PLANT INTRODUCTION FOR SPECIFIC NEEDS IN NORTHERN AUSTRALIA

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ABSTRACT

Experience has shown that the initial projections of sown pasture development in northern Australia were over-enthusiastic. Cultivars released over the last two decades have generally not had the wide adaptation that was anticipated. However, many of these cultivars are very successful within their areas of specific adaptation. If sown pastures are to be made more versatile, and their benefits extended, then more cultivars will be required to meet defined needs. More variation is required within species (and cultivars where appropriate).

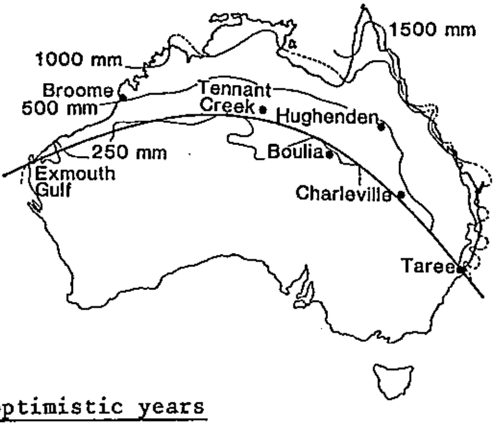
Plants are required to meet the following specific needs (in order of priority from a pastoral viewpoint): legumes for clay soils, revegetation, wet places, browse, saline and alkaline soils, horticulture and agroforestry, and amenity plantings.

INTRODUCTION

The area under consideration is that part of northern Australia with predominantly summer rainfall (Fig. 1) - about 2.7 million square kilometres.

FIGURE 1

Australia, showing selected rainfall isohyets (mm) in the predominantly summer rainfall tropics and sub-tropics north and east of an arc from Exmouth Gulf in Western Australia to Taree in north-east New South Wales.



The optimistic years

During the first two decades of intensive research on tropical pastures in northern Australia (1950-1970), there was an air of enthusiasm for broad brush solutions to the problems of sown pasture development. This optimism was bred by a buoyant beef cattle industry, and the very promising results of early experiments on the naturalised legume *Stylosanthes humilis* (Townsville stylo) (Norman and Arndt 1959; Shaw 1961). It was encouraged by the release of Siratro (Hutton 1962); and it fed and grew fat on the demands of large scale land development. There was a vision of a wide-spread tropical pasture revolution which would rival the impact of sub clover in southern Australia.

The panaceas

In 1965 Davies and Eyles saw some 113 million ha of the gross area of about 164 million ha above 500 mm annual rainfall in northern Australia, as available for intensive pasture development. Twenty years on, in the case of Queensland, actual development of sown pastures has averaged less than 170 000 ha/year (based on the total of 3.9 million ha quoted by Weston _et al_. (1981).

What happened? Firstly, the beef slump in the 1970s brought pasture development to a halt. But in addition to that, we believe the projections made in moments of high enthusiasm in the 1960s were just too optimistic to be achieved with the limited suite of plants then available.

Even the official descriptions of registered cultivars tend to reflect the optimism of the times and the broad brush approach. Glycine (_Neonotonia wightii_) is a good example. It is _described_ as useful between the 760 and 1500 mm isohyets - about 318 000 square kilometres of Queensland. Its _actual_ area of potentially useful pasture production is barely 10 000 square kilometres (Weston _et al._ 1984), yet it is not until one reads further into the registration that one becomes aware of its restricted edaphic and temperature tolerances. Unfortunately, the build up of extravagant expectations may obscure the fact that well-adapted plants can contribute a great deal to animal production in specific situations; albeit each on a small scale when measured on area alone. Some 29 species are currently doing so in tropical Australia ('t Mannetje 1984).

We argue that the broad brush approach is inappropriate, even potentially dangerous.

There is a mosaic of interacting biological and economic factors: climate, soils and landform; enterprise, infrastructure, management and motivation. These enjoin us to work towards a comparable range of options in terms of plants. The optimum specific solution to a need will usually be more acceptable (i.e. profitable) than a general solution which will suffer from the lowest common denominator syndrome. Moreover, there is the very real danger that introduced plants which seem to be highly productive over a very wide range of conditions, may be exhibiting an artificial and probably short term advantage conferred by the absence of their natural pests or diseases.

