STYLOSANTHES—A SOURCE OF PASTURE LEGUMES

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ABSTRACT

In this review we begin by considering why such emphasis has been placed on Stylosanthes *as a source of pasture legumes. The early introduction and evaluation programmes are described and the main features of the resulting cultivars presented. We then consider the more recent commercial varieties and the role that various disciplines have played in highlighting the potential value of this material. The need for a more meaningful approach to plant evaluation is stressed. We conclude by considering the potential for further introduction and plant breeding.*

INTRODUCTION

It has been estimated that some 50 leguminous genera of tropical origin (henceforth termed tropical legumes) are likely to contain species of potential as pasture legumes (Williams 1964). Of these, *Stylosanthes* is a relatively small genus. *Stylosanthes* has, however, figured much more prominently in the quest for pasture legumes than much bigger genera. It contributes about one third of all commercial varieties suitable for tropical and subtropical areas. It is the only genus to furnish species of widespread use in both the wet and dry tropics. It has commanded a high proportion of our research effort and is one of the best known tropical genera.

In reviewing *Stylosanthes*, we should consider why such emphasis has been placed on this genus, which avenues of research have been most rewarding, and what remains to be done. Although *Stylosanthes* is the main topic under investigation, many of the principles and considerations involved may apply equally well to other genera.

Early introduction and commercial varieties

In the 1930's the most likely source of improved pasture legumes for the tropics was uncertain. William Davies (1933) suggested three alternatives; the breeding or selection of indigenous plants, the possible extension of the use of temperate species of known value into the tropics and, finally, the use of imported plants from tropical and subtropical areas. The quest has now been largely limited to the importation and screening of imported tropical legumes.

The potential value of *Stylosanthes* was noted by William Davies (1933). Even before this time, however, Townsville stylo (*S. humilis*), an accidental introduction, was a valued pasture plant. By 1937, McTaggart drew attention to Townsville stylo and stated that this early success stimulated the introduction of other *Stylosanthes* material. One of these early introductions, C.P.I.‡ 5630 (*S. guyanensis*), was incorporated in grazing experiments at South Johnstone, northern Queensland (Schofield 1941). It proved to be a well adapted, productive species and was in commercial use long before it was registered. Townsville stylo was proved to be well adapted, increasing the carrying capacity of coastal spear grass pastures (Shaw 1961).

These two species dominated the introduction and research scene for many years. Of the 154 *Stylosanthes* accessions assembled in the late 1960's, 86 were of these two species. A third species mentioned by McTaggart (1937), *S. hamata*, was introduced at about the same time as C.P.I. 5630. This particular genotype was not adapted to the environments in which it was tried and further introduction was limited. In the mid 60's however, what was almost a chance introduction of this species was found to be well suited to dry tropical conditions. It has been released commercially as the cultivar Verano.

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It seems possible, therefore, that the emphasis on *Stylosanthes* has been due at least partially to a historical accident—the chance introduction and subsequent spread of *S. humilis*. If dryland *Centrosema* accessions had been acquired earlier then more attention may have been paid to this genus. Certainly this genus was already of interest since *C. pubescens* had proved to be well adapted to wet tropical conditions.

CHARACTERISTICS OF AGRONOMIC AND ECOLOGICAL INTEREST

For the present purpose, it is not necessary to delve into the taxonomy of this genus. We note, however, that taxonomic and agronomic studies have often been mutually dependent. 't Mannetje (1966 and 1969) provided a valuable insight into the genus with his morphological, physiological and rhizobial studies. Robinson and Megarrity (1975) have clarified inter-relationships between species and species forms using seed protein studies. Classifications based on mixed performance/ morphological data (Burt *et al* 1971) are proving to be useful in delimiting species and species forms and in the related field of plant geography.

Stylosanthes, taxonomically, is quite distinct from most of the other tropical legumes which have furnished cultivars; *Desmodium* is the only other genus to be placed in the same tribe. Some of these basic taxonomic differences could help to account for the success of *Stylosanthes*. We find for instance that *Stylosanthes* species are "herbaceous" or "suffruticose" rather than the usual herbaceous tropical legume which tends to be a climber. Possibly, the climbing habit is basically not suited to withstand the grazing pressures imposed on improved pastures. We note also that the fruit is non-dehiscent. The seed pod of Townsville stylo, by regulating germination requirements, aids adaptation in the dry tropics (Holm 1973). We find further that the fruit is terminated by a persistent style, which is often hooked. This may be of value for seed dissemination by the grazing animal.

