THE FUTURE ROLE OF PLANT INTRODUCTION IN THE DEVELOPMENT OF TROPICAL PASTURES IN AUSTRALIA

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ABSTRACT

Tropical pasture development with exotic grasses and legumes will continue in Australia, at a rate and in a form which will vary from time to time. The purpose of plant introduction will be primarily to produce cultivars, directly or indirectly, in order to improve animal production, stabilise pasture systems or provide nitrogen for crops. The inadequacies of existing cultivars provide the rationale for further plant improvement activity. Because of the long lead-time in plant improvement programs, any short-term disinterest by graziers and scientific administrators should not be allowed to prejudice the comprehensive requirements of long-term priorities.

The genetic resource base is sufficient to allow considerable progress in plant improvement for the next ten years. No more general purpose plant exploration and collection is needed for at least the next five years. We should increasingly search for specific genes for key species while continuing to seek untried species within the limited set of potentially useful genera. To exploit the genetic resource more efficiently we need to intensify research on adaptation and evaluation.

Plant introduction and plant breeding are complementary activities. Past trends suggest that plant introduction *per se* will continue to provide the bulk of the new cultivars until the turn of the century, but this projection may be modified by a number of factors. The availability of key personnel, the maintenance of resolve, and support from scientific administrators and funding bodies will be key elements directing both the continuing flow of new cultivars and the balance between introduction and breeding.

INTRODUCTION

Pasture plant ecosystems are being modified continually. There is no schism between "native" and "exotic" pastures, but only a difference in the degree of infusion of introduced species. Plant introduction is relevant not only to cleared forest lands, but also to native grasslands and the savanna woodlands. We have been asked to predict the future role of plant introduction in the development of improved tropical pastures in Australia. Pasture development in the tropics will continue. Are we to believe that pasture development must cease in the tropics after less than one human life span when it has proceeded in temperate regions for a thousand years? Of course not. Just as in temperate regions, development will depend on a continual influx of new germplasm and selection of new varieties. The *forms* of development may vary, depending on the suitability of the available pasture enterprises in particular land systems, and the expectations and biases of graziers and farmers. The rate of development will also vary, depending not only on politico-social and market forces but also on the drive and enthusiasm of graziers, scientists and administrators. Attitudes are as important as scientific rationality in determining policies, whether they are the policies of agricultural development or scientific research. The challenge to plant introduction scientists is to overcome short-term disinterest in improved pastures. We need to take a positive, long-term attitude to pasture development. The long lead-time in plant improvement programs (including both introduction and breeding) is another important reason for taking a dispassionate and objective view of the need for continuing plant introduction research.

PRESENT STATE OF THE GENETIC RESOURCES BASE

What is the current state of the Australian introduced germplasm base, and how well have we sampled the potential pool of material?

Let us first consider the legumes. There are about 17,000 legume species, of which 13,000 occur in the tropics. In a survey conducted in 1979, 3,400 tropical legume species were considered to have some potential for tropical pastures (Williams 1983). These included 2,500 herbaceous ones. About 1,300 of these herbaceous species have been introduced to Australia. For our current study we have surveyed the descriptive literature on the remaining 1200 herbaceous species. We believe that only about 70 of them have any significant potential, considering their growth form and freedom from toxic and other noxious characteristics. These 70 species are concentrated in ten genera in three major tribes, the Aeschynomeneae, Desmodiae and Phaseoleae.

Introduction of any of the 900 non-herbaceous woody legumes not yet introduced should be pursued with caution because of their potential for developing into woody weeds, as has occurred with *Acacia nilotica*, *A. farnesiana* and *Prosopis juliflora* (Scanlan 1986).

The "reconnaissance" phase of tropical legume introduction, i.e. the introduction of a few accessions of all species with pasture potential, is almost completed. Most of the recent legume introductions are members of genera and species already familiar to pasture scientists in the tropics. The Australian tropical legume collection has grown from 10,000 accessions in 1981 to 13,000 in 1985. Of the 3,000 new accessions, 2,100 belong to five genera (*Stylosanthes*, *Centrosema*, *Desmodium*, *Aeschynomene* and *Alysicarpus*).

