THE DISTRIBUTION AND GROWTH CHARACTERISTICS OF THE NATIVE LEGUME *PSORALEA ERIANTHA* IN WESTERN QUEENSLAND

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SUMMARY

A study was made of the growth rhythm, yield, seed dormancy, root distribution, nodulation and persistence of a native legume, *Psoralea eriantha*, growing in a deep sandy levee soil at "Gowrie", Charleville, Western Queensland.

The legume produces most of its yield during the hotter months from October to May but there is a significant and valuable year-round production. In a glass house trial, the cumulative yield of *P. eriantha* cut every twelve weeks was comparable to that of lucerne, *Medicago sativa*, cut every six weeks. One seed sample exhibited 84% hard seed dormancy. This may be broken by scarification. The plant has a deep root system which enhances its persistence and it will regenerate from the tap root. The roots are effectively nodulated with native *Rhizobium* strains. An isolate, CB762, was shown to be an effective strain. Its palatability to stock and its persistence further indicate that *P. eriantha* is worth more attention from plant breeders and agronomists to develop improved cultivars.

INTRODUCTION

In Australia, the native legumes have received little attention from agronomists. Davies (1951) pointed out the untapped reserves in these species;. in particular suggesting it is from this rich store of species and gene complexes that plants may be found to rehabilitate and improve the semi-arid areas. Millington (1958) noted that no serious attempt has been made to domesticate or even preserve the indigenous flora. Thus, there is a danger that many indigenous species may be exterminated through selective grazing by large numbers of domestic animals, rabbits and the increasing numbers of native animals, and by drastic habitat modification when native species are replaced by introduced species. One detailed study of native legumes that included an agronomic evaluation was that of Silsbury (1958) for the genus *Kennedya* in Western Australia.

Psoralea in Australia

Psoralea is a world-wide genus and contains about 130 species. It is most abundant in South Africa and North America. There appear to be about 16 species in Australia of which Bailey (1900) listed 12 in Queensland. Of these *Psoralea eriantha* appears to be closely related to *P. patens* with some taxonomic confusion existing between the two species.

Psoralea eriantha was originally collected in the neighbourhood of St. George in south-west Queensland by Sir Thomas Mitchell (Mitchell, 1848), and has been described by Bentham and Mueller (1864). Guilfoyle (c. 1900) listed the plant under the common name of "woolly-flowered pea". In 1939, the late K. B. Cameron of "Bullamon Plains", Thallon recorded that it was readily eaten by stock on his property and retained its succulence after months of dry weather. From then, the plant has become known as "Bullamon lucerne". (Allen (1949) noted that the species occurred in the loose grey sandy soils near the Moonie River, Nindigully. He described it as having a deep tap root, with stems of large plants often longer than ten feet, and flowering in May (Autumn). The presence of many root nodules was observed and its good fodder value noted. An attempt by Allen to establish the plant at "Gilruth Plains", Cunnamulla, failed.

Skerman (1957) has drawn attention to *P. eriantha* as a potential pasture legume for the sandy levee soils of Western Queensland. A composite sample

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collected by him from naturally occurring plants growing at "Gowrie", Charleville, consisting of trailing stems and leaves, contained 17% crude protein, 1.03% calcium and 0.30% phosphorus. It was deeply rooted and well nodulated, growing in soils of over 90 ppm. available P_2O_5 (dil. H_2SO_4 extract).

The present distribution of *P. eriantha* is shown in Figure 1 which has been compiled from the records of the Queensland Government Herbarium and from our own field observations. According to Guilfoyle (c. 1900), the species is found in Victoria, New South Wales, Queensland, South and Western Australia.

