSOCIATED PROTEINS FOR ENHANCED TOLERANCE TO MULTIPLE ABIOTIC STRESSES AND IMPROVED N USE EFFICIENCY IN PLANTS

Om Parkash Dhankher, **Stockbridge School of Agriculture, University of Massachusetts Amherst, MA 01003, USA**

Environmental stresses adversely affect the growth and productivity of crop plants and thus are serious threats to agriculture. Recently, members of Stress–Associated Proteins (SAP) gene family have been suggested to play significant roles in multiple abiotic stress responses in rice, however, their exact functions/molecular mechanisms are not known. Overexpression of AtSAPs provided strong tolerance to multiple abiotic stresses such as salt, drought, and various toxic metals including zinc, cadmium, nickel, manganese, and arsenic, without causing a significant difference in metals accumulation. Through yeast one hybrid assay, we have proved that expression of SAP genes is regulated via the interaction of cis–elements present in the SAP promoters with abiotic stress related trans factors such as DREB, ERE, ZIP, HSE etc via protein–DNA interactions under different abiotic stresses. Additionally, we have identified a small gene family encoding γ–glutamyl cyclotransferases, GGCTs, in Arabidopsis, which are involved in the γ–glutamyl cycle required for maintaining GSH homeostasis via recycling Glu, a key nitrogen–storing amino acid. Recombinant GGCT2;1 protein was able to convert γ–glutamyl–Ala and GSH to 5–oxoproline (5–OP), a precursor of glutamate (Glu) in in vitro conditions. Manipulation of GGCT genes in Arabidopsis also showed enhanced tolerance to heavy metals and other abiotic stressors including ABA, mannitol and salt and produced higher levels of Glu precursor 5–OP as a result of GSH degradation. Our studies suggest that by efficient recycling of Glu as part of the γ–glutamyl cycle, GGCT2;1 decreased the de novo synthesis of Glu, thereby decreasing the nitrogen requirement. These novel stress associated genes are ideal for developing "Climate Resilient Crops" with enhanced tolerance to multiple abiotic stresses and decreased N requirements under stress conditions.

FOOD SYSTEMS RESILIENCE: TOWARDS INTERDISCIPLINARY RESEARCH AGENDA

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Resilience has been extensively used in a variety of fields but not very consistently applied, nor holistically interpreted, in the field of food systems. This system and the supply chains which in part constitute them are increasingly vulnerable to external or internal shocks – be these climatic, political, ecological, supply chain practice or economic. Within resilience thinking, this vulnerability to shocks can drive adaptation or more profound transformation, with associated risks and benefits that vary depending on both the nature of the inter–relationships between actors and where they are situated in the food system. This paper identifies several research gaps of resilience studies in food systems, caused by an analytical blindness of academic and practitioner literatures to the inherent complexity of food systems, composed by multiple and often competing biophysical, social, economic and political dynamics. Based on a conceptual review of the recent literature, this paper builds on these gaps to map out a research agenda for food systems resilience. It starts by looking at the ways the concept of resilience has been applied in business–, socio–environmental systems and political economic literatures. The paper then discusses the concept of food system and the difficulties for an actual interdisciplinary approach. After identifying a series of research gaps on resilience in food system studies, it argues that an appropriate focus of analysis is needed, which allows differentiation of the way in which resilience may promote the interests of the different agents within supply chains and of different elements within food systems. Our paper then proposes that resilience acquires different meanings for upstream actors in food supply chains, vis a vis downstream actors; and that studies of resilient food systems need to adopt a dynamic approach engaging with (non–linear) processes of environmental and social change (both at spatial and temporal scales). Furthermore, we recommend that both inclusive governance and social justice should be placed as key elements for promoting resilience across the food system. The paper concludes by mapping out a research agenda to begin unpacking resilience thinking and its normative assumptions within food systems. The concept of differentiated resilience is proposed to point out how the role of specific interests along the chain contributes to different definitions of resilience. In addition, we call for new business and analytical tools that look at multi–metrics both external and internal to the food system.