The adequacy of the "reconnaissance" phase of grass introduction has not been assessed here, because no surveys of tropical grass genera, similar to that carried out for tropical legumes (Williams 1983), have been carried out to identify potential species not yet introduced. The grass collection has grown from 4,000 accessions in 1981 to 4,600 in 1985. Unlike the legumes, many of the 600 newly introduced grass accessions are from genera (*Bothriochloa*, *Chrysopogon*, *Sehima*, *Dichanthium*) and species less familiar to Australian pasture agronomists. The collection of I.B. Staples (pers. comm.) from India represents a turning point in grass introduction programs in tropical Australia, as it contains a number of species represented only poorly in our genetic resources bank. They reflect new interests in adaptation to heavy grazing and clay soils.

How adequate are our collections for purposes other than reconnaissance screening? Do we have enough representatives of genera and species known to be especially promising although poorly commercialised, and of the few very successful species? In southern Australia, genetic resource centres hold about 8,000 accessions of Trifolium species and more than 10,000 accessions of annual Medicago species and M. sativa (Crawford 1983). None of our collections of any individual tropical genera can match these figures. The largest, Stylosanthes, contains about 2,300 accessions.

Details of the collections of tropical legumes and grasses are presented in Tables 1 and 2 respectively. In these Tables, data for the most promising and economically important genera are summarised. For each genus, the number of accessions of the single most important species in commerce is given. (For Stylosanthes, the number of accessions of the four most widely sown species is given.)

With respect to the legumes (Table 1), tolerably representative collections of key species are held. Typical examples are Centrosema pubescens (571 accessions), Leucaena leucocephela (540), Neonotonia wightii (319) and Stylosanthes guianensis (635). Exceptions are Cassia rotundifolia (28; only recently commercialised) and perhaps Vigna parkeri (22) and Lotononis bainesii (44). Two species, Macroptilium atropurpureum and S. hamata, because of their particular importance in northern Australia, are also under-represented.

The number of accessions of individual grass species (Table 2) is in fact quite small, with the exception of Cenchrus ciliaris (550 accessions) and Panicum maximum (345). However, for outbreeding species such as Setaria sphacelata (208), Chloris gayana (146) and Digitaria pentzii (102), a good deal of variation is included within each accession. Further introduction of some species (e.g. Andropogon gayanus) should be delayed until their role in northern Australia is established.

The emphasis by Australians on collecting plants from Central and South America and southern Africa has been moderated in recent years. Since 1981, as well as new collections made by H.M. Stace in Brazil and R. Reid in Mexico, substantial collections have been made by K.L. Mehra (IBPGR) in Indonesia, R. Reid in Sulawesi, I.B. Staples in India and B.C. Pengelly in Papua New Guinea, of material from regions previously not well explored by Australian plant collectors. In South-East Asia and China, in contrast to India, there are very few grass species with adaptation to continuous grazing. Although the number of promising legume species is limited, the few collections that have been made in South-East Asia and China display a large intraspecific diversity, the value of which remains to be assessed.

THE NEED FOR EVALUATION

In 1979, the Northern Australian Pasture Plant Introduction and Evaluation Liaison Committee drew up a set of priorities for regional testing of introduced pasture plants, concentrating on genera such as

Desmodium, Macrotyloma, Rhynchosia, Alysicarpus, Aeschynomene and Vigna. First, the collections which existed at that time were assembled and characterised. However, further introduction has provided a host of new accessions in these genera. Although it is to be hoped that sensible classification will allow us to allocate new introductions to recognised morphological/agronomic groups and so reduce the numbers of accessions which need to be evaluated in detail, there remains a substantial backlog of material which has not been evaluated. Our first priority must be to reduce this backlog of material by further classification and evaluation. Because of this backlog, no general-purpose introduction is encouraged during the next five years, and further intensive introduction should be restricted as far as possible to key species, for which specific characters such as disease resistance should be sought.

TABLE 1

Potential and actual resources of principal cultivated tropical forage legume genera held by the Australian Tropical Forages Genetic Resources Centre

Genus (main cultivated species in parentheses)	No. of species in genus	No. of species in collection	No. of Accessions in collection
Aeschynomene (americana)	250	14	477 (182)
Cassia (rotundifolia)	450	66	318 (28)
Centrosema (pubescens)	40	28	1262 (571)
Desmodium (intortum complex)	350	160	1749 (196)
Lablab (purpureus)	2	1	187 (187)
Lotononis (bainesii)	110	25	135 (44)
Leucaena (leucocephala)	20	20	804 (540)
Macroptilium (atropurpureum)	12	8	669 (325)
Macrotyloma (axillare)	15	9	169 (40)
Neonotonia (wightii)	1	1	319 (319)
Stylosanthes	30	25	2334
(guianensis)			(635)
(hamata)			(239)
(humilis)			(219)
(scabra)			(259)
Vigna*	96	50	519
(parkeri)			(22)

* forage species only

TABLE 2
Potential and actual resources of principal cultivated tropical forage grass genera held by the Australian Tropical Forages Genetic Resources Centre.

