CENTROSEMA PUBESCENS IN AUSTRALIA

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ABSTRACT

Since its introduction into Australia some 40 *years ago, common centro has proved to be one of the most versatile legumes in the wet tropics. Its general productivity, ability to withstand poor grazing management in grass-legume combination and freedom from important pests and diseases are the chief reasons for its popularity. Fairly exacting soil fertility, rainfall and temperature requirements are the most important weaknesses. The agronomic potential of* Centrosema *is largely unexplored but a relatively simple introduction programme resulted in the release of Belalto, a cultivar which is not as temperature-sensitive as common centro.*

INTRODUCTION

Centro (*Centrosema pubescens*) was among the first of the tropical legumes to be introduced and used commercially in northern Australia. After 30 years it is still one of the most important and productive legumes in certain situations in the tropics. Rather surprisingly it is only recently that a variety (cv. Belalto) deemed to be better than the original has been found. No other species of *Centrosema* is commercially available. This contrasts strongly with the genus *Stylosanthes.*

In this review, Australian knowledge of the commercially available varieties is summarised and helpful reference to information gained overseas made. Data on cv. Belalto is still somewhat restricted and unless otherwise stated, information presented in the subsequent sections refers to the common centro, comparisons with Belalto being made where possible and relevant.

ORIGIN AND DISTRIBUTION

The genus *Centrosema*, containing some 30 (Standley and Steyermark 1946) to 70 (Ducke 1949) named species, is distributed through Central and South America and the Caribbean. *C. pubescens* is one of the most widely distributed of all the tropical legumes, and is now found in most wet tropical areas of the world. Although it appears, characteristically, to be a low altitude (Atkinson 1970), long growing season species, it has been found at altitudes of 1260 m in Panama, growing just below the subtropical *Desmodium intortum.*

Centro (*C. pubescens*) was first introduced into Australia from Java in 1930. Originally imported into south-east Asian areas, probably in the latter part of the 19th century, centro rapidly found favour as a green manure or cover crop in plantations (Barnard 1969). Subsequently it was sent to other areas, such as India and Ghana, becoming naturalised in Java (Schofield 1941, Walsh 1948). Evaluation was undertaken by the Department of Primary Industries at South Johnstone, as early as 1939 and resulted in the release of common centro. Subsequent examinations have been carried out throughout much of Queensland including the Mackay district (Goodchild 1955), under irrigation in the Burdekin Valley (Allen and Cowdrey 1961) and south-eastern Queensland (Douglas 1962, Schofield 1945, von Stieglitz, McDonald and Wentholt 1963). Experience has shown, however, that centro is not well suited to areas other than the wet tropical lowlands (Bryan 1968, Barnard 1969).

Belalto was the result of a plant collecting and testing programme aimed specifically at finding legumes with improved cool season growth. It was collected in

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Costa Rica and following testing at South Johnstone where it exhibited consistently better cool season growth and higher annual yields than common centro (Grof and Harding 1970a), it was released commercially (Harding and Cameron 1972).

ENVIRONMENTAL ADAPTATION

Climate

Commercial centro is classically a legume for the wet tropics. Of the species studied by 't Mannetje and Pritchard (1974), centro showed the most dramatic response to a change in temperature. At a daylength of 14 hours, centro yield at day/night temperatures 26°/15°C was only 16% of that at 32°/24°C. Below screen temperatures of 25.6°C (maximum) and 12.8°C (minimum) growth is severely restricted (Bowen 1959*a*). Frost causes severe damage although regrowth may occur in well established stands if the crown and the stem bases have been sufficiently well covered (Douglas 1962, Schofield 1945, Barnard 1967). In more southerly latitudes (New South Wales) lack of cold tolerance causes this strain to act as an annual (Cameron 1958). The newly released cultivar of *C. pubescens*, Belalto, is much more productive in the "cool season" than common centro (Grof and Harding 1970a). This probably reflects its relatively high altitude origin.

Although common centro will grow in areas receiving as little as 1,000 mm of rain per annum (Wilson and Lansbury 1958, Humphreys 1974), its performance is much better in higher rainfall areas (Walsh 1958, Barnard 1967, Goodchild 1955).

Soil type and drainage

Common centro can be grown over a wide range of soil types (Humphreys 1974) but recent evidence suggests that it is most suitable for pasture mixtures on soils of moderate to good physical and chemical fertility. On poorer soils, stylo (*Stylosanthes guyanensis*) is preferred (Teitzel, Abbott and Mellor 1974*b*). This recommendation applied across all drainage situations although both legumes perform better in well drained situations. On the other hand, De-Polli *et al* (1973) in Brazil found that stylo was more tolerant to flooding than centro.

