Diversification of crops and management for long-term sustainability of agro-pastoral production in Western Australia

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Since 1999, the Department of Agronomy and Land Management of The University of Florence has established continuative collaborations with UWA (The University of Western Australia), DAWA (Department of Agriculture Western Australia), CSIRO (Commonwealth Scientific and Industrial Research Organization), CLIMA (Centre for Legumes in Mediterranean Agriculture, UWA). Links existing within ARIA-WA (Association for Research between Italy and Australasia) have contributed to strengthen this program even further. The collaborations developed have resulted in 13 scientific visits from Italy (1 professor, 9 students specializing in pasture science and 2 in crop science) to Western Australia and 3 from Western Australia to Italy (1 professor of UWA, 1 PhD student of CLIMA, 1 researcher of CSIRO).

Research activities of common interest have focused on environment protection and conservation, biodiversity restoration in agricultural systems, sustainable crop yield increase. In more detail, specific investigations have been done on: productivity and biodiversity in native or sown pastures, cover crops management in vineyards and olive groves, influence of cover cropping and diversity of soil use on insect populations in vineyards, weed spread through pastures, cropped areas and forests and their effect on wild fire risk, morphology and phenology of forage legumes, seed size in chickpea hybrids and genetically modified lines, association of wheat and forage legumes, diffusion of plant pathologies in legume-based pastures. A particular aspect of the existing collaboration is the introduction of genetic plant material from Italy, the University of Florence has provided seeds of Hedysarum coronarium ecotypes adapted to sandy soils, and acidic resistant Rhizobium strains. This material was given to Australian scientists in 1999 and is at present under evaluation for its potential use in Western Australian cropping systems. Although these investigations were only preliminary, importantly they were based on a multi-disciplinary approach. Due to their diversification, they have produced results that can be applied from a broad perspective, approach which is more familiar in Italy than Australia.
Preliminary results have shown a much lower degree of plant biodiversity of native or sown pastures in Australia than in Italy (Melozzi, 2002). This is because the long history of land cultivation in Italy has favoured the gradual integration of exotic species in any area, whilst man-driven changes to native vegetation occurred too recently and abruptly in Australia (Longhi et al., 2002), thus endangering native plant species without integrating a wide range of exotic species (Pardini et al., 2002).
The low level of plant biodiversity and variability of land uses in wide areas has created favourable conditions for the diffusion of weeds in all the main crops, as well as the development of weed herbicide resistance (especially in Lolium rigidum). Furthermore, the great reduction of insect species in specialized areas (e.g. vineyards) has lowered the possibility of controlling plant pathogens and parasites naturally (Dinatale, 2004, Dinatale et al., 2004). This has occurred more in Western Australia than in Italy. For example, the size reduction of populations of arachnids and useful insects has been advantageous for specialized crop parasites that are no more controlled by predators.

The study of native flora in search of new potential uses has started only recently, while traditionally these plants were considered just as possible source of forage for

European livestock species and consequently neglected for possible alternative uses. In fact, nowadays only exotic species are sown and sometimes spread naturally. Unfortunately, the fragile Australian agroecosystem is not able to limit their diffusion as weeds, as it happens with Arcthoteca calendula, a casually introduced species from South Africa, which is considered only a weed in wheat and pasture crops but has a potential as cover crop for soil protection in vineyards (Vercelloni, 2003). Several other exotic plant species are unwanted weeds of main crops but could be useful to limit soil erosion in orchards and olive groves (Della Pina, 2002, Faiello et al., 2003).
The reduction of the complexity of flora, cropping systems and management is also an advantage for tall and fast growing weeds that complete their biological cycle by the summer and produce high amount of dry biomass that may increase the fire risk and fire spread into forests (Fedi, 2004). Some of the most unwanted weeds like Lolium rigidum or Avena fatua are also good forages and could be controlled by improving crop-pasture rotations. Moreover, the former has developed herbicide resistance and should be controlled by agronomic practices such as crop diversification and rotation, deep and frequent soil tillage that, by contrast, have been abandoned decades ago in favour of cheaper crop management and higher short-term returns for the farmers.
Some newly introduced crops are pulses, especially chickpea, lupin, field pea, broad bean, lentil, but unfortunately their performance is below optimal in acidic soils, widespread in Western Australia. A wide area is currently used for the production of lupins, 2/3 of which are exported and the rest is retained for local consumption and on farm use. Genetic research will be very useful to develop new pulse cultivars, including GM Cicer arietinum suitable for Western Australian soils and climates (Gremigni et al., 2004; Maoggi, 2004; Pratesi, 2004, unpublished data).
A broader use of legumes could be planned in rotation or association with wheat, that remains the main crop for Western Australia. Articles on this topic have been published in the Italian scientific literature for about two centuries, and the tradition dates probably even before then. An old type of association named bulatura is still used in some marginal areas to protect the legume from cold temperatures and to supply an organic source of nitrogen to the companion grass. The competition between the two crops, together with increased management difficulties, has restricted the use of this crop association in Italy. However, the same association could be useful in Western Australia, where soil constraints limit growth in Medicago sativa and consequently reduce plant competition. At the same time, the deep roots of M. sativa would help to increase water use in areas where the destruction of the native eucalyptus forest has increased the level of the soil water table, thus bringing salts at the soil surface (Pardini et al., 2001a).
Notably, in Western Australia the diffusion of plant pathologies has increased, especially in the monocultures established long time ago, consequently crop diversification would be recommendable in an effort to find varieties more resistant to diseases than those currently available. One of the researches in this sector concerns Cercospora zebrina, a fungal disease of legumes, and recent investigation has involved also a student of the University of Florence.

The considerations reported above are based on preliminary results of collaborative research, but also on more substantial results from local research. All together, these results suggest that it is necessary to increase crop diversity in Western Australia by introducing new species and cultivars. It is also important to increase the complexity of cropping and pastoral systems (Pardini, 2002) especially by introducing trees in pastures and cropped areas, similarly to the windbreaks or the Spanish Dehesa and Portuguese Montados, where some trees are kept at low density to reduce wind

erosion, with little or no penalty for pasture yield and actually improved seasonal availability of forage (Pardini, 2004).
In conclusion, it is the long term planning of crop cultivation that will be more and more necessary in Western Australia, to warrant high productivity and at the same time conserve the environment for future generations. In fact, issues of sustainability are currently investigated just for new scientific and technological improvements possibly able to cope with a degrading natural environment. Nonetheless, periods of insufficient advances may occur. Although short-term returns have gradually increased in Western Australia since the beginning of the rural colonization, this happened together with a loss of almost 4,000,000 ha of cropped land, due to acidification and salinization caused by the cropping systems in use. Australian experts forecast an increase of the salinized area to almost 12,000,000 ha before a new equilibrium is reached and, should the cropping systems remain unchanged, another 30% loss of the cropped land in the next 200 years (Pardini et al., 2001b). Consequently, the choice management strategies apparently less profitable in the short term could be useful to maintain soil fertility and to improve environmental conservation, at least at a level comparable to Mediterranean European Countries, where crop and management diversification occurred during history has avoided critical and irreversible damages.
The identification of the most suitable changes requires an integrated perspective of the agricultural and native environment, that can interpret the whole agro-silvo-pastoral system as an interactive entity. This research approach is common in Italy even if details of some parameters are not sufficiently investigated in the agronomic sector, while it is not much common in Australia where few key parameters are always analysed in depth but they are less integrated. From this point of view, further collaboration between Italian and Australian scientific institutions will give both holistic and specialized perspectives and will contribute to improve results in both Countries more than if they would go ahead with separate strategies.

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