Genus (main cultivated species)	No. of species in genus	No. of species in collection	No. of Accessions in collection
Andropogon (gayanus)	113	22	195 (76)
Bothriochloa (insculpta)	20	12	282 (21)
Brachiaria (decumbens)	50	23	193 (67)
Cenchrus (ciliaris)	25	8	636 (550)
Chloris (gayana)	40	22	228 (146)
Digitaria (pentzii)	380	50	635 (102)
Panicum (maximum)	500	62	710 (345)
Paspalum (plicatulum)	250	51	469 (39)
Setaria (sphacelata)	140	27	348 (208)
Urochloa (mosambicensis)	25	7	220 (115)

FUTURE SCENARIOS FOR PLANT INTRODUCTION ACTIVITIES

One possible scenario for future plant introduction is that it should be totally *responsive* to the perceived immediate needs of organisations, committees (e.g. Herbage Plant Liaison Committees) or individuals. Another is that plant introduction should be totally *prospective*, continually scanning and describing the world germplasm in such a way that evaluation becomes more efficient and less *ad hoc*; description should be very broad, catering for a range of end-uses (soil conservation, landscape stability, animal production etc.). The optimal strategy is probably closer to the latter than the former scenario. Because fashions and perceptions change, the long lead-time in plant introduction makes it inefficient to chop and change priorities frequently. Plant introduction should be more prospective than responsive.

A third scenario is that plant introduction should cease altogether. It could be argued that, having already introduced so many accessions, the opportunities for further useful collection are greatly reduced. Apart from considerations of genetic resource conservation, the continued success of plant collectors in discovering new characteristics in temperate pasture plants that have been cultivated for hundreds or thousands of years provides a convincing counter to this argument. An outstanding recent example of the value of wild races of cultivated temperate pasture plants is Grasslands Wana cocksfoot (Dactylis glomerata), a variety derived directly from a Spanish accession (Rumball 1982). We consider this point in more detail in the following section.

While we are discussing the future role of tropical forage plant introduction in Australia generally, and not the activities of any particular group, it is necessary to consider the changed status of the Australian tropical forage collection. In 1983, a National Network of Plant Genetic Resource Centres was established in Australia by the Standing Committee on Agriculture. One of the designated Centres is the tropical forage collection held by the CSIRO Division of Tropical Crops and Pastures. As a member of the Network, this Centre is charged with the long-term responsibility for collection, maintenance and supply of tropical forage germplasm for the various institutions concerned with pasture plant improvement in northern Australia. The International Board for Plant Genetic Resources has designated this collection as a base Centre for the international maintenance of key genera (Stylosanthes, Centrosema, Desmodium, Macroptilium, Desmanthus, Cenchrus, Digitaria and Urochloa) (IBPGR 1984). This Centre therefore has a responsibility to be a focal point for the maintenance and supply of tropical forage germplasm to the tropical world. This national and international role not only broadens the responsibilities of the Centre, but will assure the Centre of long-term access to useful germplasm from tropical regions.

INTRODUCTION AND BREEDING

Should plant introduction aim at producing new varieties suitable directly for release to graziers, or at obtaining useful genes for plant breeders? Arguments for both activities can be advanced. It is helpful to consider the relative contribution of plant introduction (providing varieties directly) and plant breeding to the total pool of pasture plant cultivars in Australia. In Figure 1, data are summarised for the years 1950 - 1985 inclusive; the "introductions" include a few cultivars bred overseas and introduced subsequently to Australia. About 280 cultivars have been released, of which about 60 were bred in Australia. The most surprising feature of the graph (apart from the remarkable linearity of the production of new varieties since about 1960) is the constant relativity of new varieties provided by breeding and introduction. Since about 1965, when the first products of Australia's post-war breeding programs were released, approximately one-third of the varieties have come from breeding programs and two-thirds from plant introduction. There is no sign that this relativity is changing.

The situation since 1980 is examined in more detail in Table 3. The overall ratio is 26 introduced varieties to 13 locally bred varieties, exactly in agreement with the long-term trend. For subtropical and tropical species, the ratio is much more in favour of plant introduction, but even for temperate/Mediterranean species more cultivars have been produced by introduction than breeding during the last five years. Irrespective of whether these trends reflect real differences in the success rates of introduction and breeding, or whether they reflect the policy decisions of research managers, we can predict confidently that plant introduction per se will continue to provide most of the new tropical pasture plant varieties until the end of this century. Indeed, taking into account the reduced pasture plant breeding activity in northern Australia since 1980, and the long lead-time mentioned previously, this result is a foregone conclusion.

