SIRATRO—A SUCCESS STORY IN BREEDING A TROPICAL PASTURE LEGUME

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ABSTRACT

The paper is an introduction to a Symposium on Siratro (Macroptilium atropurpureum). *The circumstances leading to the breeding of Siratro are described, and the more important characters of the cultivar are summarized. A review of current use of Siratro throughout the world indicates that it is already one of the most important pasture legumes in Australia, Brazil, Mexico and some of the Pacific Islands, and that increased use is likely in other tropical countries.*

INTRODUCTION

There is probably no better indication of the success of the legume *Macroptilium atropurpureum* cv. Siratro than the fact that the Tropical Grassland Society of Australia has arranged a Siratro Symposium to mark the retirement from C.S.I.R.O. of its breeder Dr. E. M. Hutton. Siratro was the first tropical pasture cultivar to be produced by plant breeding. Since its release in 1960 it has steadily gained recognition in northern Australia and elsewhere in the world, and today it is undoubtedly one of the major pasture legumes in use in the tropics and subtropics.

Other contributors to this Symposium will deal with establishment, management and ecology of Siratro pastures, with levels of plant and animal production achieved, with seed production and with breeding for improvement of Siratro. Our purpose is to set the stage by describing some of the important characteristics of the cultivar and by reviewing the extent of its use in Australia and other tropical countries. Since this Symposium aims to honour both the plant breeder and the plant it is appropriate to start with a brief historical account of how Siratro came to be bred.

HISTORY

Dr. Hutton transferred from Canberra to Brisbane at the end of 1953 to start a plant breeding unit in the C.S.I.R.O. Plant and Soils Laboratory which was the forerunner of what is now the Division of Tropical Crops and Pastures. Major emphasis was placed on legumes and it is interesting to recall that the range of species available at that time was very limited. Species which had been used to any extent in experiments comprised *Stylosanthes humilis, S. guianensis, Macroptilium lathyroides, Desmodium uncinatum, Indigofera spicata, Centrosema pubescens, Pueraria phaseoloides* and *Calopogonium mucunoides*, the last two being restricted to the high rainfall tropical regions. In addition there was new material still in plant introduction testing plus some shrub legumes such as *Leucaena leucocephala* and *Cajanus cajan*. Experiments had shown *I. spicata* to be particularly promising from agronomic viewpoints but it was known to be toxic to grazing animals, and Hutton was asked to breed a non-toxic cultivar. However, this program had to be curtailed because the toxic principle had not then been identified (Hutton 1965) and he therefore looked for other breeding possibilities. He was attracted to *M. lathyroides* which had grown very well on a wide range of soil types, had mixed well with grasses and had been highly acceptable to animals, but still had serious deficiencies which prevented it being a successful pasture legume. These deficiencies were poor regeneration from seed under grazing, which is critical in an annual, and susceptibility to root-knot nematode, to

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bean fly (*Agromyza phaseoli*) and to bean virus 2 (Hutton 1962). Hutton therefore decided to look for perennial types in the same genus without these deficiencies. His basic requirements for a good legume were that it should be strongly perennial, resistant to virus and root-knot nematode, and grow well under a wide range of the climates and soils of northern Australia. In his papers he always stressed the importance of a high level of symbiotic nitrogen fixation, and he believed that the stoloniferous character was important in this regard to ensure a continual replacement of ageing roots by young ones which would nodulate freely (Hutton 1962). He also believed that stoloniferous development would be important in maintaining the stand of legume.

Through the efforts of the late J. F. Miles, who was Plant Introduction Officer at the time, he obtained a number of perennials and of these he chose *Macroptilium atropurpureum* (then known as *Phaseolus atropurpureus*) as the species most likely to produce the kind of plant he was seeking. The original breeding program which led to the release of Siratro in 1960 has been described by Hutton (1962) and subsequent developments are dealt with in another paper in this Symposium (Hutton and Beall 1977).