Keywords: resilience; food systems; supply chains; supply chain management; social–environmental systems; food; agriculture; value chain.

Speaker Abstracts

ANTIOXIDANTS AND CELLULAR REDOX HOMEOSTASIS

***Christine H. Foyer**, Centre for Plant Sciences, Faculty of Biology,* **University of Leeds**

The cellular reduction–oxidation (redox) hub, which is comprised of oxidants such as reactive oxygen species (ROS) and antioxidants such as ascorbic acid and reduced glutathione (GSH), integrates information from metabolism and the environment to regulate gene expression in plants and animals. Concepts of the roles of ROS have shifted in recent years from the original focus on oxidative damage effects to the current view of ROS as universal signalling metabolites. Rather than having two opposing activities, i.e. damage and signalling, the emerging concept is that all types of oxidative modification/damage are involved in signalling, not least in the induction of repair processes. Appropriate compartmentalization of ROS and antioxidants is crucial to the maintenance of redox homeostasis and oxidative signalling processes that regulate plant development and determine the outcome of plant responses to biotic and abiotic stresses. This talk will focus on the role of ascorbate as an essential metabolite and important redox gatekeeper in the maintenance of cellular redox homeostasis.

ENHANCING CROP DROUGHT TOLERANCE THROUGH STOMATAL MANIPULATION

***Julie Gray**, Professor Department of Molecular Biology,* **University of Sheffield**

Our studies of epidermal patterning factors that regulate of stomatal development in the model plant Arabidopsis thaliana, have allowed us to create more drought tolerant crop plants. Manipulating the expression of epidermal patterning factors in cereals has led to substantial reductions in stomatal density and transpiration. Barley plants with significantly reduced stomatal density exhibit significantly enhanced water use efficiency, drought tolerance and soil water conservation properties, with no reductions in grain yield. Our results demonstrate the potential of manipulating stomatal frequency for the protection and optimisation of cereal crop yields under future drier environments.

MEETING FUTURE FOOD AND SUSTAINABILITY DEMANDS USING TARGETED SELECTION SYSTEMS DESIGNED TO IDENTIFY IMPROVED VARIETIES FOR AGRICULTURAL NICHES

***Gerry Hoppe**, Principal Research Scientist,* **Agri–Food & Biosciences Institute (AFBI)**

The talk highlights the contribution that targeted crop selection systems can provide in the identification of improved elite crop varieties generated by UK and European plant breeders. Varieties selected in such systems ensure a genetic diversity, whilst providing high quality, productive and resilient crops for a sustainable Agri–Food sector in the UK. The use of diverse genetic material in breeding varies between crop types. Plant breeding approaches are increasingly recognised and valued for generating new improved varieties for agricultural niches and geographic regions.

The three case studies illustrate different selection and evaluation methodologies, each detailing the gains made towards meeting the future demands on agriculture for food and sustainability, while supporting biodiversity and the environment. These systems ensure a high degree of confidence in the resilience and reliability of results. Suggestions for improving current selection and evaluation systems for a range of crops are made.

Speaker Abstracts

WHAT CAN PLANT METABOLIC ENGINEERING DO FOR HUMAN HEALTH?

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There are currently global epidemics of overweight and obesity, Type 2 diabetes, metabolic syndrome and these conditions all increase the risk of chronic diseases such as cancers, Alzheimer's and cardiovascular diseases. Dietary advice in most countries focuses on increasing the consumption of fruits and vegetables. A large part of the benefits of consuming F&V is due to their content of phytochemicals such as polyphenols, carotenoids and glucosinolates. But, average fruit and vegetable consumption has remained stubbornly static in many countries, including the UK.