GENERAL MORPHOLOGY OF *C. PUBESCENS*

The following description of *Centrosema pubescens* is a composite from Anon (1961), Barnard (1969), Chandapillai (1968), Grof (1970), Harding and Cameron (1972), Humphreys (1974), Monteiro and Aranovich (1965), Schofield (1941), and Wilson and Lansbury (1958).

Growth habit—Centro is a vigorous perennial herb. It is prostrate when unsupported but has a climbing twining habit when support is available. Trailing runners have a slight tendency to root at the nodes giving it a stoloniferous appearance. This tendency is not, however, well developed in commercial centro. When grown in a pure sward it forms a dense, compact cover 35 cm to 45 cm deep, 4-8 months after sowing.

Roots—Centro has a deeply penetrating root system. Development of tap roots and lateral roots is almost equal although soil type exerts some influence.

Stems—The stems are leafy and climb rather than trail. They are slightly hairy and do not become woody for at least 18 months. Roots will develop from the nodes if soil moisture is high. Leaf stems arise from the main runners 0.5-1.5 m apart.

Leaves—The leaves are trifoliate, the leaflets being dark green elliptic or ovate-elliptic, obtuse or shortly obtusely acuminate, about 4 cm by 2-2.5 cm and slightly hairy especially on the lower surface. The stipules are long and persistent.

Flowers—The flowers are large, showy and of the pea type; they are borne in axillary racemes. Each flower has two striate bracteoles. Flowers are pale mauve with purple lines in the centre and there are 3-5 per raceme. The plant is cleistogamous and is therefore self pollinating. The calyx tube is campanulate, the teeth unequal, the two

upper ones being ovate triangular 1.5-3 mm long. The standard which is much longer than the other petals is broad and hairy on the outside, bright or pale lilac on either side of a median greenish yellow band with numerous dark violet stripes or blotches.
Seed Pods—The pods are linear, 7-15 cm long, flat and thick with prominent margins. They may be straight or slightly twisted and are acuminate. Pods are dark brown when ripe, septate and contain up to 20 seeds.
Seeds—The seeds are shortly oblong to square with rounded corners 4-5 mm x 3-4 mm, brownish black, with mottled darker blotches with a lighter coloured halo. Serpa (1965) reports: seeds of centro were sorted into 2 types, one with a contour round the hilum and the other without, and this appeared to affect coat permeability and subsequent germination.

Harding and Cameron (1972) tabulated differences between common and Belalto centro. Their table is reproduced as Table 1. These authors suggest that the strong tendency of Belalto to root at the nodes is likely to confer better survival under grazing.

TABLE 1

Difference between Common and Belalto Centros

Cultivar	*Common*	*Belalto*
Growth habit	mainly twining with little tendency to root at the nodes	twining-trailing with a strong tendency to root at the nodes
Young leaflets and growing tips	light green	purplish brown
Leaflets	longer (by about 1/3) and oblong shape slight fine hair	shorter with similar width, more rounded much fine hair
Flowers	light bluish-violet, pink to white	smaller, uniform deep mauve or bluish-violet
Seeds	dark brown or grey with black markings	yellow or yellow-green turning yellow-brown with age. Deep brown markings

SYMBIOTIC NITROGEN FIXATION

Legume Bacteriology

Although centro will nodulate with a range of rhizobia found in Queensland soils, it will only produce satisfactory plant yields with a few of these (Bowen 1959*b*). Experience in Brazil has been similar (Franco, Serpa and Souto 1973). From his work, in which it was found that above ground plant weights are positively correlated with nodule number, Bowen was able to select a suitable rhizobial culture (QA 549). Subsequently CB 1923 has proved to be more effective. In our experience, productive uninoculated stands of centro have largely been confined to the knasnozems in the Innisfail area, a soil in which QA 549 occurs naturally.

Commercial centro seed populations are not, however, homogenous in their reaction to rhizobial strains. Bowen and Kennedy (1961) found that commercial seed lots from within Australia and those imported from Malaya all contained sparsely nodulating and profusely nodulating genotypes. Yields of the former genotypes on nitrogen deficient substrates were low.

