Registered cultivars of subterranean clover: their origin, identification and potential use in Western Australia.

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Note: As Esperance is similar to Daliak and Larisa is similar to Trikkala, photographs of these two cultivars have been omitted.

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Registered cultivars of subterranean clover — their origin, identification and potential use in Western Australia.

By: W. J. Collins, C. M. Francis and B. J. Quinlivan.

Introduction

The annual species subterranean clover (*Trifolium subterraneum* L.) is the most important pasture legume in Western Australia. In addition to providing nutritious feed for livestock, it is an important source of nitrogen for non-leguminous species in pastures and for the State's cereal crops. The key to its widespread use is a diversity of cultivars which enables it to be grown successfully in areas ranging from the high rainfall districts of the lower south-west through to much of the dry wheatbelt.

The use of subterranean clover in pastures in Western Australia began very slowly during the economically difficult 1930s and '40s, but this was followed by a dramatic increase in its use during the 1950s and '60s. The area sown to subterranean clover reached a peak of about 7,000,000 hectares in the early 1970s, but has since declined to about 6,000,000 hectares. It is difficult to determine the precise area because, particularly in the drier wheatbelt, many pastures classified as 'improved' currently contain very little subterranean clover.

Subterranean clover originated in the Mediterranean basin and western Europe (see Figure 1). It is not surprising that it grows well in the agricultural districts of Western Australia, where there is a predominance of acid sandy soils, to which subterranean clover is particularly suited, and a typically Mediterranean climate with cool wet winters and hot dry summers.

Subterranean clover was introduced to Western Australia probably as early as the 1830s with the first settlers. Collections made by Dr J. S. Gladstones and colleagues since the early 1960s have resulted in the discovery of over 100 naturalized strains, the majority of which were found along the stock routes used by the early settlers. It is generally thought that most of the original introductions came into the colony from or near the Atlantic seaboard of western Europe, that is, from southern England to southern Portugal and Spain. However, some may have come from the Mediterranean basin proper, particularly after the opening of the Suez Canal in 1869. In the absence of any precise records, the mode of introduction of subterranean clover has been the subject of considerable speculation. It is generally assumed that lines came into Australia either accidentally with livestock and fodder, or as contaminants of agricultural seeds imported from the United Kingdom and continental Europe. It is also possible that subterranean clover was deliberately introduced since the value of clovers was already well known in Europe by the time settlers began to arrive in Western Australia.

Variation within subterranean clover — the varietal complex

Varieties of subterranean clover are classified into three subspecies:

- *Trifolium subterraneum* subsp. *subterraneum*
- *Trifolium subterraneum* subsp. *brachycalyxinum*
- *Trifolium subterraneum* subsp. *yanninicum*.

In the Mediterranean region there are vast numbers of distinct varieties. Most of these are members of either subspecies *subterraneum* or *brachycalyxinum*, both
of which are widely distributed throughout the region. The *yanninicum* subspecies is more restricted both in its distribution, being mainly confined to Greece and Yugoslavia, and in the number of varieties present.

Since 1951 there have been about 25 plant collecting missions to the Mediterranean region resulting in the acquisition of nearly 6,000 varieties. These are currently maintained at the Department of Agriculture in Perth along with some 300 varieties that have been collected in southern Australia.

Varieties can vary markedly in their appearance as well as in a number of important agronomic characteristics. Many of the visible differences such as leaf markings and pigmentation of flowers are important in seed certification schemes. They enable varieties to be identified quickly and accurately, ensuring that pastures being used for certified seed production are true to type.

Varieties that have been registered and released for commercial use are known as cultivars. In order to qualify for registration as a cultivar, a variety must be different from, and possess some character of merit in comparison with, previously registered cultivars. Currently there are 22 cultivars registered in Australia; 15 of these were found in Australia; two are introductions from Greece, and the remaining five are the products of breeding programmes.

**Desirable characters in subterranean clover cultivars**

The characters required in subterranean clover if it is to make a successful pasture component vary from district to district, and often within a district in accordance with topography and other factors.

The ability to tolerate heavy grazing is perhaps one of the more fundamental attributes for any pasture species, particularly in sheep raising districts. In general, subterranean clover is particularly good in this regard. Even 'showy' varieties, with tall, upright growth habits, which intuitively might be considered non-grazing types, appear to be able to adapt fairly well to heavy grazing.