We have been engineering the polyphenol biosynthetic pathways in tomatoes to generate lines that accumulate high levels of different polyphenols, and using these as tools in research that seeks to assess the role of specific polyphenols in the health benefits of complex foods. For example, fruit–specific expression of the Myb12 transcription factor generates high–flavonol tomato fruits, expression of the Delila and Rosea 1 transcription factors from snapdragon generates high–anthocyanin, purple tomatoes, while transformation with stilbene synthase or isoflavone synthase genes generates tomatoes with high levels of resveratrol and genistein, respectively. The presentation will include results of comparative nutrition studies in rodent models that have assessed the potential health benefits of the different, polyphenol–enriched tomatoes.

THE REAL MEANING OF NUTRITIONAL VALUE IN LIVESTOCK

Helen Miller*, Professor of Animal Bioscience,* **University of Leeds**

Nutrients are the complex molecules and minerals that an animal needs to survive, grow and reproduce. In terms of livestock feeding we are aiming to produce high quality food products for humans in a profitable manner and so we consider the amount of each nutrient that a particular animal requires to give optimum output of the desired product (meat, milk, eggs) whilest promoting good health and welfare of the animal. We then look at the concentration of those nutrients in the feed ingredients available. We aim to blend the ingredients together to match the requirements of the animal as nearly as possible at an optimal cost.

THE CONSTANT EVOLUTION OF URBAN FOOD SUPPLY CHAIN

Eleonora Morganti*, Senior Researcher Fellow on freight transport and logistics policies at the Institute for Transport Studies,* **University of Leeds**

Food sustainability issues are no longer only rural and agricultural issues, the debate includes an urban dimension related to both food demand and distribution in cities. The progress of processing, refrigeration and transportation technology together with cheap and abundant energy resulted in a complex and fragmented way to provision food to city dwellers. As a result, the urban food supply chain is inextricably linked to other community systems, including transport, land use, and waste management. The complexity of the issue opens various questions on what is defined as last food mile and how sustainable it is. The goal is to explore the food flows occurring in modern cities, including the new shopping habits and the online deliveries and the food waste and the food recovery option.

IS IT TIME FOR A SOCIO–ECOLOGICAL REVOLUTION IN AGRICULTURE?

Lisa Norton*, Head of Land Use Group, Countryside Survey Project Manager,* **Centre for Ecology and Hydrology**

Sustainable intensification is touted as the future for agricultural land management in a world demanding greater food production. Agricultural practices remain primarily driven by the 'intensification' and not the 'sustainable' agenda. To turn this around requires clear evidence from ecologists about the nature of farming systems, the fundamental underpinning role of natural resources and ecological processes within them and the provision of feasible alternatives. Alternative ecologically based farming systems must reflect current wider food systems and the actors engaged in them with ecologists playing a key role in advocating change; from international global agreements which force political change, through changes in focus for agri–businesses, to decision–making by individual land owners.

Speaker Abstracts

IMPACT OF STRESSORS ON NUTRITIONAL VALUE OF WHEAT AND THE CONSEQUENCE THEREOF TO FOOD SECURITY IN AFRICAN COUNTRIES.

Anna–Maria Botha Olberholster, *Genetics Department,* **Stellenbosch University, South Africa**

Sub–Saharan Africa is regarded as one of the regions most vulnerable to climate change. This threat of climate change, and linked to that, biodiversity loss, and the lack of water and food security have highlighted the failure of current economic models in addressing the development challenges that the world faces. Agriculture is a very important sector that plays a crucial role in sustainable development, including the economy, employment, food security, trade, hunger and poverty eradication, and human health. Wheat is an important cereal crop in many African countries but production thereof is limited by various abiotic and biotic factors. Changes in yield, protein composition and nutritional value, as well as the consequence of these on human health will be discussed.