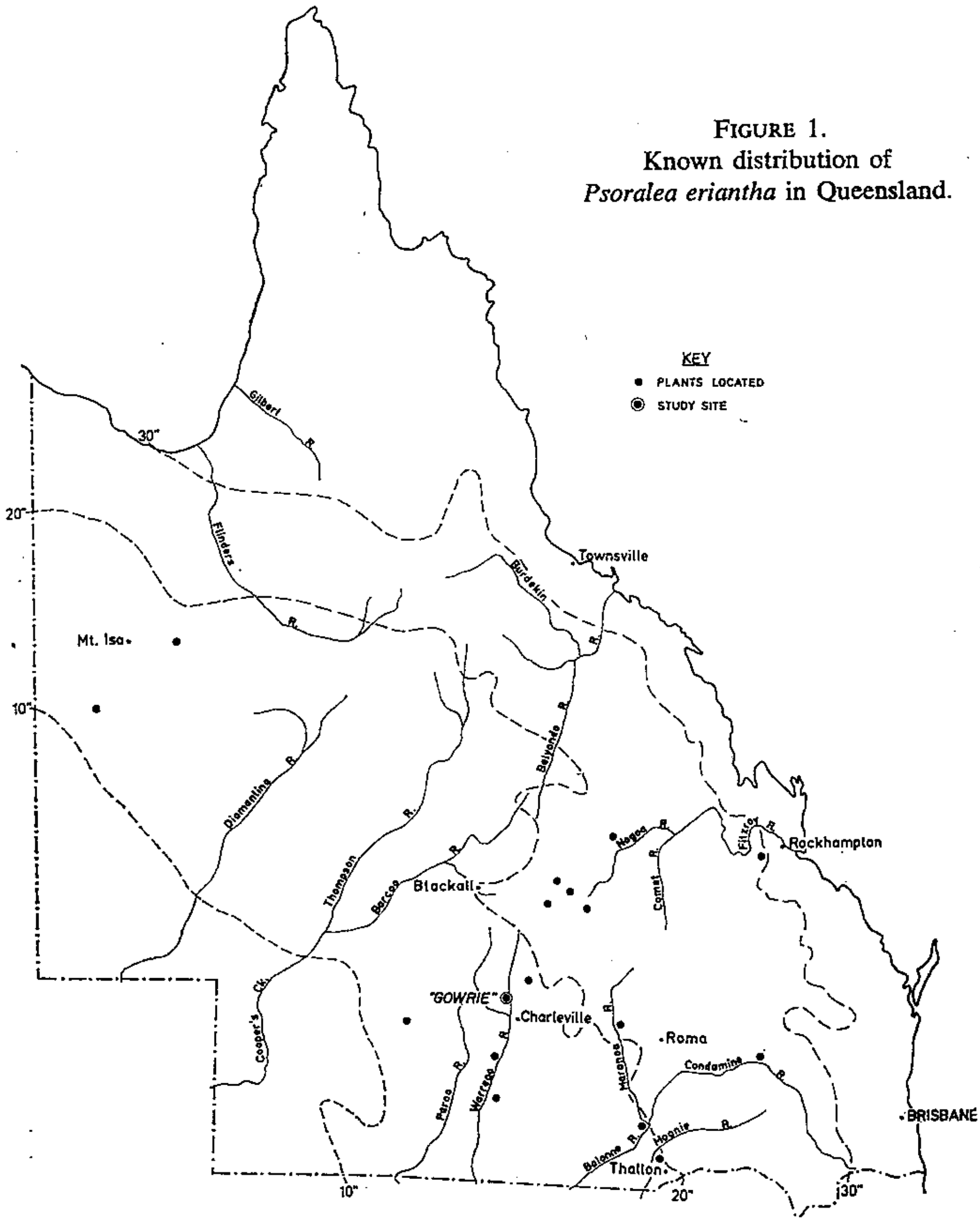


FIGURE 1.
Known distribution of
Psoralea eriantha in Queensland.

In general, the plant occurs in areas with an annual rainfall of less than twenty-five inches and mostly on the deep sandy soils of the levees, although it does occur on soils of heavy texture in other areas.

MATERIALS AND METHODS

The field experiments were carried out at "Gowrie", Charleville in Western Queensland, where a natural population of plants was used. Plants were growing on a deep sandy loam on the flood plain of the Warrego River. Charleville has an average annual rainfall of 19 inches; rainfall variability is high (Average Variability Index > 300); mean summer temperature of 83°F; and mean winter temperature of 56°F.

Vegetative Growth Rhythm

Forty plants were selected at random in the field. They were cut back equally on 26/2/59 and ranked into groups of four on the basis of herbage yield. From each group, one plant was assigned at random to each of four treatments giving 10 plants for each treatment. The treatments were as follows:

A. Cut to the crown every 6 weeks for 12 months.
B. Cut to the crown every 12 weeks for 12 months.
C. Cut above the second node every 6 weeks for 12 months.
D. Plant cut to the crown at beginning of experiment and then left uncut for 12 months.