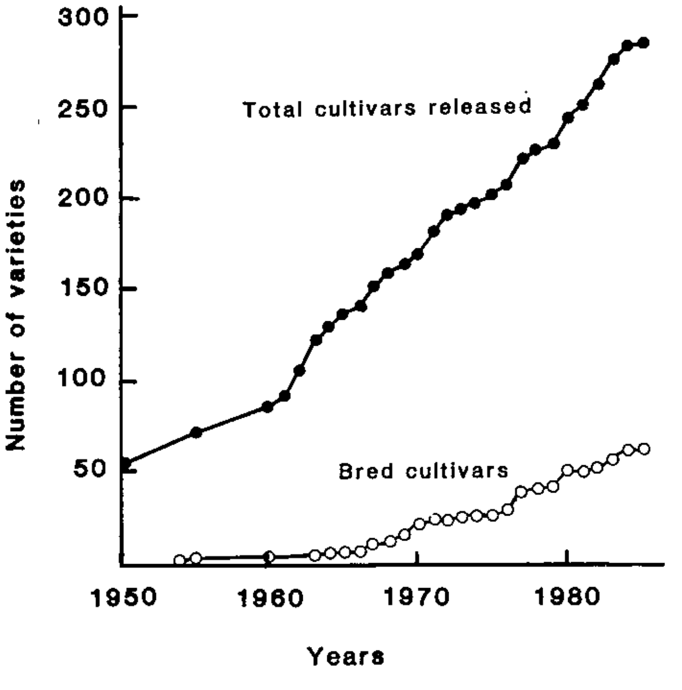

FIGURE 1
Cumulative number of pasture plant cultivars released in Australia 1950-1985.

Plant introduction and plant breeding are complementary activities. Both rely heavily on key personnel and long-term commitment by scientific administrators and funding bodies. Several factors interact to determine the priority given to each activity. Factors which favour plant breeding include emphasis on key species, increasing precision of objectives (e.g. disease resistance), a reduction in the plant evaluation network, and an over-emphasis on "trendy" research. Factors which favour plant introduction include changing niche priorities (e.g. "legumes for clay soils"), the need to preserve genetic diversity, overseas aid activities requiring germplasm diversity, the failure of breeding programs, and inadequate definition of adaptive characters.

The problem of defining adaptive characters deserves a special comment. Compared with cultivars of crop plants, most of which are re-sown in prepared seedbeds every year and managed more or less intensively, pasture plants must cope with much more variable and hostile environments. For them, success depends much more on adaptation to environmental stresses associated with climate, soils and

TABLE 3

Numbers of pasture plant cultivars released in Australia since 1980, classified by family, gross climatic adaptation and derivation.

	Temperate Mediterranean			Subtropical tropical			
	Legumes	Grasses	Total	Legumes	Grasses	Total	Grand Total
Introduced* or collected locally	12	3	15	4	7	11	26
Bred in Australia	8	2	10	1	2	3	13
Total	20	5	25	5	9	14	39

* Includes 6 cultivars bred overseas and introduced to Australia.

Sources: Mackay (1982), and unpublished minutes of State Herbage Plant Liaison Committees.

biotic hazards such as grazing, burning, pests and diseases. In the pastoral environment, uncontrollable stresses interact and it is difficult to observe or isolate the effect of a particular adaptive response on the overall fitness of a variety (Clements et al. 1983). Discipline-oriented scientists tend to invoke certain specific attributes as "key" factors in success or failure; the truth is, these adaptive features are only a few of many possessed by the plant, and their study commonly reflects the interests of individuals in a particular feature perceived in the plant after it has been selected by empirical techniques. The diversity and complexity of adaptations in pasture plants is so great, and the scope for combinations and interactions of adaptive characters so pervasive, that we may always be limited by a lack of understanding of adaptation and co-adaptation at the level of individual characters. Furthermore, at this level the breeder has to deal with co-adapted gene complexes and linkages which are poorly understood; statistical-genetic techniques for "measuring" adaptation in breeding programs rarely provide insights into "key" adaptive characters. Advances in understanding adaptation ultimately will make the plant introduction process more efficient as well as focussing the efforts of plant breeders.

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