INNOVATIONS TO SUSTAINABLY INTENSIFY SMALLHOLDER FARMING SYSTEMS TO ENHANCE FOOD AND NUTRITIONAL SECURITY

P.V. Vara Prasad, *Gary M. Pierzynski, Jessie L. Vipham, Zach P. Stewart and B. Jan Middendorf*

Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification, Kansas State University, United States

The grand challenge of increasing production of nutritious food to meet growing population requires a systems approach towards agriculture. The goal of sustainable intensification (SI) is to increase farm productivity from existing croplands per unit area per unit time, improve nutrition, and raise net income while reducing reliance on inorganic pesticides and fertilizers, and reducing emissions of greenhouse gases. Malnutrition, stunting and low birthweights, is a serious concern across the globe. These conditions are not only related quantity and quality of food but also to deficiencies of micronutrients, vitamins, protein, and other essential and beneficial elements. Targeted interventions will be required to enhance both food and nutritional security. Increasing overall farm productivity and intensification requires incorporation of livestock, aquaculture, home gardens, and fruit and vegetable crops. Enhancing micronutrient content in the edible portion of the plant will also require efficient management of soil, plant, nutrients, and water. In diets with a high proportion of the calories coming from a staple food such as grains, the absorbable and utilizable micronutrient content of that staple is important in meeting nutritional requirements. Biofortification represents deliberate attempts to increase the nutritional value of food crops through crop breeding as well as agronomic fertility management. Some proven examples of biofortification using traditional crop improvement include – high Fe beans and millet, high Zn rice and wheat, orange-fleshed sweet potato, high vitamin A cassava, and high protein maize. Changes in diets and selection of food consumed that can help with improving micronutrients include – enhancing diet diversity (legumes and pulses), consumption of indigenous vegetables, fruits and animal source proteins (particularly poultry, eggs and milk) and fish in diets. Empowering households, particularly women and youth, on the value of nutrition and diet diversity is critical for enhancing food and nutritional security.

LONG–TERM MEMORIES OF BIOTIC STRESS IN PLANTS. IMPLICATIONS FOR CROP PRODUCTION.

Mike Roberts, **Lancaster University**

'Priming' of plant defence refers to the establishment of a state in which future defence responses can be triggered more rapidly and/or to a greater degree, following a prior stress or chemical priming treatment. Such priming responses are one way in which plants can optimise the trade–off between growth and defence. We have shown that not only can priming persist over long time scales within individual plants, but that the primed state can be inherited by future generations. I will discuss applications of such priming responses for crop protection, and describe a range of maternal effects on offspring phenotypes that we have identified following herbivory or disease in parent plants.

Speaker Abstracts

FROM DARWIN TO BORLAUG: THE EVOLUTIONARY SIGNIFICANCE OF IONOMIC VARIATION

***David E Salt**, University of* **Nottingham, UK**

Abstract: Genome–wide association (GWA) mapping using wild–collected Arabidopsis thaliana is starting to identify the genetic architecture and molecular mechanisms underlying natural variation in the capacity of A. thaliana to accumulate from the soil mineral nutrients and trace elements (aka ionomic variation). Furthermore, association of the loci controlling variation in the ionome with soil features across the landscape is suggesting ecological functions for this natural ionomic variation. Studies on standing populations of A. thaliana in Catalonia, Spain, coupled with common garden experiments in the field in the same region, are revealing the existence of locally adapted populations over short geographical distances (~30 km). These field studies are also identifying a potentially adaptive role for the ionomic variation identified by GWA mapping. The genes controlling natural ionomic variation in A. thaliana appear to be conserved in crops, raising the possibility of a robust 'Darwin to Borlaug' translational pipeline between functional ionomic variations in A. thaliana and crops.

SECURING A SUSTAINABLE FUTURE FOR A 5,000 YEAR OLD BEVERAGE

***Jacquie de Silva,* Unilever**

Providing sustainable nutritional security for a growing global population is surely one of society's greatest challenges. Deforestation is not a viable option. Climate change is already increasing the frequency of extreme weather events and causing pests to move to new locations, affecting crop yields and exacerbating the problem. To complete the perfect storm, intensification of agriculture will become increasingly unsustainable, with demand for water and fertiliser expected to outstrip supply. The crops we grow will need to become more resilient to extreme weather and pests and less reliant on agricultural inputs. Crop genetic diversity has an important role to play, yet the very diversity on which sustainable food production will depend is being eroded at an alarming rate. Here, I will describe the work that Unilever is doing to future proof the nation's favourite beverage. A long lasting evergreen tree, tea is mainly grown in parts of the world most susceptible to climate change. Developments in precision agriculture and genomic selection (genome assisted conventional breeding) are being harnessed to fit the crop for a challenging future. A collaborative approach between industry, government, NGOs and academia is needed to ensure security of supply for the long–term.