In the early 1950s, almost the only criterion for selection of clover cultivars was flowering time. Today, many other criteria are considered important and there is little doubt that with further field experience and additional research the list of requirements for the 'ideal clover' will be further modified.

It is convenient to group the characters considered desirable in subterranean clover cultivars into two categories:

- **characters related to persistence** — these include flowering time and seed maturity; seed production; seed conservation through hard-seededness; capacity to bury burrs; and tolerance of grazing, diseases and insect pests.

- **characters related to productivity** — which include good winter and spring growth; ability to grow in winter waterlogged or other specific soil situations; oestrogenicity and palatability.

However, it should be noted that there is some overlap between these two categories. For instance, early winter production in subterranean clover is largely influenced by the density of seedlings which establish at the break of the season and this in turn is closely related to seed production and seed conservation, which are listed as persistence characters.

**Flowering time and maturity**

Time of flowering has long been considered to be of major importance in determining the suitability of cultivars for particular environments. The essential requirement is that flowering must start early enough for adequate seed to be produced by the end of the growing season. There are marked differences between cultivars in their time of commencement of flowering (see Table 1) and this facilitates the selection of suitable cultivars for a wide range in length of growing season.

Flowering time in all cultivars is influenced by the time of the break of the season. If the break is delayed then flowering will be later than that occurring with a normal break. However, the extent of the delay varies between cultivars with early flowering cultivars such as Nungarin, Northam and Dwalganup, being much more affected than later ones such as Woogenellup, Mt Barker and Tialarook. The location in which a cultivar is grown can also affect its flowering time. For example, it has been found that at more northerly and relatively warmer locations such as Geraldton and Perth, flowering in early cultivars may be two to three weeks earlier than at cooler and more southerly sites such as Mt Barker and Esperance.

In addition to differences in time of flowering, cultivars vary in their rate of seed development. For instance, in the
later cultivar might give in good seasons. In fact, such extra production would often go unused by the grazing animals. The cultivars now available span a wide maturity range (see Table 1), with Nungarin the earliest cultivar and Tallarook the latest. It seems unlikely that the range will need to be greatly expanded in the future. In fact, at the late end, Tallarook is suited to areas where perennial clovers are grown and any later maturing type would probably be less persistent and useful than perennial species such as strawberry and white clover.

Seed production and burr burial

As with any annual species, the success of subterranean clover is largely determined by its ability to produce seed. In any location the level of seed production in a cultivar is influenced by a number of factors including its maturity in relation to the length of the growing season, its burr burial ability, its capacity to set seed above ground, the level of grazing and the degree of competition from other species in the pasture.

Seed yields in subterranean clover cultivars vary markedly from year to year, primarily because of differences in the amount of available soil water during the flowering and seed production phase, which in turn is a reflection of variability in rainfall. Nevertheless, within maturity groups some cultivars have been more reliable than others. Geraldton has proven superior to Dwalganup in dry areas and Daliak is generally better than Yarloop under similar dryland conditions. Also, Dinninup shows out amongst the later maturity cultivars for its seed setting ability.
The ability to bury burrs in the soil, a characteristic feature of subterranean clover, is of considerable importance in relation to seed production. Compared to unburied burrs, buried burrs are larger, they produce more and larger seeds, and the seeds have higher levels of viability and hard-seededness. Sensitivity to light in the developing seeds is the main reason for the differences between seeds formed above and below ground. Burr burial is also important for pasture re-establishment in the following season. Seeds situated below ground usually establish more successfully than seeds on the soil surface where seedling losses may be very high as a result of desiccation.

Despite the significance of burr burial for seed production and seedling survival, cultivars differ greatly in their capacity to bury burrs. Later maturing cultivars such as Mt. Barker, Woogenellup and Bacchus Marsh have rather poor burial ability compared to cultivars such as Nungarin, Geraldton, Dwalganup and Daliak. Burr burial is markedly influenced by soil texture. On soft sandy soils such as at Esperance there is less need for cultivars with strong burr burial; even the weaker cultivars in this respect are able to achieve some penetration. Thus Woogenellup, a weak burier, has been a most successful cultivar in the area. Burial is also affected by the amount of moisture in the surface soil; generally more burrs are buried in the early part of the seed production phase, when soils are usually moist, than later on when the surface is drying out.