Relative Performance of P. eriantha and Lucerne under Cutting

Lucerne (*Medicago sativa*) is the only legume that has shown promise as a perennial introduced species in the Charleville area. A pot trial was carried out in a glasshouse in Brisbane to compare relative performance of the two species. Polystyrene pots were equally filled with 6lb. Moggill sandy loam and given a complete basic fertilizer dressing including trace elements. There were five replications of the following treatments:

A. *P. eriantha* cut every 6 weeks to one node (ground level)
B. *P. eriantha* cut every 12 weeks to one node (ground level)
C. *P. eriantha* cut every 6 weeks to two nodes (approx. 2in.)
D. *P. eriantha* cut every 12 weeks to two nodes (approx. 2in.)
E. *Medicago sativa* cut every 6 weeks to 1 inch above ground level.

The trial lasted for 48 weeks.

Seed Setting, Seed Dormancy and Germination

In the field, *P. eriantha* flowers from late September to May but mainly between November and January. The flowers mature from the base of the raceme upwards and as each seed nears maturity, it drops from its peduncle. The final maturation appears to take place after the seed and calyx have dropped from the peduncle. There is not a high proportion of seed set, the highest we have recorded being 40 per cent, but generally it is much lower.

Germination of from 14 to 25% was obtained in the laboratory on various samples of untreated seed. To determine the amount of hard seed and ease of breaking this dormancy, a germination study was conducted on one sample of seed. In a 3^2 factorial, the seed treatments —

A. scarification with emery paper (S)
B. nicking the seed coat with a scalpel (K)
C. untreated seed (C)

— were germinated at 20°C, 25°C and 30C. One hundred seeds were used per treatment. There were three replications.

Root Studies

Skerman (1957) mentioned that on excavation, the tap root of a plant of *P. eriantha* was still half an inch thick at a depth of five feet.

During the drought of 1957-58, *P. eriantha* persisted well and since drought resistance of arid and semi-arid plants is often associated with a deep root system, some observations of this characteristic were made.

A pit was dug beside two plants so that they occupied adjacent walls. One plant had surface runners up to eight feet long and a large crown. The second plant had runners four feet long and a small crown. The soil was very dry at the time of excavation. Working with a geologist's hand pick, the roots were exposed to a depth of fourteen feet where a perched water table was encountered.

FIGURE 2. Root profile of two *Psoralea eriantha* plants.
(FIGURES ON DIAGRAM ARE DIAMETERS IN mms.)