PLANT VASCULAR DEVELOPMENT AND THE REGULATION OF PLANT GROWTH

***Simon Turner,* University of Manchester**

The rate of plant cell division and the orientation of those divisions are a fundamental part of plant growth. These processes are particularly apparent in plant vascular tissue where divisions of the meristematic cambial cells must be highly ordered to generate the ordered files of cells and the number of cells in each file accurately report the number of cell division. We have used genetic analysis in Arabidopsis to identify a receptor kinase, known as PXY, and its ligand, known as TDIF, a short peptide encoded by members of the CLE gene family. The interactions between PXY and CLE are central to a multifunctional pathway that is essential for both determining the rate of cambial cell division, the orientation of these divisions and preventing their differentiation into the xylem cells. We have used the information derived from Arabidopsis to determine to what extent we can increase the rate of wood formation in trees and other crop plants. Our initial results suggest this is likely to be a productive means of increasing plant biomass.

TRACKING SUSTAINABILITY AND IMPACT–LESSONS FROM THE INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENTS INVESTMENTS IN CLIMATE CHANGE

HOW CAN RESEARCH IN DEVELOPMENT HELP?

***Stephen Twomlow**, Regional Climate and Environmental Specialist,* **IFAD**

The significant problems we face cannot be solved at the same level of thinking we were at when we created them.
Albert Einstein (1879–1955)

The vagaries of current and future climate change represent important challenges to sustainable development throughout sub–Saharan Africa (SSA). Yet, we still argue where is the best place to invest our limited financial resources to support adaptation. For many smallholder farmers in SSA, crop production is a risk–averse practice that makes very little investment in improved management of varieties. In fact, in many seasons poor agronomic management practices (e.g poor tillage and seed, late planting, inappropriate plant spacing's, poor fertilization, poor harvesting, drying practices and storage) of the crop by the smallholder farmer, are key challenges still to be resolved and can create drought conditions that exacerbate climate change. Household coping mechanisms to climate–induced stresses often include practices (e.g. unsustainable charcoal production) which are harmful to the environment's capacity to provide medium to long term ecosystem services, or which reduce the already limited households' productive capacity (e.g. early selling of agricultural production, or sale of productive assets) thereby entering into a downward spiral of decreasing resilience.

To address these challenges IFADs Strategic Framework 2016–2015 is working to strengthen countries' capacity to respond to climate change threats and the degradation of natural resources by applying diverse financial instruments on environment and climate. As an incentive for mainstreaming climate, social and environmental issues into country operations, IFAD established the Adaptation for Smallholder Agriculture Programme (ASAP) in 2012 and implements programmes on adaptation and mitigation as a GEF agency. These supplementary funds to IFADs core loan programme, have been put in place by IFAD to make climate and environmental finance work for smallholder farmers. These investments are being used to promote multiple benefit approaches to sustainable agriculture (good agricultural practices, diversified livelihoods such as bee keeping, improved rural structures for rain water management, green energy sources) that both reduce risk and build climate resilience.

To meet donor expectations and increase the impact of these investments IFAD must constantly invest in better–informed project design, improved baseline assessments, and strengthened results–based management on the ground to look at trade offs through a growing plethora of monitoring approaches. Better, readily measurable and scientifically rigorous indicators are needed to properly assess landscape "ecosystem health" in terms of both biophysical indicators (e.g. soil erosion, soil fertility and vegetation dynamics) and socio–economic indicators, especially field–level information on production and household incomes.

Some emerging lessons will be shared from IFADs ongoing grant investments in research. The question for this fora is, can research help development in a meaningful, timely and cost effective manner. Too often development practitioners see research as an additional problem than a solution.

