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The career and contribution to Australian and international agricultural science of Clive McDonald Francis: an introduction

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Abstract. Dr Clive Francis is amongst a small group of scientists whose efforts have changed the face of Australian agriculture. This special issue of *Crop & Pasture Science* highlights his broadranging impact delivered through the pasture cultivars he bred, the knowledge that he generated and the influence that he had on peers and policy makers. His cultivars of subterranean clover are still grown on many millions of hectares across southern Australia and his efforts were pivotal in generating momentum for creative research on a wide array of crop and pasture legumes, particularly the collection, evaluation and preservation of genetic resources for use in current and future breeding initiatives.

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Introduction

This Special Edition has been assembled in recognition of the 50-year career of Dr Clive Francis who died recently at the age of 73. His career was notable for his scientific achievements and the impact of his research on farms and farming systems across Australia. His influence and leadership stood out during an era where agricultural science was a key driver of national economic performance and growth.

His leadership and impact was expressed at many levels, covering the development and operation of projects, programs, and research centres. He was a generous mentor of individuals who shared his research interests. Although capable of being outspoken and assertive in public forums, his influence most commonly played out in quiet conversations where his partner in conversation often departed feeling that they had just generated an important new idea or insight.

His strategic insights were the major drivers of research directions in pasture science in Western Australia. Over time his influence grew and helped to shape national and international research agendas. During this era Western Australia was recognised as a national and international leader in pasture research and development, and the scientific achievements were matched by wide-scale adoption of the resultant technologies by farmers both in Western Australia and nationally. It is notable that his interests were not confined to pastures and he also applied clear strategic thinking to the development of crops, with a focus on species such as crop legumes used as break-crops in sequences with cereals. A special aspect of Clive's career was his engagement in, and leadership of, an international network of scientists with strong interest in the collection, maintenance, and use of genetic resources in pasture and crop breeding programs (see Berger *et al*. 2013, this issue).

Career chronology

Two institutions loomed large in the career of Dr Clive Francis. For 33 years (1968–1999) he was an employee of the Department of Agriculture, Western Australia (DAWA), now the Department of Agriculture and Food Western Australia (DAFWA). Dr Francis was initially appointed as a Research Officer working in pasture science and breeding. He was promoted to Principal Research Officer in 1975 and continued to concentrate on research until his appointment as Chief of the Plant Production Division in 1982. In this role, his duties were increasingly managerial and during this period he was heavily engaged in national agricultural strategy development and was appointed to a series of state and national grain research and development committees, through which his influence widened. In 1989 he became Chief Scientist at DAWA before being seconded in 1992 to the Centre for Legumes in Mediterranean Agriculture (CLIMA) as Deputy Director, a position he held until his retirement. In this role he initially partnered with Professor Alan Robson and subsequently with Dr John Hamblin to create a specialised centre for research into crop and pasture legumes which gained local, national, and international recognition for its focused leadership and scientific excellence.

Spanning his tenure at DAFWA were stints associated with The University of Western Australia (UWA). Dr Francis was an undergraduate student and then undertook a PhD from 1957 to 1964. This was followed by a post-doctoral Fellowship before his appointment to DAWA in 1968. Following his retirement from the DAWA in 1999, Clive became a Professorial Fellow at UWA and continued in the role as Deputy Director of CLIMA. During this period he expanded his interest to include development of plants with pharmaceutical valuable properties and novel oilseed crops (see Campbell *et al*. 2013, this issue).

Scientific contributions

Subterranean clover

The development, commercial release, and wide-scale use of a series of cultivars of subterranean clover was the crowning element of Clive's scientific achievements. At one stage, Australian farmers were using more than 1000 t of 'his' cultivars of subterranean clover each year to sow as several hundred thousand hectares of new pastures. There are now millions of hectares of southern Australia covered by the more than 20 cultivars he bred or which resulted from breeding programs he instigated. These include iconic cultivars such as Nungarin (Francis 1976*a*), which remains the main cultivar for low-rainfall areas after 30 years, and Trikkala, which has waterlogging-tolerance characteristics (Francis 1976*b*).

The new cultivars were critically important because they overcame key constraints to the farming systems of the time. Work undertaken by Dr Francis was at the forefront of pioneering research that delivered an understanding of the negative role of a group of plant compounds, isoflavones, and particularly the compound formononetin, which causes infertility in animals grazing common cultivars such as Dwalganup and Yarloop (Millington *et al*. 1964). Not only did the work provide an understanding of the underlying plant biochemistry and its role in animal response but it led to his development of practical screening protocols that enabled selection of appropriate breeding parents from available genetic diversity (Francis and Millington 1965) to use in crossing programs to deliver adapted cultivars. Initially, the subterranean clover crossing program was undertaken in collaboration with Dr John Gladstones (Francis and Gladstones 1983), who had recognised the importance of incorporating traits from genotypes of subterranean clover that had naturalised in Australia (Gladstones and Collins 1983).