The genus *Stylosanthes* is generally considered to be adapted to lighter textured, acid, infertile soils. (See data quoted by Hutton 1970). As the tropics contain large areas of such soils this may help to explain the success of *Stylosanthes*. Jones (unpublished data), has however, shown that different species or species forms may have different pH response patterns. One form of *S. hamata* is poorly adapted to acid conditions. *S. hamata* is, in fact, well adapted to calcareous soils in the Caribbean. Possibly *Stylosanthes* is adapted to a wider range of soils than was once thought. The same may also be true for other genera.

Commercial varieties of *Stylosanthes* are adapted to a wide range of climatic conditions. This widespread adaptation reflects the distribution of the genus in nature. *Stylosanthes* species are to be found growing in most tropical and some subtropical environments throughout south and central America (Mohlenbrock 1957, Burt and Reid unpublished). Individual species, such as *S. guyanensis,* contain a wide range of markedly different forms coming from different climatic conditions. In contrast to *Stylosanthes,* we find that other genera have provided cultivars for only one or two climatic types and are similarly of limited distribution in nature.

EARLY RELEASES, THEIR HISTORY, CHARACTERISTICS AND CLIMATIC ADAPTATION

It is not proposed to review our knowledge of the commercial releases in detail. We shall briefly consider the history of these plants and summarize those attributes which are deemed to have contributed to their adaptation in the various environments.

S. guyanensis *cv. Schofield.* (See reviews by Tuley 1968, Gilchrist 1967 and Barnard 1972.)

Introduced in the 1930's, this material was widely tested throughout northern Australia. It was registered as a cultivar in 1961. It is adventive in the wet coastal regions of North Queensland. Commercially, its use in Australia has contracted to this region. It is widely used in similar climatic areas throughout the world. Schofield stylo is well adapted to wetter, tropical, frost-free areas with long growing seasons. It is capable of growth at high temperatures and withstands waterlogging and periods of drought. Schofield is daylength sensitive, flowering in daylengths of less than 12 hours; hence it flowers and sets seed relatively late in the season. Although it may regrow after light frosts it is generally frost susceptible and is also intolerant of fire. Schofield nodulates with indigenous *Rhizobium* strains and is capable of growth on acidic soils of low phosphate status.

Schofield was accepted as a pasture plant before much detailed work, other than agronomic trials, was attempted. Much of the work on this genotype was carried out using it as a successful, "standard" plant. Although it has been suggested that their better crown development may enable *S. guyanensis* cv. Cook and Endeavour to withstand closer defoliation than Schofield, little is known of the phenology of these plants. Little is known of the root system. Work in Africa, however, (Talineau *et al* 1971) suggests that Schofield can extract soil moisture (and minerals?) from deeper levels than centro or Guinea grass. This may help to explain such attributes as its ability to compete with Guinea grass, to grow into the dry season, and to survive drought, and may affect its ability to grow on deep but infertile soils.

S. guyanensis *cv. Oxley.* (See reviews by Stonard and Bisset 1970, and Barnard 1972.)

Derived from material introduced in 1948, this form of *S. guyanensis* is markedly different from that which contains Schofield. It was released commercially in 1969. This cultivar is suited to drier regions of sub-coastal southern Queensland. It withstands fires, frosts and droughts, but is intolerant of waterlogging. Oxley can grow at lower temperatures than Schofield and Townsville stylo. It does not nodulate effectively with the common 'cowpea' type of commercial inoculant. Morphologically, this cultivar is finer stemmed and smaller leaved than Schofield; it has a subterranean crown which may be a significant factor contributing to the tolerance to environmental extremes mentioned. Oxley is a daylength sensitive plant flowering when daylengths exceed 12 hours (see data quoted by Barnard 1972). Flowering thus occurs early in the summer months.

S. humilis *cv. Gordon, Paterson and Lawson.*
(See reviews by Barnard 1972, Humphreys 1967 and Sillar 1968.)

This species was used commercially before it was the subject of detailed scientific investigation. It is now widely used on infertile, sandy soils in seasonally dry tropical and subtropical areas. This is an annual species which has a short day requirement for flowering ('t Mannetje 1966). Cameron (1967a and b) extended 't Mannetje's studies and showed that naturalized material had a range of critical daylengths; daylength response is of importance in causing the plant to flower at that time of year most likely to ensure its survival. 'Hard' seed is also of importance in this respect. *S. humilis* nodulates readily with indigenous rhizobia and commercial 'cowpea' inoculant; it is reputedly efficient at extracting P from infertile soils and is capable of growth at low pH levels. Although capable of growth at high temperatures, low temperature impairs seed set (Skerman and Humphreys 1973). Detailed studies on mineral nutrition, effects of defoliation and micrometeorology have also been carried out (see, for instance, Torsell 1973).