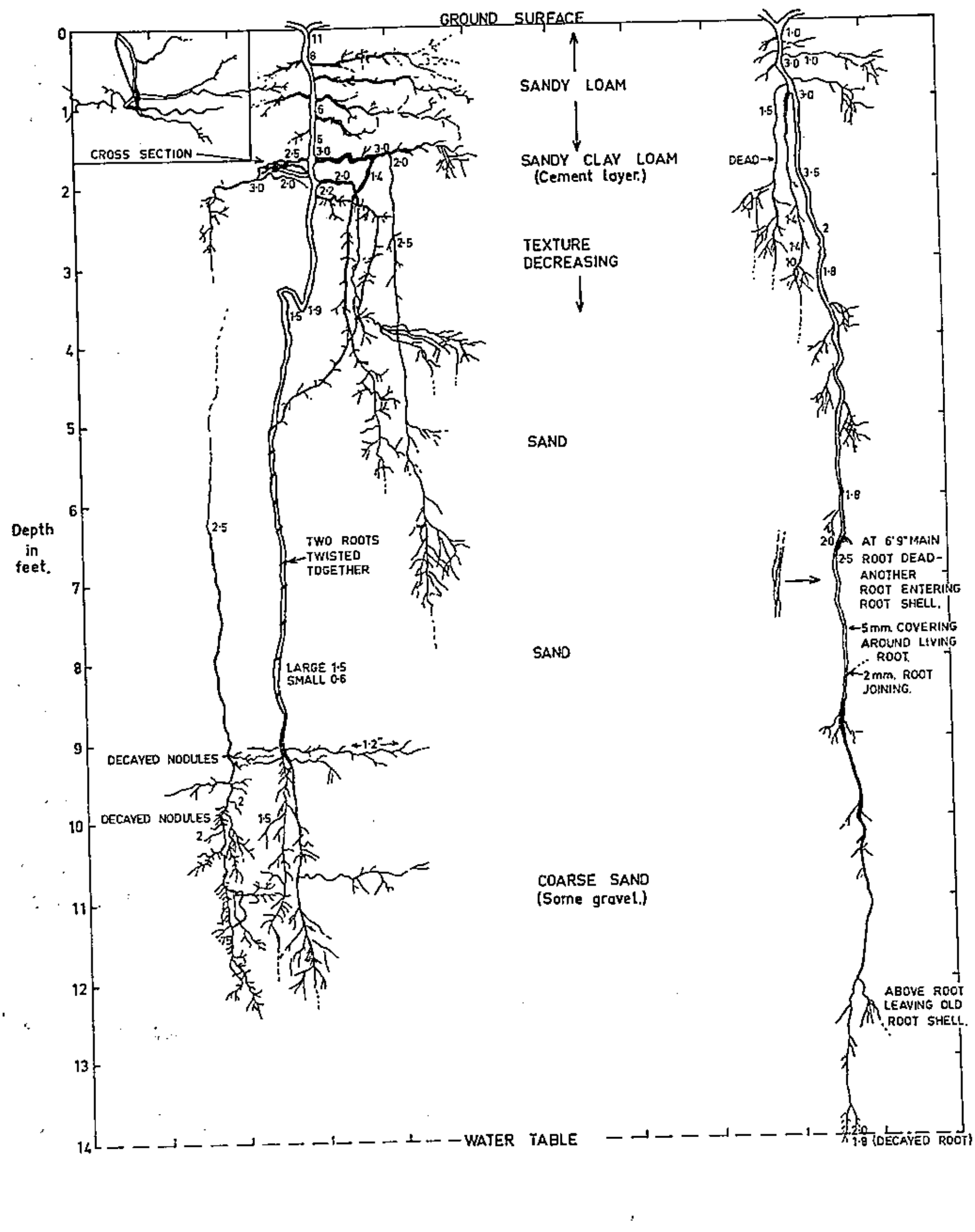


Figure 2 shows the root system as drawn from the excavation. The diameters of the roots are not to scale but their actual measurements in millimetres are indicated on the drawing. All root branches in the surface sandy loam were dead and broke off easily. They were followed out 2ft. 6in. from the main taproot in one plant but there was little side branching in the other plant. The presence of meristematic tissue in the roots of both plants was noted at the twelve to the fourteen-foot depth and suggested that the roots were active in this region.

Nodulation

Skerman (1957) collected nodules from the roots of *P. eriantha* on two occasions and isolates of *Rhizobium* were made by Dr. D. O. Norris of the C.S.I.R.O. Cunningham Laboratory. Also available in Norris' *Rhizobium* collection were isolates from *P. patens* and *P. cinerea.*

Sterile, nitrogen-free Leonard jars were set up containing washed sand and nutrient solution and autoclaved after the method of Norris (1964). Seeds of *P. eriantha* were treated with sulphuric acid to sterilize the seed coat and break any dormancy, washed in sterile water and planted in sand culture on 7/3/58. After germination, the plant number was reduced in each bottle to five. There were five replications of the following treatments:

A. *Rhizobium* Strain CB762 (*P. eriantha*)

B. *Rhizobium* Strain CB362 (*P. eriantha*)

C. *Rhizobium* Strain CB541 (*P. patens*)

D. *Rhizobium* Strain CB685 (*P. cinerea*)

E. Nitrogen added to nutrient solution from commencement of experiment.

F. Control — no nitrogen, no *Rhizobium.*

The nutrient solution was changed every two weeks.

The trial continued until plants from treatments C, D and F showed signs of necrosis and then harvested on 26/6/58. They were washed free of sand and oven-dried to constant weight.