On many soils, such as those that occur in the mallee wheatbelt, the surface sets hard early in the spring, and even strong buriers like Geraldton cannot bury their burrs. In other situations, where there is no cropping, burr burial may be reduced because of compaction of the soil by grazing animals. In some traditional grazing areas, lack of burial undoubtedly contributes to deterioration of subterranean clover pastures. This problem may be offset to some extent by the use of cultivars, such as Daliak, which are particularly good at setting seed above the ground. However, it must be stressed that above ground seed production in such cultivars is still inferior to that obtained when the burrs are buried.

It is generally accepted that frequent grazing of subterranean clover swards up to the commencement of flowering greatly increases seed production. This has been shown to be due to an increase in the number of burrs produced and to an increase in burr burial. In addition, grazing reduces competition, particularly for light, from taller growing components of a pasture such as grasses and some weeds.

**Hard-seededness**

Hard-seededness or seed coat impermeability, is an important character
influencing the long term persistence of subterranean clover. Hard-seededness is due to an impermeable layer in the seed coat which prevents uptake of water by the seed. In this way it can delay germination of a proportion of the annual seed crop for a year or more. Thus, hard-seededness protects clover seed reserves in the soil from complete destruction as a result of unseasonally early summer or autumn rains, and it ensures that some seed will remain for regeneration of a pasture following severe droughts or years in which the area is cropped. Breakdown of hard-seededness, or seed softening, is largely governed by the summer temperatures to which the seeds are exposed and in particular by the range of diurnal fluctuations in temperature which occur. Breakdown is faster in environments which have high summer temperatures and large diurnal ranges in temperature.

The need for cultivars with high levels of hard-seededness is less important in high rainfall environments (>600mm annual rainfall) where the summers are shorter and cooler and where breakdown of impermeability during summer is relatively slow. In fact, cultivars with excessive hard-seededness may be at a disadvantage in these areas, particularly in the second year, if too much of the previous year’s seed crop remains impermeable. The resultant poor stand in the second year may allow competitors such as less desirable clovers, grasses and herbs to predominate. Nevertheless, the inherent hard-seededness of cultivars like Mt Barker and Bacchus Marsh that are grown in these areas is too low. Woogenellup on the other hand, seems to be hard-seeded enough to ensure good persistence, and this degree of impermeability could perhaps be regarded as a reasonable minimum for high rainfall areas.

There are no other reasonably hard-seeded cultivars of the subspecies subterraneum group in the later maturity range, a deficiency which will be rectified by current breeding and selection programmes. The recently released subspecies yanninicum cultivar Meteora has a high level of hard-seededness, but its very late maturity will greatly limit its potential use in this State.

Hard-seededness can be beneficial in disease-prone areas, enabling subterranean clover to survive severe losses in seed production in one or more years. For example, there is evidence at Esperance, that Woogenellup-based pastures have been more severely reduced in clover density by clover scorch disease (caused by the fungus Kabatiella caulivora), than the harder-seeded, but equally scorch susceptible Yarloop and Seaton Park cultivars.

In the drier wheatbelt environment the situation regarding hard-seededness is quite different to that in the higher rainfall areas. Cropping is frequent and due to its relatively greater profitability the intensity of cropping has increased in recent years. Annual medics, which have about 75 per cent of their seed still “hard” at the break of the season can easily persist through two or more crops. Using this as a guideline, the original low rainfall cultivar Geraldton, with about 20 per cent hard seed at the break of the season in the wheatbelt, falls well below requirements. By contrast, the more recently developed Nungarin cultivar has, at the break of the season, 40 per cent or more of the previous
Table 1. Some important characters of the subterranean clover cultivars registered in Australia.