Important features of this plant are still being discovered. Hall (1971) for instance, suggests that it is very susceptible to the chloride ion, Possingham *et al* (1971) suggest that mychorrhizal associations may aid in P uptake.

LATER COMMERCIAL RELEASES

In this section, we shall include two varieties of *S. scabra* at present in the pre-release stage. A feature of all of the early commercial varieties of *Stylosanthes* is the length of time between their introduction and their release. With the exception of *S. guyanensis* cv. La Libertad, all of the following varieties were only introduced in 1965. All were included in an integrated testing programme designed to describe and evaluate a collection of *Stylosanthes* accessions over a range of climatic conditions (Burt *et al* 1971).

S. guyanensis *cv. Cook.* (See Harding and Cameron 1972, Barnard 1972.)

This cultivar was commercially released in 1971. Although generally similar to Schofield this variety exhibits better crown development and flowers some six weeks earlier. Cook was incorporated into grazing experiments in the wet tropics in 1970 and was proved to be superior to Schofield in its ability to compete with grasses and weeds, to withstand heavy grazing and to grow during the colder months. Like Schofield, it withstands waterlogging, is adapted to infertile soils, and nodulates readily with the commercial 'cowpea' inoculant.

S. guyanensis *cv. Endeavour*

This variety is intermediate between Schofield and Cook in many respects. It shows more vigorous early summer growth than the former.

S. guyanensis *cv. Libertad*

Selected from native material, this plant has proved to be resistant to the fungal disease anthracnose. It has given good yields on the Colombian Llanos.

S. hamata *cv. Verano*

At the time of its introduction, little was known about this type of plant. It was incorporated into the testing programme previously referred to and its broad general characteristics determined (Burt *et al* 1971 and 1974). It is adapted to dry tropical areas acting as a perennial or an annual-perennial mixture. It resembles Townsville stylo in its general appearance, ability to produce large amounts of seed, general rhizobial response (Date and Norris unpublished data), response to phosphorus (Jones 1974) and the manner in which P is distributed within the plant (Robinson unpublished data). It has some protein bands similar to those found in *S. humilis* and is a tetraploid (Cameron unpublished data). Differing markedly from the more 'typical' *S. hamata* described by Mohlenbrock (1957) it seems possible that the Verano form of *S. hamata* may be a hybrid between *S. hamata* and *S. humilis*.

Verano has a much wider climatic tolerance than individual genotypes of *S. humilis* (Burt *et al* 1974). The wide tolerance of the latter species may be a feature of population heterogeneity rather than the tolerance of an individual genotype (Burt, Williams and Compton 1973, Torssell 1974). Unlike Townsville stylo, vegetative growth is not markedly restricted by the onset of flowering, which occurs over a wide range of daylengths. Verano competes well with grasses and is of good feeding value (Playne unpublished data).

S. scabra

Like Verano, little was known about this material at the time of its introduction. Several species forms are now known, different forms being adapted to different types of dry tropical climates. One form thrives in areas generally regarded as being too dry for Townsville stylo. Unlike *S. hamata* and *S. humilis*, *S. scabra* is a highly persistent, shrubby plant. It is relatively low yielding in its establishment year, its yield increasing with time (Burt *et al* 1974). It is generally eaten relatively late in the season and also flowers relatively late. Like Verano, information on feeding value, phosphorus nutrition, protein patterns and rhizobial requirements have been obtained.

THE NEED FOR A CO-ORDINATED APPROACH TO PLANT EVALUATION

In comparing the early and the later commercial releases several interesting features are apparent. The first point concerns the rapidity with which the later cultivars were released. It seems likely that the provision of an objective description of a large range of *Stylosanthes* accessions, coupled with a widescale testing programme over a range of environments, contributed to this development. Earlier workers had acknowledged the importance of this approach but lacked the necessary data handling methods and communication channels to bring it about.

The second feature of interest is the part played by the various related disciplines. Unlike the early programmes these disciplines became involved at an early stage. Rather than being used to explain why a plant was or was not suitable they have been of value in determining the *potential* use of a plant form. In *S. scabra*, for instance, we now know that this species generally accepts the common type of *Rhizobium*, and grows at very low phosphorus levels. Recent information (Robinson unpublished data), suggests that it may not respond to applications of superphosphate in its second year of growth. This may then be the type of plant required for the dry tropics where continued application of superphosphate may not be economical.