Such was probably the case with Townsville stylo. This once vigorous annual of high quality and digestibility was thought capable of colonising some 40 million ha of tropical Australia (Begg 1972); but because of its susceptibility to anthracnose it is no longer recommended for sowing, and the productivity of existing areas is much reduced.

Large scale development based on a single species, or a few closely related species, can be a very risky business. Perhaps more so in the absence of a serious pest or disease to put a ceiling on expectations.

The overriding case for productivity

On the other hand, there is no joy in low productivity. There is profit in production, and we need it, and the prospect of higher levels of it, to have the means and motivation for development.

Moveover, it is not sufficient that the plants themselves be productive, it is necessary that stock grazing those plants should do appreciably better (in whatever relevant sense) than they would do under the status quo. Thus, on the ancient, leached, impoverished soils common in much of far northern Australia, species of Stylosanthes grow satisfactorily in the absence of phosphorus fertiliser, but beef cattle grazing such low phosphorus pastures do not grow satisfactorily in the absence of direct mineral supplementation (Hendricksen et al. 1986).

The disadvantage of low cost development is that the return is usually slow. Graziers may prefer to start at a more intensive level of development where the outlay is higher, but the return is fast. This is certainly much of the appeal of nitrogen-fertilised pure grass pastures compared with legume based mixed pastures in the dairying industry on the Atherton Tableland. It may be a factor in recently expressed intentions to clear land for fertilised Stylosanthes pastures on a number of properties on Cape York Peninsula, despite the official recommendation to sow direct into undisturbed woodland.

The need for quick returns on money invested has implications for plant introduction and evaluation. In the first place, persistence under low fertility and responsiveness to high fertility (as in Stylosanthes) is a double bonus because pastures established in boom times may survive the bust cycles and be available for rejuvenation at lower cost in the next boom. Secondly, it suggests there may be less resistance than we might have supposed to a form of catch cropping in a pastoral sense, given species of obvious value in specific situations. Certainly, oat crops for finishing beef cattle are already widely used in central Queensland. Perhaps we could also give attention to possible companion species for the relatively slowly establishing but strongly persistent species, to ensure greater productivity early in the life of the pasture.

VARIABILITY AND PERFORMANCE

In addition to the requirement for a range of species to meet the range of environmental conditions encountered, there is a need to provide variation within species of apparent wide adaptation to ensure adequate productivity and reliability throughout the regions where they are recommended for sowing.

Although a species may have wide adaptation, narrowly based cultivars are not likely to give optimum production throughout the species range. Evidence of the necessity for variation may be found in the naturally developed ecotypes of Townsville stylo (Cameron 1965; Downes 1966) and subclover (Quinlivan and Francis 1977); and the variation between natural populations of important widespread native grasses such as spear grass (Heteropogon contortus) (Tothill 1966, 1968) and kangaroo grass (Themeda australis) (Evans and Knox 1969; Groves 1975).

Intraspecific variation may be achieved by providing a number of cultivars, each with a defined range of adaptation. This approach did not find commercial acceptance in the cases of glycine and Townsville stylo ('t Mannetje 1984), but it seems to have been very successful with subclover in southern Australia (Quinlivan and Francis 1976).

Alternatively, an intrinsically variable cultivar may be deliberately released with a view to encouraging its rapid adaptation to specific environmental conditions once in commercial use. Hutton (1962) adopted this approach with Siratro. However, in self-pollinating species this could lead to a loss of vigour in later generations.

Thirdly, the cultivar may contain a deliberate mixture of genetically diverse lines in the expectation that one or more of them will prove specifically adapted to a given environment. This approach may have benefits from the point of view of disease control as well (Irwin *et al.* 1986).

There are dangers in the second and third approaches unless there is sufficient natural outcrossing to ensure genetic variability is maintained at high levels in seed production fields. For example, the shrubby stylo (*Stylosanthes scabra*) cultivar, Seca, can be changed dramatically in plant form and flowering time by a single early harvest of the seed crop (J.M. Hopkinson pers. comm.).