As part of this work, Dr Francis was able to tap into a critical plant collection organised by CSIRO in northern Greece (Kalznelson 1966). Genetic diversity of the subterranean clover subspecies *yanninicum* from this source was used to produce the ground-breaking, waterlogging-tolerant cultivar Trikkala, which replaced Yarloop across southern Australia (Little and Beale 1988). This breeding program gave emphasis to the importance of access to sources of exotic genetic diversity and sparked his involvement in concerted activity to expand the gene pool available to the breeding team. Genetic diversity for the subspecies *yanninicum* was subsequently added to by a collection mission to northern Greece (Francis and Katznelson 1977), and this became part of a much wider initiative to assemble genetic diversity.

Another set of cultivars (Esperance, Junee, and Green Range) was produced in response to the arrival of a major new threat, *Kabatiella caulivora* (the cause of clover scorch disease) (Chatel and Francis 1974), and again rapid screening of the genetic diversity held in genetic resource collections was fundamental to its success. In this case the critical breeding tool was the development of fast and effective disease screening methods, and a field-based protocol that resulted in identification of tolerant genotypes and resistant new cultivars followed promptly (Chatel and Francis 1975).

Over time, the scale and sophistication of the subterranean clover breeding effort grew under the broad leadership of Dr Francis, with scientific collaboration being developed to give the initiative the necessary exposure to key scientific disciplines and geographic diversity. The subterranean clover breeding program in Western Australia became the basis for the national program, with strong collaboration being built with key scientists in eastern Australia, initially with Roger Southwood and Ted Wolfe and later Brian Dear in New South Wales, Kevin Reed in Victoria, and Phillip Beale in South Australia. The elite material identified in preliminary assessments undertaken in Western Australia was multiplied and made available for evaluation in appropriate environments across the country. Over time this led to formal collaboration with pasture scientists from all southern states and the development of formal networks through which the activity was funded and managed. When cultivars were commercially released, there was a strong body of local information in place to support their adoption by growers. This process and its associated scientific and applied achievements have been comprehensively documented by Nichols *et al*. (2013, this issue)

Alternatives to subterranean clover

While passionate about the virtues of subterranean clover, Dr Francis was not oblivious to the strengths of other potential pasture species and he participated in, and advocated, a broad program of pasture species domestication based on his insights into plant adaptation and his ever-widening understanding of Mediterranean ecosystems. As a direct results of these activities a large number of species, mainly annual legumes, have been domesticated, initially for use in Australian farming systems and subsequently more widely in other regions with Mediterranean climatic conditions. The mature outcomes of this work are reported in Nichols *et al.* (2007). The species in which Dr Francis had a direct research interest included *Ornithopus compressus*, *T. michelianum*, *T. purpureum*, *T. resupinatum*, and *Medicago murex*.

Pharmaceutical uses for pasture plants

Trifolium pratense (red clover) was another target of research activity outside his primary focus on subterranean clover. Dr Francis recognised the importance of the species internationally and demonstrated that the oestrogen content of cultivars could be reduced by recurrent selection within the outbreeding populations using his efficient bioassay technique. Two low-formononetin cultivars were the outcome of this early work.

Later in his career, he became aware that concentrated plant sources of isoflavones were being sought by the pharmaceutical industry for their potential role in cancer prevention and as a natural alternative to hormone replacement therapies. He reversed the selection pressure he had earlier applied to red clover to select for enhanced levels of desirable isoflavones, and as a result, three cultivars of red clover were developed and have been used as sources of extractable isoflavones for the pharmaceutical industry.

Plant genetic resources and their application

Rationale

Dr Francis was initially motivated to engage in the collection and accumulation of genetic resources to provide material for his active breeding and selection programs, and collections were undertaken in areas where subterranean clover was likely to be located, based on a general understanding of the plant's adaptation to acidic soils and the climate of target regions. While subterranean clover was the primary target, associated species were also collected, documented, and subsequently morphologically and agronomically characterised.

The close link between germplasm acquisition and the needs of the breeding program meant that collected material was generally subject to systematic characterisation and preliminary agronomic evaluation soon after collections were completed. This was typically painstaking work that relied heavily on the team of dedicated support staff, of whom a number took part in later collection missions to further expand the collection (Nichols *et al*. 2013, this issue). The genetic diversity identified in subterranean clover and other species has subsequently been used to systematically overcome identified constraints with existing cultivars, respond to emerging challenges with pests and diseases, and to fill gaps in the array of species demanded by dynamic farming systems.

While initially motived by the direct needs of his breeding program, Dr Francis came to recognise that there was a more fundamental need to systematically collect, document, and store germplasm of a wide array of pasture and crop species to ensure their ongoing availability to plant improvement programs. Of particular concern was the pressure he observed on wild populations of many plants of interest from changing land uses and management systems. While his primary interest remained with pasture plants, he also became an advocate for conservation of genetic resources of crop plants (Francis 1986). The geographic focus of his interest also expanded to include areas adjacent to the Mediterranean (Berger *et al*. 2013, this issue).