CHALLENGES ASSOCIATED WITH THE INTRODUCTION OF NOVEL PASTURE LEGUMES IN AUSTRALIA – THE CASE OF BISERRULA (BISERRULLA PELECINUS L.) AND FRENCH SERADELLA (ORNITHOPSIS SATIVUS L.)

Leslie A. Weston[1], *Jane C. Quinn* [2], *Sajid Latif* [2], *Paul A. Weston* [1], *Craig Stewart* [3] *and Russell Barrow* [3]

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Biserrula and French serradella are annual legumes native to the southern Mediterranean. Serradella was widely cultivated throughout France and temperate Europe in the Middle Ages while biserrula was found more sporadically in mixed legume stands. These legumes were rediscovered in the 1990's through the efforts of Australian breeders and are now well adapted to diverse Australian conditions. With ample rainfall, they establish dense stands, are deep rooted and regenerate due to the production of hard seeds the following winter. Both legumes are drought tolerant and adapted to acidic soils but serradella does not tolerate waterlogging or high salinity. Despite proving to be a valuable addition to the limited pasture toolbox, producers have identified key factors limiting uptake. In the case of French serradella, intolerance to heavy weed infestation and high soil Mg resulted in reduced stands. Despite a competitive growth habit and high protein content, biserrula uptake has been limited by the development of photosensitization in grazing livestock. The pathogenesis of biserrula photosensitization and associated metabolite(s) have been the focus of recent experimentation. Bioactivity–guided metabolic profiling using UPLC/MS–QToF along with separation of crude extracts resulted in identification of multiple metabolites associated with photosensitisation. Strategies to limit photosensitivity in livestock will be discussed.

EARLY CAREERS RESEARCH ABSTRACTS

WHAT CAN AUTOMATED SENSOR TECHNOLOGY OFFER FARM ANIMAL WELFARE?

Lucy Asher, *Research Fellow,* **Newcastle University**

Animal welfare is a multi–faceted and construct, comprised of physical and mental well–being. New and exciting methods are being developed by welfare scientists to measure mental well–being, but generally speaking these methods are yet to leave the laboratory. In the real world, welfare assessment tends to focus on measures of physical wellbeing due to the challenges of measuring mental well–being objectively. However, physical measures of animal welfare cannot always be taken for all animals for practical reasons, particularly in large groups of animals. Here I argue that automated sensor technology could be advantageous for measuring both physical and mental aspects of animal welfare. I present key examples to illustrate this point, with particular focus on broiler chickens. I outline the potential advantages of using automated sensor technology from two perspectives: 1) real world implementation of welfare assessment; 2) improved understanding of animal behaviour and welfare.

QUANTIFYING SOURCES OF FOOD LOSSES AND WASTE IN INSTITUTIONAL CATERING SERVICES

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Abstract: Events catering is a significant generator of food waste (Parfitt et al., 2013). Waste arises due to several factors, including event type, time, venue and type of food chosen. Additionally, there are human factors, in ordering, preparing, serving and cleaning, that may affect the level of waste generated. Limited research quantifies sources of waste in institutional event catering services. This research aims to: 1) determine how food waste varies between event types and venues; 2) ascertain to what extent customers booking event catering influence the level of food waste. Using a quantitative approach, combining waste quantification, via visual estimation, with survey techniques, data has been collected from a sample different event types held across Newcastle University campus between March and May 2017. Data will be used to assess how factors, including type of event catering, number of attendees, location and time of event, affect food waste generation. This research is being completed in collaboration with BIND (a community interest group) for Newcastle University's EAT@Newcastle Catering Service. This research will enable the development of decision tools to mitigate waste generation in institutional catering services.

Key words: Food losses; Food waste; Event catering; Higher education.

References:

Parfitt, J., Eatherley, D., Hawkins, R. and Prowse, G. (2013) Waste in the UK Hospitality and Food Service Sector (Technical Report No. HFS001–00 6). Banbury: Waste and Resources Action Programme (WRAP).