CHARACTERISTICS OF SIRATRO

Full descriptions of Siratro have been given by Hutton (1962) and Barnard (1972), while its growth responses to soil and climatic factors have been reviewed by Jones and Jones (1977). It is a vigorous perennial with deeply penetrating and swollen main roots and trailing stems which may root anywhere along their length. Its trailing stems enable it to spread through a stand of grass, and their twining habit enables the plant to climb over tall grass and over shrubs and small trees. It nodulates freely with native strains of *Rhizobium* and with commercial inoculants.

Siratro is a quantitative short-day plant (Hutton 1962) with a critical maximum daylength greater than 12 hours (Whiteman, unpublished data). Low temperatures tend to delay flowering but do not alter the basic short-day response (Imrie 1973). This means that flowering occurs mainly in autumn but also in spring.

't Mannetje and Pritchard (1974) found that growth responses of Siratro to temperature and daylength were similar to those of *Glycine wightii, Pueraria phaseoloides, Stylosanthes humilis* and *S. guianensis*. Regrowth of these species was reduced on average by 35% when temperature was reduced from 32°/24°C (day/night) to 26°/15°C at a 14 hour daylength; at this latter temperature growth was further reduced when grown in an 11 hour day. At 20°/6°C and an 11 hour day there was very little regrowth. Sweeney and Hopkinson (1975) reported generally similar temperature responses but they used temperatures up to 36°/31°C day/night and found that *Desmodium uncinatum, D. intortum* and *G. wightii* exhibited a growth depression above 30°/25°C whereas Siratro, *S. guianensis, S. humilis, P. phaseoloides, Calopogonium mucunoides* and *Centrosema pubescens* did not.

The foliage of Siratro is sensitive to frost leading to leaf fall. Severe frosts will kill the stolons but whole stands are not normally killed by the frosts experienced in south-east Queensland. Jones (1969) reported 83 and 65 per cent survival in two first year stands in a year when the lowest terrestrial minimum temperature recorded was −8°C.

Characteristics of Siratro which influence its growth and its adaptation to different soil situations are that it is tolerant of low pH, low soil calcium and high aluminium (Andrew, unpublished data), but it is less tolerant of high manganese than other tropical legumes (Andrew and Hegarty 1969). It is quite tolerant of salinity (Hutton 1971, Russell 1976). However, despite its tolerance of acid soils it has been observed to grow well at a number of sites with alkaline soils (Pocthier 1966, Lucas 1968, Gutteridge *et al.* 1976). Glass-house experiments also indicate some tolerance of flooding (De Polli *et al.* 1973, Seitlheko and Whiteman, unpublished data), but it is not nearly as tolerant as *Macroptilium lathyroides*.

Much of the success of Siratro may be attributed to its ease of establishment and its persistence. Seedling growth and nodulation is rapid (Whiteman 1972) and the species maintains a satisfactory population of plants both by vegetative means and by replacement of plants from self-sown seeds (Jones and Jones 1977). These characteristics also contribute to its success when oversown into native pastures (Lowe 1974, Tothill 1974).

Information on the susceptibility of Siratro to pests and diseases has been reviewed by Jones and Jones (1977) and Hutton and Beall (1977). The main problem is foliar blight (*Rhizoctonia solani*) which is most troublesome when annual rainfall exceeds about 1600 mm. A fungal disease caused by *Synchytrium* sp. is also reported as serious in the 1000-2000 mm rainfall zone of Brazil (Namekata *et al.* 1974).

USE IN AUSTRALIA

There are no statistics available for Siratro use in the early years following its release in 1960, but the approximate areas sown in Queensland in each of the years 1969/70 to 1975/76 are shown in Table 1. This table includes pastures in which Siratro was the sole legume and those in which other legumes were sown as well. There was a steady increase to a peak in 1972/73, followed by a sharp decline over the last three years. This decline undoubtedly reflects the difficult financial position experienced by beef and dairy producers over this period, and occurred with all sown pasture species.