Proven and proving performance

Crop plant improvement programmes place great emphasis on adapted varieties as the bases on which to build for the future. However, in pasture plant improvement there has been a strong tendency to stick with the new and the pure. *Panicum maximum* cv. Riversdale is a rare example of a tropical pasture plant cultivar deliberately selected from an existing, highly adapted and productive population (Mackay 1982) - and its development had more to do with commerce than with pastures.

In some ways it was desirable that introductions should be individually examined and tabulated, for in this approach lay the groundwork to build a theoretical structure for plant introduction, as distinct from assessment. However, at least in the dry tropics, it is painfull work, with a very large component of wasted time putting quantitative values on failures to meet the formal requirements of "the experiment" (e.g. see Anning 1982; Clements *et al.* 1984).

We suggest more emphasis should be given to mass selection techniques, at least in those species where some degree of outcrossing can be expected. This would be a far more efficient way to expose a large number of genotypes to a wide range of environments, and should speed the development of ecotypes well adapted to specific enviroments. However, the development of such techniques will need careful consideration and experimental validation before they can be applied with confidence to the evaluation of perennial plants under grazing. Perhaps this approach could be adapted for selection at the species level too, provided all the material being assessed has similar management requirements.

In general, the techniques for plant evaluation used to date have aimed at finding "the" genotype for the widest possible area. It may be more profitable in the future to develop techniques for selecting and utilising genetically variable cultivars when there are serious constraints (e.g. commercial seed production) on the development of a number of specifically adapted lines.

SPECIFIC NEEDS

When talking of "wide adaptation" in the first part of this paper, we have been considering needs arising from rather subtle changes in various aspects of the total environment: climate, soil type, land form, application and management. However, one or more of these factors may have an overriding influence on plant growth and production, thereby giving rise to well defined specific needs for adapted plants.

The limiting factor(s) may be intrinsic (e.g. saline soils, impeded drainage, frost incidence, photoperiod, rainfall extremes), or imposed by the needs and methods of commercial practice (hay and cover crops, irrigated pastures, under- or over-utilisation). Whatever their nature, there are many which can be identified in northern Australia. In fact, specific needs exist wherever existing plants are not specifically adapted. Excellent regional analyses of them may be found in the proceedings of the plant introduction and evaluation workshop held in Brisbane in September 1984 (Cameron 1985). At the trans-regional level, we suggest the following order of priority: (i) legumes for clay soils; (ii) revegetation; (iii) wet places; (iv) browse; (v) saline and alkaline soils; (vi) horticulture and agroforestry; (vii) amenity plantings.

Obviously, priority is a matter of perspective and the above list was written from a pastoral point of view. Other groups of specialists and users may define other needs for plants, which plant introduction people will endeavour to satisfy.

Legumes for clay soils (vertisols)

This is seen as a major need in northern Australia, especially in view of the large area concerned. Legumes are needed to reinforce the native grasses on the vertisols of the semi-arid zone, especially in situations such as where presently low quality Mitchell grass (*Astrebla* spp.) hay is made. There are also more specialised needs relating to the feeding of weaner ewes for as short as two months in April/May, which could involve bore-water irrigation where practicable.

Native legumes which typically grow on these vertisols are found in the genera *Alysicarpus*, *Psoralea*, *Rhynchosia*, *Sesbania* and *Vigna*. Perhaps these could be encouraged? They certainly give a guide to likely new introductions. There are also introduced plants known to be adapted to these soils, which makes them or their relatives potential candidates for commercial exploitation: *Clitoria ternatea*, *Desmanthus illinoiensis*, *D. subulatus*, *D. virgatus*, *Indigofera schimperi*, *Macrotyloma daltonii*, *Rhynchosia minima*, *R. sublobata*, *R. totta* and *Vigna trilobata*. As well, *Trifolium alexandrinum* tolerates saline conditions, so may be suited to bore water irrigation for autumn feed.