The failure of some genotypes to nodulate may be due to seed coat diffusates which enter the rhizosphere of the germinating seed. As shown by Bowen (1961) these diffusates can inhibit a wide range of rhizobia. Pelleting with lime can also be harmful (Norris 1967) and should not be carried out except in specialised situations such as on manganese toxic soils. If pelleting of centro seed is necessary, the best material to use is rock phosphate.

Nodulation continues throughout the active growth period of the plant (Bowen 1959*a*) with the nodules remaining small but active during dormant or slow growing phases. The same author showed that inactivation and subsequent loss of nodules occurred when vegetative growth was checked as a result of unsuitable environmental conditions or damage to the plants. As the plants matured an increasing proportion of the nodules formed were located on the roots arising from the stolons; low soil moisture impeded such nodulation.

Nitrogen fixation

The nitrogen fixing ability of centro compares favourably with those of temperate legumes (Moore 1962, Whitney, Kanehiro and Sherman 1967, and Henzell 1962). The following are estimates of quantity of nitrogen fixed by centro when grown in association with grass: 138 kg N ha^{-1} yr^{-1}, Bruce (1967); 173 kg N ha^{-1} yr^{-1}, Whitney (1966); 123 kg N ha^{-1} yr^{-1}, Whitney, Kanehiro and Sherman (1967); 280 kg N ha^{-1} 0.3 m depth of soil yr^{-1}, Moore (1962). More nitrogen is generally fixed when centro is grown in a pure stand as shown by the following estimates: 235 kg N ha^{-1} over a 5 month period, Watson (1957); 269 kg N ha^{-1} yr^{-1}, Whitney, Kanehiro and Sherman (1967); 204 kg ha^{-1} up to flowering, Montofos and Gargantini (1963).

The nitrogen fixing ability of centro is important in maintaining the stability of a pasture system. Bruce (1965) showed that soil nitrogen and organic carbon content in the top 15 cm of a red basalt soil at Utchee Creek remained constant over a period of 16 years under guinea (*Panicum maximum*)-centro pastures. Where the centro was not present, both these parameters declined, and were still declining slowly after 22 years. Similar trends were measured in Nigeria by Moore (1962) who measured significantly higher levels of organic matter, total nitrogen and nitrifiable nitrogen in soil underlying a two year old grazed mixed grass-centro pasture in soil under the corresponding straight grass pasture treatments.

AGRONOMY

Establishment

Centro is notoriously slow to establish (Teitzel, Abbott and Mellor 1974 *b*) and requires good conditions during the establishment period (8-9 months). Slow initial establishment of centro is due in part to a high proportion (up to 60%) (Verhoeven 1958) of hard seed. Serpa and Archicar (1970) indicated that the proportion varies with seed size and harvest date, but simple mechanical scarification prior to planting is recommended by Teitzel, Abbott and Mellor (1974*c*). Various planting methods have been employed successfully and some of these are outlined by Verhoeven (1958), Humphreys (1969) and Teitzel, Abbott and Mellor (1974*a*). It appears that in areas of mesophyll vine forest which burn readily following crashing, establishment may be effected by sowing into the ash immediately following a burn. However to enhance the chances of successful establishment, windrowing of crashed timber and the preparation of a firm, moist, weed free seed bed is generally recommended. On vegetation types which do not burn as readily as true rain forest, the latter recommendation becomes a requirement for success. When replanting old pasture land it is desirable to have a winter-spring bare fallow, during which weed seed and old pasture seed is encouraged to germinate. Successive germinations are killed by herbicide and/or tine cultivation.

Weed control

In wet tropical environments, where seed growth is usually rapid and aggressive, weed control in newly sown pastures may be essential. The situation is aggravated by the slow early growth of centro.

From the age of 5 weeks up to the period of vining, 2,4-D applied at 0.34 kg a.e. ha^{-1} causes only moderate check to the growth of centro with relatively little loss of plants (Bailey 1965, 1969). Surviving plants recover and growth is much the same as on unsprayed areas after 12 months. 2,4-DB is no more selective than 2,4-D on centro and is not recommended. Diquat applied at 0.11 kg ion ha^{-1} from the age of 5 weeks causes some leaf fall and loss of plants but recovery is again rapid. Once established, and during winter when growth of the centro is slow, 2,4-D applied at 1.7 kg a.e. ha^{-1} causes only a slight check to the growth of the legume.