Persistence

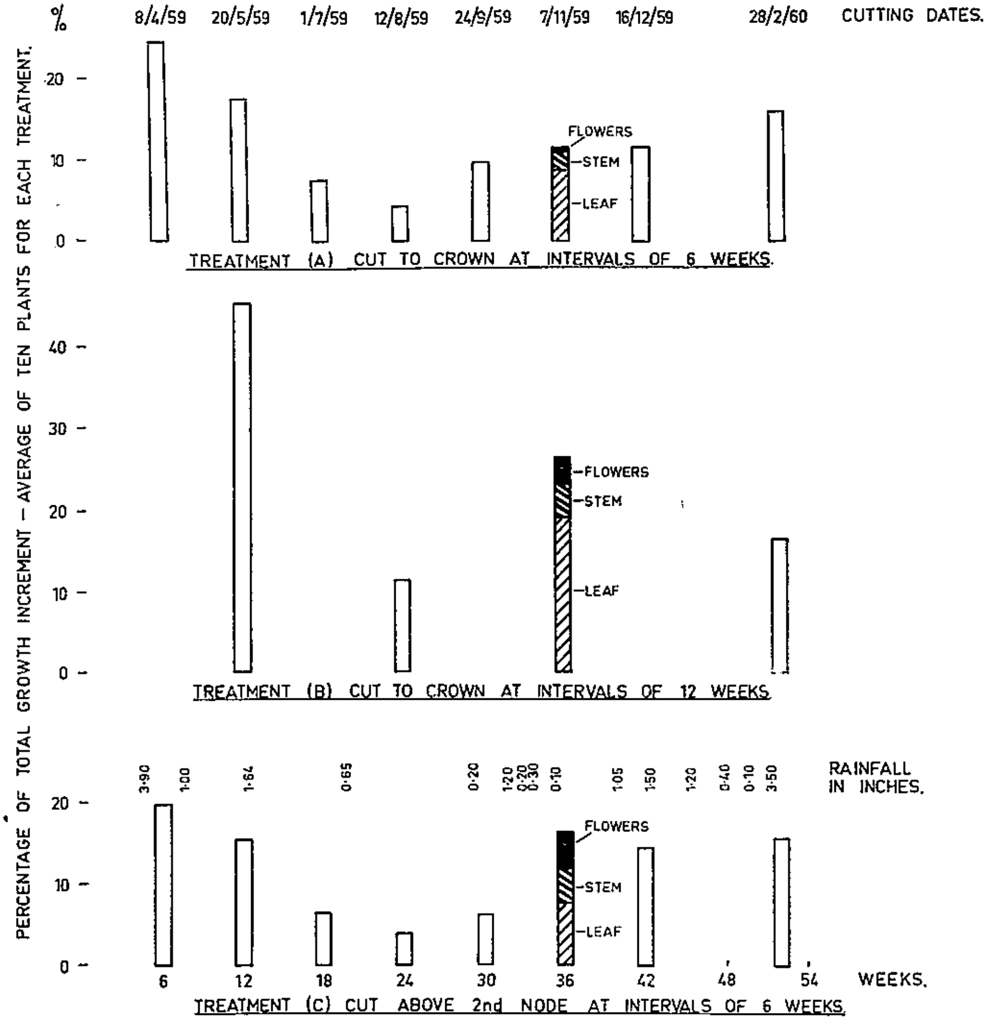
A fixed quadrat, 100 links x 5 links, was laid down in an area where *P. eriantha* occurred abundantly. The area was under continuous grazing pressure because of the prevailing drought at Charleville during 1958-59. Feed was scarce and *P. eriantha* was the only species making growth. Counts were made of plant numbers within the fixed quadrat in June 1958, April 1959 and February 1960.

RESULTS

Vegetative growth rhythm

Total dry matter yields for the 10 plants from each treatment over the 52 week period were for treatment A — 520 g; B — 530 g; C — 570 g; and D — 555 g. There was considerable variation in the amount of growth from individual plants. In treatment A, one plant accounted for 45% of the total yield; in the other treatments, the highest contribution from one plant was 17% in treatments B and D and 26% in treatment C. The growth at each sampling date as a percentage of the total growth is shown for treatments A, B and C in Figure 3. The proportions of leaf, stem and inflorescence were determined for the sample cut on 7/11/59. For treatment D, which was not cut until 28/2/60, the proportions of leaf, stem and inflorescence were 15, 43 and 42 per cent respectively. respectively.

FIGURE 3.
Effect of interval of cutting on yield of *Psoralea eriantha* at Charleville 1959–60.



Treatment A. Growth was retarded during the period of heavy frosts and the tips of the leaves were affected. However, growth increased as the weather warmed up in early September. Some flower buds appeared in late September and these increased in number from December through to February although at no time was flowering prolific.

Treatment B. Increasing the cutting interval to twelve weeks reduced leaf damage by frosts slightly, but did not accelerate winter growth. As with Treatment A, growth increased with the warm weather and a few flowers appeared in late September after which growth and flowering were more prolific than in Treatment A where cutting was more frequent. Flowering decreased in January and only a few flowers were produced during February 1960.