TABLE 1

Approximate areas of new sowings of Siratro in Queensland in each of the years 1969-70 *to* 1975/76 *including mixtures with other legumes. (Derived from data in "Sown Pastures and Seed Production in Queensland", Queensland Department of Primary Industries)*

Agricultural Extension Region	1969/70 ha	1970/71 ha	1971/72 ha	1972/73 ha	1973/74 ha	1974/75 ha	1975/76 ha	Total Area Sown ha
Far Northern	170	750	390	1600	60	2000	110	5080
Northern	120	220	140	160	230	30	230	1130
Capricornia	2400	4480	5830	6330	1770	1910	1430	24150
Burnett	2270	4280	4750	6720	10440	5950	2120	36530
South Burnett	390	360	420	580	1390	690	720	4550
Near North Coast	2230	3660	3890	2740	1440	360	200	14520
East and West Moreton	2970	2840	2600	2760	2070	1160	1940	16340
Darling Downs	0	0	100	450	390	230	240	1410
Total	10550	16590	18120	21340	17790	12330	6990	103710

Table 1 also shows that the main areas of use have been between Mackay and the Moreton Region. In the Capricornia Extension Region almost all the sowings were in coastal shires from Mackay to Gladstone and there has been little use further inland because this takes in much of the brigalow country where Siratro has not been successful. However, in the Burnett Region use has been fairly evenly divided between the coastal areas from Gladstone to Tiaro, and the more inland areas (Monto, Mundubbera, Gayndah). There is some suggestion in the figures that use in the Near North Coast Region may have been declining before the onset of the rural slump, and this view is supported by P. E. Luck (personal communication) who advises that *Desmodium intortum* has proved more popular in these cooler environments.

Estimates have also been made of the use of Siratro relative to that of the other main tropical legumes (Table 2). These show very clearly that Siratro has been by far the most favoured species with the area sown being more than twice that of any other species in almost all years.

TABLE 2

Approximate areas of new sowings of the major tropical legumes in Queensland in each of the years 1970/71 to 1975/76. (Derived from data in "Sown Pastures and Seed Production in Queensland", Queensland Department of Primary Industries).*

Legume	1970/71 ha	1971/72 ha	1972/73 ha	1973/74 ha	1974/75 ha	1975/76 ha
Siratro	16590	18120	21340	17790	12330	6990
Stylosanthes humilis	8650	7780	9200	6960	2760	n.a.‡
S. guianensis†	5900	6940	7100	2260	6670	770
Glycine wightii†	4880	9580	6240	2990	1300	1602
Desmodium intortum	3230	4990	2940	1630	2410	1430
Lotononis bainesii	3130	4520	3380	2120	2580	1977

*With mixtures of legumes the total area of the pasture was credited to each species.
†Total of all cultivars.
‡Figures not available.

Siratro is also used to a limited extent in the Northern Rivers of New South Wales but its lack of cold tolerance becomes increasingly important as one moves south. It has also shown some promise in the higher rainfall parts of the Northern Territory near Darwin.

Other papers in this symposium will deal with the ecology of Siratro pastures and with their productivity and feeding value. It will suffice here to state that Siratro-based pastures in Australia have been highly productive and persistent. The legume is generally adapted to areas with annual rainfall of from 750 to 1800 mm, although in southern Queensland the lower limit is probably nearer 650 mm. It does not perform well in the high rainfall humid tropics where disease is an important factor. It will grow on a wide range of soils from sands to clays, but it has not persisted on the heavy clays of the brigalow region and it is not suited to poorly drained soils. It is generally considered to be more tolerant of low fertility than *Glycine wightii* or *Desmodium intortum*, but less tolerant than *Stylosanthes humilis*. However on infertile soils it responds very well to improved nutrition. It is compatible with a wide range of grasses and these mixtures stand grazing very well.

The ease and rapidity of establishment of Siratro have made it well adapted for reclamation projects, and in Australia it is used for covering road and railway cuttings, revegetating road batters and embankments, and reclaiming coal spoils. It is also being used to reclaim recent deposits of lava in drier areas of Bali and West Java.

USE OUTSIDE AUSTRALIA

A search of papers listed in Herbage Abstracts has shown that Siratro is being widely used in pasture research in the tropics. Many of the papers refer to early stages in research programs and in the following sections we have summarized what we believe to be the main points relating to its present or possible value in various countries, but without presenting a full review of all published work. In addition we have made use of information available to us directly from colleagues who have visited parts of the tropics in recent years.

South and Central America

The greatest impact of Siratro outside Australia has been in Brazil and Mexico.