Nearer the coast where rainfall is higher, the vertisols are being increasingly cultivated and cropped. Good ley species are needed to provide a pasture phase in the cropping system for soil conservation purposes. The disturbance and fertility inputs implicit in a ley farming system give scope for plants such as *Alysicarpus*, *Cassia mimosoides*, *Indigofera hirsuta*, *Macroptilium gibbosifolium*, *M. lathyroides*, and African *Psoralea* spp.

Caution is needed with ley species to ensure that they are not too competitive as volunteer weeds during the cropping phase, and will not contaminate the commercial produce. Given modern farming practices, they should be susceptible to at least one common, economical herbicide.

Revegetation

Degraded lands There is a need for quick growing grasses in areas such as the Fitzroy Basin in Western Australia (350 mm average annual rainfall). Perhaps they should not be too palatable either. But great care is needed with that approach lest they become weeds and displace more useful grasses in other areas. Grasses and legumes which come from very low rainfall areas may be useful here, e.g. Cenchrus ciliaris and Zornia glochidiata. There are others which we in Australia know of, but very little about, e.g. Digitaria nodosa, Eleusine compressa, and Sporobolus nervosus (Bogdan 1977).

River frontages In the dry tropics these are often seriously overgrazed, weedy, and eroding. There are many legumes and grasses which could be evaluated, depending on rainfall and soil. It is difficult to imagine any coping with the extreme overgrazing and trampling typical of many of these situations, unless they are very unpalatable and therefore weedy. Stock control would appear to be a prerequisite for successful revegetation, in which case many existing legume cultivars would do a good job where they are climatically adapted. Sward-forming grasses from the genera Bothriochloa, Cynodon, Digitaria and Urochloa could be tried; and tough low growing legumes from the genera Alysicarpus and Zornia.

The problem may also exist in moist environments such as on the Daintree River, which is a notorious example of man's stupidity.

Grass associate for fertilised legume pasture It has become apparent in the dry tropics that the introduction of legume (Stylosanthes spp.) plus fertiliser into natural savannah, leads to rapid loss of the native perennial grasses due to the high grazing pressure possible in such circumstances. Vigorous perennial grasses which can withstand this pressure, and which can be established economically along with or subsequent to the legume, are urgently needed. Candidates for evaluation include Andropogon, Bothriochloa, Cenchrus, and Urochloa from comparable climatic regions.

Mine revegetation We believe there is no argument for the introduction of exotic plant material of little intrinsic value except that it will grow at pH 2. Mining companies should be expected to ameliorate conditions to the point where either (i) some economically viable primary industry can be established; or (ii) the native flora can be re-established so as not to interfere with land use options at some future time.

Wet places

These include seasonally flooded areas, swamps and shallow ponds, areas of impeded soil drainage, and seepage areas. They are especially important because they may extend the growing season on a significant proportion of a property and, in the case of swamps and ponds, there is already a well accepted technology for their use in central Queensland based on para grass (Brachiaria mutica).

Species of grasses and legumes adapted to wet places include: Aeschynomene flutans, A. americana, A. indica, Sesbania spp., Vigna luteola; Acroceras macrum, Brachiaria mutica, Echinochloa polystachya, E. pyramidalis, Hemarthria altissima, Hymenachne amplexicaule and Sporobolus helvolus.

Seepage areas are especially important in northern New South Wales and some promising legumes are Arachis repens, Glycine sp. nov. (native), Lotus spp., Macroptilium lathyroides, Trifolium spp. (African) and Vigna parkeri. Other genera worth evaluating in this situation are Desmodium and Teramnus.

We urge extreme caution in evaluating plants for use in flooded, swampy or ponded situations. There is serious risk of totally changing the biology of streams and lagoons to the detriment of native fauna, and commercial and recreational fishing.

Browse plants

Leucaena leucocephala is the pre-eminent browse plant as far as ruminants are concerned in the tropics. However, it does not have wide edaphic adaptation. Other possibilities include species of: Acacia, Codariocalyx, Desmanthus, Desmodium , Flemingia, Grewia, Indigofera, and Otoptera. Many potentially useful leguminous (and other) shade and fodder trees have scarely been evaluated in northern Australia (e.g. Albizia, Baphia, Brachystegia, Gliricidia and Isobelinia).