Treatment C. The less drastic pruning of the plant in this treatment did not improve the winter growth over that of treatment A but the plants were a little more tolerant of frosts. Flowering was general by late September and growth and flowering increased through October to December. From December to February the growth rate was maintained but tapered off with flower production.

Treatment D. The plants produced a few flowers towards the end of May. They all survived heavy frosting but damage to leaf tips increased through July to August. The older leaves yellowed and were shed during early August and were replaced by new crown shoots bearing abundant leaf. The new shoots continued to develop rapidly and flower buds had appeared by late September. There was no new growth on the older stems. Flower production on new growth was extensive through November and continued until February.

Relative Performance of P. eriantha and Lucerne under Cutting

P. eriantha when cut at 12 week intervals gave yields comparable to that of lucerne (Table 1). However, the yields were much lower at the shorter cutting interval. It is noted that defoliation of *P. eriantha* to the first node left less foliage than defoliation of lucerne to one inch.

TABLE 1

Yields of *Psoralea eriantha* under various cutting treatments and of lucerne when grown in pots in a glasshouse.

Treatments	Mean Yield (g D.M.)
Lucerne cut at 1 inch every 6 weeks	41.4
P. eriantha cut at 2 nodes every 12 weeks	39.7
P. eriantha cut at 1 node every 12 weeks	37.3
P. eriantha cut at 2 nodes every 6 weeks	30.3
P. eriantha cut at 1 node every 6 weeks	20.1
L.S.D. P = 0.05	3.2
P = 0.01	4.5

Seed Setting, Seed Dormancy and Germination

It can be seen from Figure 4 that at 30°C only 14% of the untreated seed germinated; with scarification this increased to 69% and with nicking the seed, to 85%. Nicking the seed promoted rapid germination. There was little effect of temperature on germination. The difference between untreated and nicked seed suggests 84% of the viable seed was dormant due to hard seed.

Nodulation

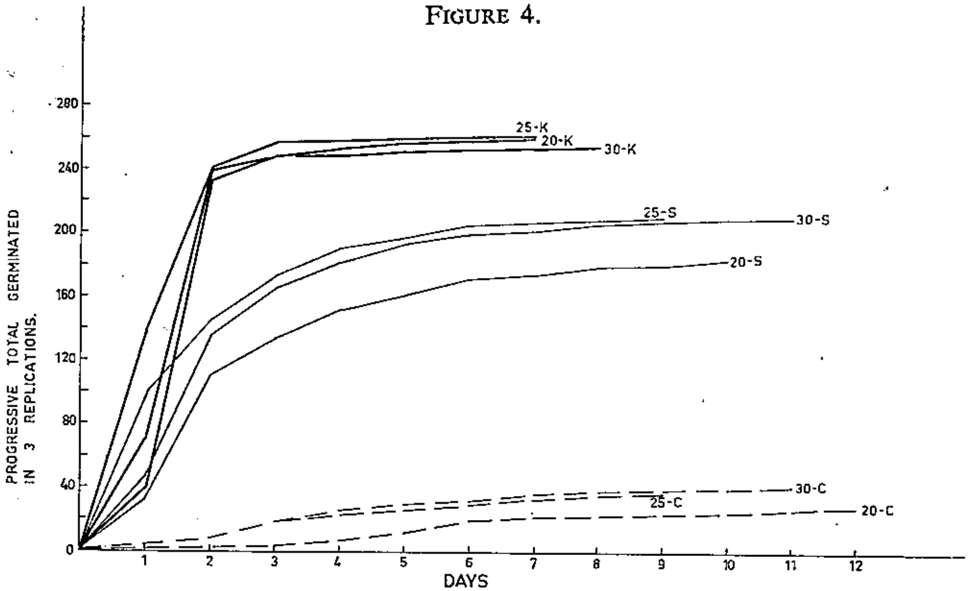
Strain CB762 was the most effective of the two *P. eriantha* isolates though strain CB362 did produce healthy pink nodules (Table 2). There were small nodules on the roots of plants treated with *Rhizobium* strains from *P. patens* and *P. cinerea* but they were completely ineffective.

TABLE 2

Yield of *Psoralea eriantha* following inoculation with various strains of *Rhizobium* using a Leonard jar technique.