Fertilizer requirements

The fertilizer requirement of centro and other pasture species grown in the Queensland wet tropics was the subject of a lengthy research programme summarized by Teitzel and Bruce (1972). It was found that soil parent material was the best guide to the range of likely deficient elements but the severity of expression of each deficiency was best indicated by the class of natural vegetation present on that particular site. Elements which produced significant plant growth increases on the various parent material types are: basalt—P, Mo, Ca, S; metamorphic—P, Ca, K, Mo, S; granite—P, Cu, Zn, K, S, Ca; mixed alluvium—P, K, Cu, Ca, S; marine sand—P, K, Ca, Cu, Zn, Mo, B.

A number of publications present data on the chemical content of centro, but because of lack of standardization in the procedures adopted, we consider that much of this is of little diagnostic value. Using the concept of 'critical percentage', levels of 0.16% P (Andrew and Robins 1969*a*) and 0.75% K (Andrew and Robins 1969*b*) have been established. For the wet tropical lowlands of Queensland, soil levels of 30 ppm available (dil. acid) P and 120 ppm exchangeable K have tentatively been established as desirable levels for the maintenance of centro/grass pastures in a productive state (Standley and Teitzel, unpublished data).

Deficiency symptoms have been described for copper (Andrew 1963), potassium (Andrew and Pieters 1970*b*), and nitrogen phosphorus, potassium, calcium and magnesium (Souto and Franco 1972). Manganese toxicity was described by Andrew and Pieters (1970*a*) and also reported by Dobereiner and Aronovich (1965). Expression of mineral deficiencies and growth rates were found by Crush (1974) to be influenced by vesicular-arbuscular mycorrhiza. *C. pubescens* produced relatively few root hairs and was much more dependent on mycorrhizas for growth than two temperate legumes.

Dry matter production

Literature referring to the yielding ability of centro covers a long time span but some of the few formal experiments appear limited in scope and applicability and as a result comparisons are difficult. Little can be gained from an exhaustive survey, but there is general agreement that centro is one of the highest yielding legumes for soils of moderate to high fertility in humid tropical lowlands. The data presented by Grof and Harding (1970*a*) are of especial interest, however, in that they show the capacity of several species and lines to produce at different times of the year. In terms of total yield, four accessions, *C. brasilianum* Q8216 *C. pubescens* Q8399, Q8397 and Q8333 (Belalto) significantly outyielded common centro. *C. plumieri* Q8274 gave the lowest yield. During the cool season, when legume growth is usually restricted, Belalto gave approximately three times the yield of common centro.

Seed production

Although the potential seed yield of centro is thought to be in the range of 340 to 680 kg ha^{-1} yr^{-1} (Allen 1958, Verhoeven 1958) commercial seed yields are generally 140-180 kg ha^{-1}. Uneven ripening of seed makes mechanical harvesting difficult although all-crop headers have been reasonably successful. There are some 33,000 to 40,000 seeds kg^{-1} (Schofield 1941, Barnard 1969) and the minimum prescribed germination under the "Agricultural Standards Act, 1952 to 1963"

(Queensland) is 50% with a minimum purity of 93.8%. In the Queensland wet tropics, common centro flowers in April and October with main seed harvesting periods in June-July and November-December. Belalto flowers in June and has a main seed harvesting period in early August.

Most commercially available seed is imported from New Guinea under strict quarantine regulations. It seems possible that Belalto seed will now be produced locally and the importation of common centro could well cease.

Pests and diseases

In Queensland, common centro is relatively free of major pests and diseases. Some virus diseases have been observed from time to time (Shaw 1968) but these have not been of commercial consequence. Belalto is considered to be more resistant to Cercospora leaf spot and red spider (*Tetranychus* sp.) than common centro (Grof and Harding 1970 *a*) and this may be considered another attribute in its favour.

GRAZING MANAGEMENT AND PRODUCTIVITY

Pasture management

In wet tropical pastures, careful post-germination management is essential (Teitzel, Abbott and Mellor 1974*b*). Grazing too early or too heavily can ruin the pasture or greatly reduce its productive life. Centro, with its poor establishment vigour, is very susceptible during this period; it is also very palatable and therefore open to damage from heavy selective grazing. Light, short intermittent grazing seems to be the most suitable during this period.