Involvement in the wider issues around conservation of plant genetic resources led Dr Francis to express concern and have input to discussions about the adequacy, location, staffing, and resourcing of plant genetic resource infrastructure. Dr Francis became a strong advocate of a systematic approach to setting up and managing such facilities. He was also influential in the allocation of resources in Australia for the training and appointment of scientists with direct interests in these areas. He made sure when the opportunity arose with the establishment of CLIMA that both scientific and operational capacities to manage genetic resources were included and given high profile (Cocks and Bennett 1999: Francis 1999).

Personal contribution

The large and diverse collection of annual species of *Trifolium* now held by DAFWA is substantially the result of activities motivated and undertaken by Dr Francis (for details see www.agric.wa.gov.au/objtwr/imported_assets/content/past/grccollectionsite-habitatdatabase.pdf). Analysis of these plant collecting efforts, particularly the focus on subterranean clover, is detailed by Berger *et al.* (2013) and Nichols *et al.* (2013) (this issue).

His near 30 ventures in plant collection covered much of Mediterranean Europe, and West Asia and North Africa. Key features of his approach to collection included: partnering where possible with local botanists, plant collectors, and breeders; sharing of the collected material with local partners to ensure access to the collected germplasm by the country of origin; and careful documentation of the context of the collection sites. This included description of location, slope, altitude, GIS reference when the technology became available, soils and land management of the site, and climate information such as rainfall.

His 1977 collection in Sardinia is an example of his systematic approach to collecting and reporting and involves observations on the distribution patterns and ecology of the species under consideration (Francis and Gillespie 1981). This information has often provided valuable insights into where species and accessions might be targeted for use beyond the site of collection. Many of the partnerships forged through collaborating in joint collections matured into scientific collaborations and were central to networks that were formed among scientists working on Mediterranean pasture science. The collection undertaken in Sardinia is an example of one such close collaboration, with the joint collection sparking an extended phase of scientific activity (Piano *et al*. 1982), leading to the release of locally selected cultivars of subterranean clover (Piano and Pecetti 1997).

Networking and advocacy

Associated with the international exposure and networking, a growing understanding emerged of the common issues faced by Australian researchers and others working with pastures in Mediterranean climatic regions. This led to a series of visits to Australia by international scientists, joint ventures in collection and evaluation, and consultancies and involvement in international development projects.

Among those to make extended visits and establish two-way networks were David Crespo (Portugal), Efisio Piano (Italy), Mustafa Bounjamate (Morocco), Enrique Correal (Spain), Gus Gintzburger (France), and Ioannis Papastylianou (Cyprus), all of whom became important players in their domestic scientific communities and in international organisations such as FAO and ICARDA. The results of these networks have been scientifically very fruitful, resulting in large and well-organised genetic resource collections, such as those undertaken in Libya (Gintzburger and Blesing 1979), Sardinia (Piano *et al*. 1982), and Morocco (Bounejmate *et al*. 1992). The networks continue in operation with ongoing collaboration, an example of which is the current collaboration in the domestication of tedera

(*Bituminaria bituminosa* var. *albomarginata*) reported in this issue (Oldham *et al*. 2013).

Dr Francis was also insistent on the need to share the benefits of plant genetic resource collections with the countries of origin. While this is clearly important in building genetic resource collections internationally, he made a major personal commitment to support the efforts and careers of motivated collaborators. A lasting result is a high degree of respect, openness, and trust afforded Australian scientists working in his wake. It also ensures access by Australian scientists to crucial genetic resources when new constraints emerge to challenge our current cultivars. For example, he was able to activate his networks to facilitate the 'off-shore' screening of pulses for tolerance to key diseases (programs put in place for faba bean, chickpea, lupins, and field pea) (Berger *et al*. 2013).

Linked to the commitment to share germplasm collections was a conviction that outside Australia locally collected plants were likely to provide the necessary adaption when seeking domestication targets. He was a strong supporter of plant domestication initiatives based on local collection, characterisation, and field evaluation and these approaches were spelled out in consultancies that he undertook in Libya and Iraq, and he put this views forward strongly at international forums (Francis 1991).

Recognition

The scientific and practical importance of the work undertaken by Dr Francis has been widely recognised both formally and informally by his peers. He was a recipient of the Institute of Agricultural Science Medal in 1982 and their Fellowship in 1994. Major recognition occurred with the award of the Farrer Medal in 1985. He used the associated oration as an opportunity to highlight his views on the importance of plant breeding and its critical dependence on the availability of plant genetic diversity in the form of plant genetic resource collections. He had a great interest in and regard for Russian science and scientists following his visit to Moscow during the International Grasslands Congress in 1974 and a follow-up visit in 1977. He was particularly impressed by their systematic commitment and expertise in genetic resource conservation and their associated understanding of plant taxonomy. He was a long-term supporter of their endeavours and of assisting their integration into international networks. He was particularly proud to be presented with the Vavilov Institute Memorial Medal in Russia in 1999 in recognition of the support he had provided.

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