Great caution is needed in evaluating browse plants, lest they should prove weedy, and form thickets.

Horticulture, agroforestry, and amenity plantings

In terms of saline and alkaline soils, horticultural cover crops, soil conservation, species adapted to agroforestry, and amenity plantings (roadsides, lawns, parks and gardens) we have, in general, only used species thrown up by the pasture programme. There has been no deliberate collection for any of these purposes, yet it may well be true that there are more lawns irrigated than pastures.

Many present park and lawn grasses in tropical Australia are not very suitable because of their high water requirements and promiscuous flowering. A very late flowering Bothriochloa pertusa type of plant could make an excellent tropical lawn grass.

Amenity plantings require species which are easy to establish and have low maintenance and water requirements. In parks we want dense cover which will stand traffic; on roadsides we want green growth, but low yield to reduce fire hazard. Consideration could be given to species of the legumes Arachis, Desmodium, Kennedia and Zornia; and the grasses Bothriochloa, Cynodon, Digitaria and Paspalum.

Orchardists want species which are easy to sow, low growing, weed suppressing, non-twining, and leguminous (to fix nitrogen). It is hard to imagine such a legume suppressing tall tropical grasses and weeds. However, perennial Arachis spp. are promising and the Indian horse gram (Macrotyloma uniflorum) can do an excellent job of smothering grasses, without being too vigorously twining. A combination of Stylosanthes spp. plus timely slashing or mowing may be the best present solution in the northern horticultural districts.

Ornamentals and culinary delights

Many tropical legumes have flowers or attractive foliage which could be exploited by the horticultural industry (nursery trade), for example: Caesalpinia, Cassia, Centrosema, Clitoria, Dioclea, Otoptera, Peltophorum, and Periandra for ornamentals; Arachis, Crotalaria and Tephrosia for ground cover. The grass, Zoysia, is an attractive moss-like ground cover for rock gardens.

On the culinary side, young seeds of lablab bean (Lablab purpureus) are quite palatable eaten as green peas, as are young pods as fresh beans. Pigeon pea (Cajanus cajan) is also good as a green pea; when dried, it is known as red gram. The yam bean (Pachyrhizus tuberosus) has an edible tuber and, if you believe the publicity, you can eat all but the leaf rustle of the winged bean (Psophocarpus tetragonolobus). Many people are familiar with lucerne sprouts. It is possible that legumes such as Aeschynomene villosa and Desmodium cuneatum could supply tropical equivalents, but they should be checked for toxins first.

FUTURE PRIORITIES FOR ASSESSMENT AND COLLECTION

Priorities in terms of needs must be determined by the affected groups of specialists and users. Some needs may be widespread, others may be localised but very important to a particular industry. The ordering of priorities on a regional, state, and national basis is a matter for consultation and consensus.

From the point of view of the plant introduction and evaluation specialist, it should be relatively easy to decide on the basic tactical approach to the problem once the need has been defined. That is, the mix of immediate assessment of existing material versus further overseas collection and introduction. This will depend on knowledge of the important attributes of a genus or species (its world distribution, soil and climatic adaptation, and phenotypic characteristics) and on the representativeness of our existing collections (Williams 1983).

Reid (1980) showed it could be relatively simple to make a very effective assessment of the likely climatic range of a species in Australia, using the mean and standard deviation of rainfall and minimum and maximum temperature from the known world range of the species.

Conversely, it should be equally simple and effective to predict target areas in the search for new variability to meet specific needs. For example, the Charleville region may be unusual with its acid soils and winter and summer rain but areas of Botswana are similar. Northern Mexico is similar to the cooler parts of south-east Queensland. Useful arid zone grasses and legumes might be found in northern Kenya and Somalia, where the grass flora is different from most other areas.

However, we would emphasise one major difficulty in this work: we have too little knowledge of many plants to be dogmatic about their potential usefulness. A flexible approach is necessary. There is always the unexpected plant which turns out to be very useful, and the "well known" plant which turns out to be useful in an unexpected place.

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