Herbage Abstracts lists many papers from Brazil indicating good performance in species evaluation studies but commercial development has far outstripped research results. Hutton has travelled extensively in Brazil in recent years and he informs us that Siratro and centro are the two main legumes being used in commercial pasture development. Siratro is the main species in central Brazil where most development is on well-drained soils of moderate to good fertility, many of them derived from basalt:

rainfall is 1000 to 1500 mm with a summer incidence, and most of the areas are frost-free. At one stage diseases threatened the continued use of Siratro, but Hutton advises that this hasn't proved as serious as was thought at first. Many of the productive stands seen by him were five to six years old. He also advises that a shortage of seed has restricted plantings since Brazil imposed a ban on importations from Australia. Centro is mainly used in the humid tropics of the Amazonian region.

The species *M. atropurpureum* is indigenous to Mexico and therefore it is not surprising that the cultivar Siratro has proved to be well adapted there. Hutton advises that it is being sown extensively by the Bank of Mexico in its farm development program, principally in the Yucatan Peninsula and on the west coast in the region of Acapulco.

There are reports of Siratro being used in experiments in other countries of South and Central America, but most investigations are at a very early stage. At Cali, Colombia, Siratro was severely affected by foliar blight and bean rust (*Uromyces phaseoli*) but other lines of the species were found to be resistant (CIAT 1974). One interesting report is from Guadeloupe (Pocthier 1966) where Siratro was one of the most promising legumes on alkaline soils. The most detailed testing has been done by Kretschmer and his colleagues in Florida and Costa Rica. Siratro is recommended for use with pangola (*Digitaria decumbens*) and *Paspalum notatum* cv. Pensacola in central and south Florida on better drained soils or soils with adequate surface drainage (Kretschmer 1972). However, disease problems have been reported (e.g. Sonoda 1976). In Costa Rica it performed very well in the Guanacaste region and remained green with continued vegetative growth in the dry season (Kretschmer 1971).

Africa

Siratro is being used in experiments in many parts of southern, east and west Africa. Reports of good performance and persistence under grazing, either with sown grasses or with native pasture, come from Swaziland (Anon. 1967), the Lilongwe Plain of Malawi (Thomas 1975), Zambia (van Rensburg 1969), Uganda (Stobbs 1969). It has also been reported as promising in Natal (Mappledoram and Theron 1972), Tanzania (Walker 1969), Malagasy (Graham 1974), and Senegal (Nourrissat 1966). On a recent visit to Kenya R. W. Strickland (personal communication) saw Siratro performing very well on deep sandy soils on the coast near Mombasa, but it was not successful in the highlands probably because the nights are too cold.

Asia

We have seen several references to work in India and Sri Lanka in which Siratro is named as a promising species but there is no indication that it has gone beyond early testing. In south-east Asia Siratro has not been a success in the high rainfall humid tropical areas (authors' own observations), but it appears that it could be a useful species in areas of moderate rainfall with a dry season. For instance in north-east Thailand Robertson (1975) reports that Siratro is promising for marginal forest areas where grazing is not heavy; these areas have poor sandy soils and rainfall of 1200 mm (85% from May to October). It has also performed well on limestone-derived soils in the south-east corner of Bali (Rika and Whiteman 1976), and in trials in Timor and North Sulawesi (Whiteman, personal observations); rainfall at these three sites is 1200 to 1300 mm annually.

Also in Bali in an area of alluvial soil (1300 mm rainfall) Siratro performed well in a grazing experiment under coconuts provided stocking rates were not too high (Nitis *et al.* 1976). After three years grazing the percentages of Siratro and centro in the pasture with *Brachiaria decumbens* were 50% and 14% respectively at 1.8 AU ha^{-1}, 16% and 30% at 2.4 AU ha^{-1}, and $<1\%$ and 16% at 3.1 AU ha^{-1} (1 AU = 1 steer of 400 kg liveweight). In another trial under coconuts at a drier site in West Bali with a 5 to 6 month dry season, Siratro performed better than centro over the dry period (Whiteman, unpublished data).