Centro combines well with tufted, tropical grasses (Humphreys 1974) and once established it has withstood stocking rates of 4 beasts ha^{-1} (Grof and Harding 1970*b*). Because of its climbing habit, centro is not shaded out by tall growing grasses (Schofield 1941, Humphreys 1974). This ability to withstand both heavy grazing as well as undergrazing may well explain the remarkable stability of guinea grass-centro pastures in the wet tropics of Queensland. In the Innisfail area good grass/legume balances exist in some areas sown some twenty years ago (Humphreys 1974). As a result, the unusual situation now exists where grazing managers pay most attention to the grass component of the pasture (Teitzel, Abbott and Mellor 1974*c*).

Feeding value and fodder conservation

Relatively little work has been done on the nutritive value of centro. Working in the intermediate rainfall areas of Nigeria, where centro gave only mediocre performance, Miller and Rains (1963) concluded that the dry matter intake was low and that the digestibility was low in relation to the protein content. They suggested that an apparent excess of protein could be utilized by growing the legume with a more energy-rich grass and quote McIlroy (1962) as having centro based experimental pastures with a nutritive value approaching that of a temperate pasture. Although comparisons are dangerous because of the paucity of the information, it is worth noting that even higher digestible crude protein values have been recorded in moister environments (Lansbury 1959).

Centro will make good hay (Goodchild 1955). On the wet tropical coast haymaking, however, is a risky proposition because of the high humidities and rainfall. Good quality silage can be produced from guinea/centro pastures and this may be a more realistic approach to fodder conservation if in fact conservation is needed to fill the feed gap (Teitzel, Abbott and Mellor 1974*c*). An alternative or complementary approach to the same problem is the development of cultivars, such as Belalto, which continue to grow into the cool season.

Animal productivity

Centro is not grown to any extent in dairying areas of Queensland. Productivity has thus been assessed with respect to liveweight gain of beef cattle on reasonably productive centro pastures.

The effect of centro inclusion in a guinea grass pasture in North Queensland has been detailed by several authors. Marriott and Davies (1958) reported liveweight gains of 134 kg ha^{-1} from June to December for guinea grass + centro as compared to 67 kg ha^{-1} from guinea grass alone. Grof and Harding (1970*b*), with a stocking rate of 4 beasts ha^{-1}, reported an increased animal production from 374 to 460 kg ha^{-1} yr^{-1}; in the second year of the experiment the difference was even greater (312 as opposed to 477 kg ha^{-1}). In the same experiment heavy applications of nitrogen to guinea alone gave even higher liveweight gains (596 and 725 kg ha^{-1} in the first and second years respectively). Per animal production is also high and on good pastures, 0.7 kg $animal^{-1}$ day^{-1} can be taken as a reasonable figure of liveweight increase throughout the year (Teitzel, Abbott and Mellor 1974*c*).

Working in the same area (Utchee Creek), Mellor, Hibberd and Grof (1973) showed that young guinea grass/centro pastures produced liveweight gains of 928 kg ha^{-1} $annum^{-1}$. Subsequently, however, there was a gradual decline in productivity until the stable and relatively highly productive level of 560 kg ha^{-1} $annum^{-1}$ was reached after three years. This reduction appeared to be related to a declining nitrogen status. Subsequent work suggests that these soils were deficient in molybdenum, and possible phosphorus, which could well have limited the nitrogen fixing ability of the legume.

Productivity estimates made in other countries are generally not as high as these Queensland figures, but work such as that of Stobbs (1969), Olubajo and Oyenuga (1971), Velloso and Freitas (1973) and Ogunmodede, Onabolu and Oyenuga (1973) ably demonstrate that the value of centro for increasing animal production and improving soil fertility is not limited to Queensland.

CONCLUSIONS

Since its introduction into Australia, some 40 years ago, common centro has proved to be one of the most versatile legumes in the wet tropics. It is easy to manage, gives good production and probably as a result is still one of the main pasture legumes used in the region. Recently, however, deficiencies in this variety have become, if not more evident, then less acceptable. A relatively simple, planned introduction programme resulting in the release of a new cultivar has already demonstrated that certain deficiencies can be overcome. The initiation of programmes designed to explore and exploit the variation known to exist in this genus could well furnish valuable legumes for a wide range of tropical and sub-tropical conditions. It is also felt that the potential of existing cultivars is largely unrealized. Much of the research on centro has been observational or of an exploratory nature and as a result the requirements for optimum production from centro based pastures are poorly understood. In particular, an increased understanding of the effect of different grazing strategies (especially seasonal variations in intensity) coupled with different soil conditions (fertilizer, drainage, geology) could result in substantial increases in production efficiency.

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