SUSTAINABLE FOOD SECURITY THROUGH SMALL–SCALE FARMING: EVALUATION OF THE ZERO HUNGER PROGRAMME IN BRAZIL

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805 million people world–wide are food insecure. Food security is commonly understood to encompass dimensions of food availability, access, utilization and stability, though increasingly also viewed in terms of the potential role of small–scale farmers in achieving a sustainable food system.

Due to our continuously evolving understandings, complex and often conflicting approaches to combat food insecurity exists. We evaluate one specific approach, the Zero Hunger programme in Brazil. Though previous evaluations show its effectiveness, resulting in similar strategies being rolled out in other countries, we argue no robust holistic evaluation exists. We therefore examine the causal relationship between the Zero Hunger programme and a range of food security metrics at the rural municipal level of Brazil between 2004 and 2013, by using econometric techniques and multiple regression models which effectively control for confounding factors.

We find evidence that overall Zero Hunger has had a positive impact on food security, particularly in terms of increased food production but also resulting in a slight reduction in poverty and child malnutrition. A further exploration of possible heterogeneous treatment effects, though, suggest varying impacts by different Zero Hunger initiatives and by geographical location, thus providing important contextual information for future initiatives.

CROPS, MYCORRHIZAS AND CO2

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Over the last 70 years, agricultural productivity has increased dramatically in terms of crop yield and predictability, being heavily influenced by the development and application of novel pesticides and nitrogen– and phosphorus–based fertilisers. However, in the last 15 years key crop yields have plateaued. With an increasing human population, depletion of global rock phosphorus and growing energy prices making fertiliser production unsustainable, Europe is now facing a food security crisis, further compounded by the environmental challenges presented by global climate change. In recent times there has been much interest in exploiting plant–fungal symbioses (mycorrhizas) for agronomic benefit such as enhanced crop access to existing soil P pools. However, given the IPCC predictions for future increases in atmospheric CO2 concentrations, it is vital that we understand how these critically important symbioses will function under a CO2–rich atmosphere. Here, I will present recent research from my group investigating how crop–mycorrhizal symbioses respond to change atmospheric CO2 concentrations within the context of future food security and climate change.

EXPLOITATION OF SPIDER VENOM PEPTIDE TOXINS FOR THE DEVELOPMENT OF NOVEL BIOPESTICIDES

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The principal components of spider venom are small cysteine–rich peptides that interact with ion channels in the nervous system of prey causing paralysis. Stability, high potency and specificity of action towards invertebrates makes them ideal candidates for development as insecticides. However, whilst lethal by injection, the efficacy of such peptides is significantly reduced when delivered orally. We have patented an approach that transforms these naturally derived peptides into orally effective biopesticides. Invertebrate specific toxins are fused to a "carrier" protein able to cross the gut wall and ingestion of the fusion protein (FP) enables transport of the toxin to the nervous system of the target pest via the circulatory system. Recombinant FPs produced in yeast have been shown to be effective against a range of crop pests, but have no deleterious effects on bees. Here we report findings to suggest that this approach could also be used for the development of novel molluscicides.

TOWARDS SUSTAINABLE DEMAND FORECASTING AND WASTE REDUCTION IN FOOD SERVICES: A VALUE STREAM MAPPING INVESTIGATION OF EVENT CATERING AT AN N8 UNIVERSITY.

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Numerous studies have addressed sustainability in larger food service organisations including Starbucks and McDonald's (Darkow et al., 2015) yet uncertainty surrounds the best tools to measure and control food wastage in SMEs. The lack of standardised processes has prompted a joint investigation with a MSc Student from Agriculture Food & Rural Development and a community group, to explore EAT@Newcastle[i] and its customers' current practices to quantify food waste, redesign ordering protocols and meet customer expectations through efficient demand management, whilst limiting food waste generation.
Interviews and waste measurements facilitate a multiple methods approach including photography, weighing, half/quarter–waste methods as visual estimations. Times and frequencies will be recorded and quantified to understand why, when and where food waste occurs. This element will utilise value stream mapping (Hines et al, 1998) given its ability to be overlaid, to collect and use qualitative data from interviews and observations, whereupon, the phenomenological 'why' of occurrences of food wastage will gain the same value as the quantitative data measurements as econometric analyses, to create waste stream maps which commence at the point of consumption and work backwards up the supply chain.