Pacific Islands

There are several instances of Siratro being used in farm pastures in the south Pacific region. Lucas (1968) reports that green panic/Siratro provides the best mixture yet tried on the island of Niue, and in a recent letter he states that the area sown is now over 400 ha. Apart from its grazing value, Siratro seed has also provided an export income for the island. The soils there are alkaline and rainfall is about 2000 mm, but there is a dry season.

In Fiji, Siratro has performed well in the dry-intermediate zone (1000-1500 mm) of Viti Levu (Partridge 1975) and it has increased the yield and nitrogen content of the associated grass. C. S. Andrew (personal communication) states that these pastures are performing very well under grazing and that they are being used in Village Group Resettlement Schemes. In trials at 5 sites in the Solomon Islands with rainfall from 3000 to 4000 mm Siratro was generally not as good as *Centrosema pubescens, Pueraria phaseoloides* and *Desmodium heterophyllum*, but at one site on an alkaline soil of pH 8.0 Siratro was best (Gutteridge *et al.* 1976).

R. J. Jones (personal communication) advises that persistent stands of Siratro/para grass (*Brachiaria mutica*) exist in the Markham Valley of New Guinea.

CONCLUSIONS

This brief survey of Siratro use shows clearly that it is already an important pasture legume in Australia, Brazil, Mexico and some of the Pacific Islands. Increased use in these countries is certain, the major constraint being the economics of animal production. Siratro has also performed well in preliminary evaluation experiments in many other tropical countries and we have no doubt that further work will lead to recognition of greatly increased geographical adaptation. However in many of these countries there is, for a variety of reasons, little immediate prospect of substantial pasture development and therefore it would be wrong to predict rapid increase in use. However, important features in favour of Siratro in less developed areas are its good seed production and the relative ease of hand-harvesting seed pods.

Information on performance outside Australia is extending our knowledge of the range of adaptation of Siratro. Latitude does not seem to be of much importance within the range 28°S to 28°N, provided that rainfall is between about 700 and 2000 mm. Nevertheless greatest use at present is at the higher latitudes within this range. Most areas of adaptation have a dry season of three to five months duration, but Siratro has not persisted in areas where the dry season is virtually rainless and of more than about four months duration. It may well extend into slightly lower rainfall regimes provided that the dry season is not too long, and provided that the year to year variability is not too high. The high rainfall end of the range of adaptation is less definite. Siratro certainly does not perform well in the true humid tropics where it is subject to severe disease problems. However, at one site in the Solomon Islands it has persisted under a 2900 mm rainfall, but the climate is not continuously humid, and the soils are well drained with a low water-holding capacity.

The temperature effects of most importance are those at the start and end of the growing season. Low temperatures at these times can severely restrict growth with consequent effects on the amount of feed produced and on the amount of nitrogen fixed. This would be particularly important in the southern parts of Africa and Brazil where much of the country is elevated. Frosts kill top-growth and therefore affect the feed situation, but they would rarely be severe enough to kill the whole plant in areas where late growing season temperatures are favourable.

Siratro is adapted to a wide range of soils with respect to texture and pH. It does particularly well on many sandy soils and can also succeed on quite shallow soils. Poor persistence has been found on some clay soils, although not all, but the reasons for failure are not yet known. Problems arise in wet soils whether they be sands or clays.

There is some uncertainty about the importance of disease in future use of Siratro. This factor certainly limits use of the cultivar in high rainfall areas, but within the general range of climatic adaption disease has not yet proved to be critical. However, there has been cause for much concern in Brazil in some years. The importance of disease may well increase as use of Siratro intensifies in any area, and therefore selection for disease resistance has been included in the current breeding program (Hutton and Beall 1977). But there seems little point in devoting research resources to breeding disease resistant cultivars for the humid tropics because there are already legumes adapted to those areas.

Finally, we must refer to the newly bred lines of *M. atropurpureum* which are nearing release. Another paper in this Symposium (Hutton and Beall 1977) describes how these have been selected to reduce the effect of some of the factors limiting use of Siratro, and therefore the range of adaptation of the species should be extended. In view of the benefits already obtained from Siratro, a new cultivar can be expected to be of great benefit to tropical agriculture.

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(Accepted for publication January 13, 1977)