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Climate change and agricultural ecosystem management in dry areas

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The world population is expected to reach 9 billion by 2050 and food production to support this population needs to increase by at least 60% while maintaining the natural resource base and the environment (World Bank 2008). The decrease in productive arable land from urbanisation, the reduction in irrigable land due to water scarcity and groundwater salinisation, competition for use of crops for biofuels, and increasing cost of inputs (e.g. fertilizers, fuel, pesticides and herbicides) suggest that agriculture needs to be much more efficient in its use of land, water and energy in order to meet the food security requirements of the rising world population. This is true without the complicating factor of climate change. According to the World Development Report (World Bank 2010), food production will be required to increase by 1.8% per annum between 2005 and 2050 rather than 1% per annum if there were no impact of climate change. This puts tremendous pressure on dryland agriculture to increase the efficiency of use of precipitation and nutrients.

The 2nd International Workshop on Ecological Assessment and Management with the theme ‘Climate change and agricultural ecosystem management in dry areas’, held in Lanzhou, Gansu Province, China, from 20 to 25 July 2010, addressed some of these issues. The workshop was organised by the Ministry of Education Key Laboratory of Arid and Grassland Ecology, Department of Arid Agro-ecology at Lanzhou University and the UWA Institute of Agriculture at the University of Western Australia, Perth, Australia and included leading scientists from China, Australia, the United States of America, Canada, Syria and Japan. In this issue of *Crop & Pasture Science*, selected papers addressing crop improvement and production are published. Other papers presented at the workshop are published in a special issue (in Chinese with English abstracts) of *Acta Ecologica Sinica* (volume 31, number 9, pages 2349–2654, 2011), in *Plant and Soil* (Volume 346, 2011) and in *Functional Plant Biology* (Palta *et al*. 2011).

Research in the Department of Arid Ago-ecology at Lanzhou University is focused on crop and pasture production on the Loess Plateau, which covers an area of 64 million ha in seven provinces – Shaanxi, Gansu, Ningxia, Shanxi, Henan, Inner Mongolia and Qinghai in north-west China – supporting a population of 34 million people (Turner *et al*. 2011). The soil is a deep silt loam blown in from the Gobi Desert and deposited over many millennia. The soil, which in many areas is from 50 to 80 m deep, has a high water-holding capacity (~26% at field capacity), but is rapidly eroded by running water. Climate change is predicted to increase temperatures on the Loess Plateau by 2.5–3.8°C, while rainfall is not expected to change, by 2050 (Turner *et al*. 2011). While farming systems on the Loess Plateau are very different from south-west Australia (Turner *et al*. 2011), the issues of increasing crop and pasture productivity with limited rainfall and increasing temperatures, are common, and are relevant to issues in other semiarid areas of the world. Thus, the papers in this special issue address the subject of increasing precipitation use efficiency (Fang *et al*. 2011; Khatib *et al*. 2011; Gan *et al*. 2011*a*, 2011*b*; Turner *et al*. 2011) and increasing nutrient use efficiency (Ma *et al*. 2011; Gan *et al*. 2011*a*, 2011*b*; Wang *et al*. 2011) in semiarid regions. The role of roots in increasing both precipitation and nutrient use efficiencies is highlighted (Ma *et al*. 2011; Gan *et al*. 2011*a*, 2011*b*) and the different depth of rooting between the crop legumes, oilseeds and spring wheat led Gan *et al*. (2011*a*) to suggest that oilseeds and wheat be grown in rotation with legumes to maximise precipitation use efficiency in water-limited environments. The carbon : nitrogen (C : N) ratio of the roots did not vary with depth in the soil, but the amount of carbon and nitrogen did vary with the amount of roots in the soil at various depths, with species and with whether the plants received adequate or limited water (Gan *et al*. 2011*b*). Legumes had the lowest C : N ratio in the roots and straw, while the oilseeds were similar to wheat except in the seeds where the oilseeds had a low C : N ratio (Gan *et al*. 2011*b*). Minimum or zero tillage (also called conservation tillage) has been widely adopted in south-west Australia and elsewhere (Farooq *et al*. 2011) and has led to significant increases in precipitation use efficiency associated with better

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weed managment and earlier planting (Turner and Asseng 2005). However, it could lead to poorer nutrient use efficiency, particularly of phosphorus with limited soil mobility, as minimum tillage systems increase the heterogeneity of nutrients in the soil. Ma *et al*. (2011) show that white lupin (*Lupinus albus*), with its cluster roots in low phosphorus soils, is more efficient in taking up phosphorus from heterogeneous soils than wheat (*Triticum aestivum*). Improving the nutrient use efficiency relies on accurate measurements of nutrient concentrations and the requirement for additional fertilizer. The paper by Wang *et al*. (2011) describes a reflectance method of remotely measuring the leaf nitrogen concentration so that plants suffering nitrogen deficiency can be identified and the deficiency rectified under the water-limited and nutrient-limited conditions common in semiarid regions.

One of the predicted consequences of climate change is a significant reduction of 20–40 mm in rainfall in south-west Australia (Turner *et al*. 2011) and a consequent increase in the frequency of droughts (CSIRO 2007; Hennessy *et al*. 2008). While rainfall on the Loess Plateau is not predicted to change overall, rainfall in areas in the east of the Plateau are predicted to decrease by 30–40 mm and to increase by up to 40 mm in the south and south-west (Turner *et al*. 2011). Further, thermal instability is predicted to increase rainfall intensity even if the frequency and rainfall amount is unchanged (Cruz *et al*. 2007). The increased frequency of droughts will have a major impact on crop and pasture production. Fang *et al*. (2011) show that even a transient water shortage event at the beginning of podding halved flower numbers and decreased seed yields by about a third in two cultivars of chickpea (*Cicer arietinum*). However, the transient water stress increased the maximum rate of seed filling and resulted in a 20% increase in mean seed size across the two chickpea cultivars. The DREB genes hold promise of increasing the drought and cold resistance of crops (Bhatnagar-Mathur *et al*. 2007). In the paper by Khatib *et al*. (2011) the methodology for introduction of the *dreb 1a* gene into lentil (*Lens culinaris*), a recalcitrant species for transformation, is developed and its expression confirmed. The success of the introduction in terms of increasing the drought tolerance of lentil has still to be confirmed and validated in practical plant breeding programs, but it is an example of the progress being made in improving the drought resistance of crops through molecular biology and crop genomics.

The following seven papers, together with those published in *Acta Ecologica Sinica, Plant and Soil* and *Functional Plant Biology* demonstrate the rich diversity of research being conducted to improve crop and pasture production and resource management in the world's dryland agricultural ecosystems. Future efforts should be directed towards translating some of the above research findings to farmer's fields in the target dryland environments.

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