Key words: Food waste; Event catering; Value Stream Mapping, Waste minimisation

References:

Darkow, I.L., Foerster, B. and von der Gracht, H.A., 2015. Sustainability in food service supply chains: future expectations from European industry experts toward the environmental perspective. Supply Chain Management: An International Journal, 20(2), pp.163–178.

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EAT@Newcastle is the University catering service located across Newcastle University campuses, Newcastle Upon Tyne

SKYLINE2D, A NOVEL AUTOMATED TECHNOLOGY

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Rising atmospheric carbon dioxide (CO2) is driving anthropogenic climate change, and two other biogenic greenhouse gases (GHGs), nitrous oxide (N2O) and methane (CH4), have global warming potentials (GWP) of 298 and 34 times that of CO2.

Almost 10% of the UK's annual total GHG emissions is due to agricultural N2O, derived from nitrogenous fertilisers, the type of which can affect consequential N2O fluxes, depending on a soil's capacity for nitrification or denitrification. In 2013 oilseed rape (OSR, Brassica napus) was grown on 11% of available agricultural land in the UK, where the oil content of its seeds is used in food production and cooking; in continental Europe, however, OSR is the most widely-used feedstock for biodiesel.

We deployed SkyLine2D, a novel automated technology developed at University of York, to investigate the effect of nitrogen (N) fertiliser application on GHG fluxes from OSR in spring 2014. Two doses of N were applied to the crop, with a double-N (69 kg-N ha-1) treatment matching the chemical and amount applied by the farmer (ammonium nitrate (NH4NO3)), and single-N treatments (34.5 kg-N ha-1), ammonium chloride (NH4Cl) and sodium nitrate (NaNO3).

The OSR was a net sink for CO2 (ca. 100 g CO2 m-2) over the study for all treatments. Fluxes of CH4 were negligible, but N2O emissions were higher (> 4000 µg m-2 h-1) than previously reported from this crop, and was emitted in short-lived bursts. Cumulative fluxes were greater from NH4NO3 than from NaNO3 but did not differ from NH4Cl; these emissions drastically reduced the carbon-sink of photosynthesis and, in NH4NO3 treatment the OSR was a net source of GHGs. Our findings demonstrate the importance of accounting for all GHGs when calculating the carbon balance of crop cultivation and suggest that OSR is particularly unsuitable to be used for biodiesel production.

ADDING VALUE TO ASH AND DIGESTATE: AN OVERVIEW OF THE EFFECTS OF ASH AND DIGESTATE BLENDS ON THE SOIL–PLANT SYSTEM

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Recovering energy and nutrients from waste offers opportunities to tackle issues of energy and food security whilst simultaneously improving waste management. Waste materials from the bioenergy industry contain valuable resources for use in agriculture and there is growing evidence to suggest that the use of digestate, from anaerobic digestion, and biomass ash from incineration could contribute to improving soil health and nutrition.

The work presented here is part of the NERC funded project 'Adding Value to Ash and Digestate (AVAnD)' which looks at the impacts of digestate (D) and ash (A) blends on soil fertility, crop yields and soil health. We present experiments carried out at different scales using two digestates (one crop based and the other from household source–segregated waste) and two ash fractions (fly and bottom). The main factor considered was fertiliser type which included A/D blends, A & D alone, no fertilisation and inorganic fertilisers. Measurements of both plant and soil properties were made in order to determine the potential impact of using alternative fertilisers on the whole plant–soil system. In this presentation we discuss how treatments affect soil pH, nutrient availability (N–, P– forms), greenhouse gas emissions (CO2, CH4 & N2O) and importantly, plant biomass and yield.

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