Treatments	Mean Yield (g D.M.)
Nitrogen	2.03
Strain CB762 (*P. eriantha*)	1.03
Strain CB362 (*P. eriantha*)	0.55
Strain CB541 (*P. patens*)	0.11
Control	0.10
Strain CB685 (*P. cinerea*)	0.09
L.S.D. P = 0.05	0.28
P = 0.01	0.38

FIGURE 4.



GERMINATION OF SEEDS OF P. ERIANTHA

Nodulation was observed in the field from all of a number of localities except one. In this case, the surface soil was of heavy texture and fairly dry when the plants were examined. In the pit study of the root system mentioned earlier, decayed nodules were seen at depths of nine and ten feet.

Seed inoculated with strain CB762 and established in an isolated area in the field germinated well and the plants nodulated freely and effectively.

Persistence

The following counts were recorded:

Sampling Date	*No. of Plants*
June 1958	184
April 1959	190
February 1960	170

Figure 3 shows that in March and early April 1959, a total of 490 points of rain fell and some new seedling growth lifted the plant population slightly.

The plant has the ability to produce shoots from below the crown and when cut off at varying levels below ground and covered again with soil. It will send up shoots from a depth of six inches below ground level and resume normal growth.

Skerman (1957) suggested that the prominence of *P. eriantha* during recent years was most likely due to the reduction of the rabbit population by myxomatosis for it has been observed that the plant foliage and its roots are particularly palatable to rabbits. There is ample evidence that the species is palatable to cattle but due to the nature of the environment it is difficult to assess seasonal changes in palatability or its relative palatability with other species.

DISCUSSION

During the period of observation, *P. eriantha* was shown to make substantial growth throughout the year, except in the winter months of June, July and August when frosts were severe (Figure 3). Moreover, even though shoot tips were damaged by frost, the bulk of the foliage remained green until fresh shoots appeared. Growth rhythm appears to be more closely related to temperature than rainfall. There was little indication of response to surface moisture. It was shown that moisture was available from 12 to 15 feet and that roots penetrated to this depth.

The plant survived severe defoliation under field and greenhouse cutting and under natural grazing. However, there was a marked and significant reduction in yield under frequent close cutting in the greenhouse and an apparent slight reduction in the field. The more severe effect of close cutting on young plants under pot conditions is probably related to lower total root reserves for regrowth in these plants as compared with older established plants in the field. This aspect of frequent defoliation requires further study.

The deep-rooting habit would seem the most important adaptive element of *P. eriantha* in this region of low and variable rainfall. Hard seed dormancy is also an important and allied adaptive element. Permanent establishment would only be expected in seasons when the rainfall is sufficient to wet the soil to 15 to 20 feet, thus allowing the taproot to grow into this region of "perennial" moisture. However, hard seed dormancy would also permit establishment following severe droughts when all plants were killed.

The plant appears relatively unaffected by disease. This offers an advantage over lucerne which is susceptible to witch's broom disease. Although strongly strain specific, the plant nodulates freely. The *Rhizobium* strain study was limited as to the extent of the number of strains tested and the checking of strains back onto host species. Nevertheless, considering the difficulty in differentiating between *P. eriantha* and *P. patens* by usual taxonomic criteria (Burbidge, N.T., private communication), the apparent existence of strain specific rhizobia for the two species suggests the use of this material for studies of the nature of host-strain specificity.

The deep rooting habit, the ability to regenerate from a severed taproot, the persistence under severe defoliation and the maintenance of green leaf after severe frosts, together suggest *P. eriantha* is well adapted and has much promise as a pasture plant in certain areas of western Queensland. More extensive field studies with this native species and lucerne and perhaps other introduced plants are indicated. Preferably, field trials should be established during some season of abundant rainfall and then continued into years where rainfall is limiting for surface feeding plants. There is a need also to study the nutrition of the plant in relation to major and minor elements. Skerman (1957) suggests P may be important; while the evidence of Norris (1957), that the *Rhizobium* isolates from most of the *Psoraleas* are acid-producing types, indicates Ca may be important. There would also appear to be scope for selection and breeding to improve plant height for direct mechanical harvesting of seed and for higher yield.

ACKNOWLEDGEMENTS

We wish to thank the Australian Wool Board for funds to carry out this investigation; Mr. and Mrs. O. W. Smith of Gowrie Station, Charleville for hospitality during the survey; Mr. K. P. Haydock of C.S.I.R.O. for assistance with the statistical analyses; and Dr. G. L. Wilson for helpful advice and criticism.

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