A third feature of interest is the difference between the types of plant now thought to be of value in the dry tropics. Thus *S. humilis* is an annual which possesses many of the attributes commonly associated with the "weedy" habit (see for instance, Baker 1965). In many situations it behaves as such. During the dry season most of the phosphorus taken up by the plant is located in the seed or in dead plant parts. By contrast *S. scabra* is a long lived perennial. It rarely seems to achieve dominance and, in its native environment at least, does not colonize disturbed areas. Unlike *S. humilis*, it holds a high proportion of its phosphorus in roots and stem bases throughout the dry season (Robinson, unpublished data). Playne (unpublished data) has further shown that the phosphorus in the perennial, shrubby legumes may be less readily available to the grazing animal than in *S. humilis* cultivars.

With the benefit of hindsight, we may say that the advantages of Townsville stylo are in accordance with its "weedy" habit. To maintain it at a productive level in pastures, we generally have to apply relatively high levels of fertilizer and maintain heavy disturbance in the form of grazing pressure. This may result in the disappearance of many of the perennial grasses and their replacement with annuals (Ritson *et al* 1971). These changes may or may not be desirable or acceptable. *S. scabra*, on the other hand, characteristically takes several years to achieve "reasonable" yields. It may lack the ability of *S. humilis* to provide the grazing animal with dietary supplement during the dry season in the form of heavy seed yields. Its characteristics may, however, preadapt it to grazed situations where regular phosphorus application is unlikely to be practised. Further studies are needed to confirm, or refute, these suggestions.

To appreciate the potential advantages and disadvantages of such diverse plants they may have to be examined under different agronomic, ecological and economic conditions. "Standard" testing programmes in which emphasis is placed on yield or annual gains over restricted time periods may not be sufficient.

Finally, we must comment upon the need to obtain a more precise definition of what is required in our pasture species. Williams (1964) states that "Once such species are established in a moderately improved pasture, intensive studies on management and the factors affecting production become the main area of agrostological research. Such studies lead to a more precise definition of the characteristics required for a region". In many regions we have little or no knowledge of what is required in a pasture legume other than saying that it needs to be climatically adapted and capable of "reasonable" yields. With rare exceptions, the need to investigate low P agriculture was disregarded until the energy crisis forced its attention upon us.

FUTURE INTRODUCTION PROGRAMMES AND PLANT BREEDING

Of the 30 species listed by Mohlenbrock (1957) only 17 have been introduced into Australia. Although it is possible to say that certain species warrant further introduction programmes, it is difficult to say which species do not warrant any. Although some of the more subtropical species have performed relatively poorly, it is possible that interesting forms are present but have not been introduced. Several approaches have been used to try and find some priorities for plant introduction. Literature reviews have revealed the presence of certain species deemed to be of value as pasture plants (for example, Skerman 1970). Unfortunately, descriptions of the legumes in many tropical regions are inadequate or misleading. Another approach has been to relate performance in Australia against climate of origin and thus to select those species, or those areas of the world, most likely to furnish adapted pasture species. It was found that success in Australia was, in fact, related to climate of origin. Plants which yielded well in dry tropical areas came from even drier regions (Burt and Reid unpublished data). After reviewing the worldwide distribution of the various species, it was suggested that efforts should be made to introduce *S. sympodialis* and *S. tuberculata*, two species as yet unknown in Australia. *S. hamata*, *S. scabra* and *S. viscosa* were found to occur in areas and climatic types not previously collected. A visit to one such area has subsequently provided a wide range of "new" forms (Burt, unpublished data).

Until we know more about the variation present and the attributes likely to be of value, plant breeders will have difficulty in selecting breeding objectives and the plants to be used. The recent outbreaks of disease in most cultivars of *S. guyanensis* may provide one such objective.

Most of the basic work on the genetics of *Stylosanthes* has been carried out by Cameron (1967c). This author showed that the species comprise a polyploid series ($x = 10$) in which *S. guyanensis* and *S. humilis* are diploid, *S. fruticosa* is tetraploid and *S. erecta* hexaploid. Fertile hybrids between *S. humilis* and *S. guyanensis* or *S. humilis* and *S. hamata* could be produced with the use of colchicine. Further investigations into the possibility of hybridization between the different species and species forms, and characterization of the type of variation produced, could provide a valuable framework on which to base future breeding programmes.

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