<table>
<thead>
<tr>
<th>Days from sowing to flowering when sown at Perth in early May</th>
<th>Flowering begins about</th>
<th>Seed formation completed by</th>
<th>Relative hard-seededness</th>
<th>Oestrogenic activity</th>
<th>Relative clover scorch resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nungarin</td>
<td>77</td>
<td>Early-mid Aug.</td>
<td>Late Sept.</td>
<td>10</td>
<td>Low</td>
</tr>
<tr>
<td>Northam</td>
<td>75</td>
<td>Mid Aug.</td>
<td>Early-mid Oct.</td>
<td>8</td>
<td>Very high</td>
</tr>
<tr>
<td>Dwalganup</td>
<td>83</td>
<td>Mid Aug.</td>
<td>Mid-late Oct.</td>
<td>7</td>
<td>High</td>
</tr>
<tr>
<td>Geraldton</td>
<td>97</td>
<td>Late Aug.</td>
<td>Early Oct.</td>
<td>8</td>
<td>Low</td>
</tr>
<tr>
<td>Daliak</td>
<td>97</td>
<td>Mid-late Aug.</td>
<td>Mid-late Oct.</td>
<td>6</td>
<td>Low</td>
</tr>
<tr>
<td>Dallaline</td>
<td>98</td>
<td>Late Aug.</td>
<td>Mid-late Oct.</td>
<td>8-9</td>
<td>Low</td>
</tr>
<tr>
<td>Univager</td>
<td>103</td>
<td>Mid-late Aug.</td>
<td>Early Oct.</td>
<td>5</td>
<td>Low</td>
</tr>
<tr>
<td>Yarloop</td>
<td>109</td>
<td>Early Sept.</td>
<td>Late Oct.</td>
<td>4</td>
<td>Very high</td>
</tr>
<tr>
<td>Seaton Park</td>
<td>110</td>
<td>Early Sept.</td>
<td>Late Oct.</td>
<td>5</td>
<td>Low</td>
</tr>
<tr>
<td>Trikalla</td>
<td>112</td>
<td>Early Sept.</td>
<td>Early Nov.</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Dinninup</td>
<td>113</td>
<td>Early Sept.</td>
<td>Early Nov.</td>
<td>7</td>
<td>Very high</td>
</tr>
<tr>
<td>Enfield</td>
<td>118</td>
<td>Early Sept.</td>
<td>Early-mid Nov.</td>
<td>1-2</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Esperance</td>
<td>120</td>
<td>Mid Sept.</td>
<td>Late Nov.</td>
<td>5</td>
<td>Low</td>
</tr>
<tr>
<td>Clare</td>
<td>129</td>
<td>Mid Sept.</td>
<td>Mid Nov.</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Woogenellup</td>
<td>130</td>
<td>Mid Sept.</td>
<td>Mid Nov.</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Howard Variable 90-135</td>
<td>131</td>
<td>Mid Sept.</td>
<td>Mid Nov.</td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>Bacchus Marsh</td>
<td>131</td>
<td>Late Sept.</td>
<td>Late Nov.</td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>Mt Barker</td>
<td>137</td>
<td>Early Oct.</td>
<td>Early Dec.</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>Larisa</td>
<td>142</td>
<td>Early Oct.</td>
<td>Early Dec.</td>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>Nangee Lake</td>
<td>143</td>
<td>Early Oct.</td>
<td>Early Dec.</td>
<td>8</td>
<td>Moderate</td>
</tr>
<tr>
<td>Meeteora</td>
<td>148</td>
<td>Early Oct.</td>
<td>Mid Dec.</td>
<td>1</td>
<td>High</td>
</tr>
<tr>
<td>Tallarook</td>
<td>163</td>
<td>Mid Oct.</td>
<td></td>
<td></td>
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</tbody>
</table>

† In areas where the cultivar is commonly grown.
‡ Scale of 1 to 10 for both hard-seededness at the autumn seasonal break and resistance to clover scorch.
1 = Little or no hard-seededness/little or no resistance to clover scorch.
10 = Very high level of hard-seededness/very high degree of resistance to clover scorch.

years seed set still remaining as hard seed. It is thus potentially a more persistent cultivar than Geraldton. Whether an even higher level of hard seededness than that in Nungarin would be desirable needs to be investigated. Nevertheless, because of the success of the much harder seeded medics in the wheatbelt, improvement in the levels of hard-seededness in subterranean clover cultivars intended for this area remains an important objective of the subterranean clover improvement programme.

Oestrogenic activity

Since the 1940s, subterranean clover has often been associated with sheep infertility, and lambing percentages of 20 per cent or less have been recorded in some subterranean clover districts. Other characteristic features of the syndrome which became known as “clover disease” include maternal dystokia and uterine prolapse in ewes and less commonly “water belly” or bladder distension in wethers.

Clover disease is caused by oestrogenic isoflavones which are formed in the green leaves of subterranean clover. Three isoflavones, formononetin, genistein and biochanin A have all been found in large quantities, with individual levels of as much as two per cent or more of the dry weight of leaf. Of these, formononetin is the one responsible for most of the oestrogenic activity.

The Yarloop, Dwalganup and Dinninup cultivars have been associated with serious clover disease problems and Geraldton has been implicated in less spectacular cases. The other potentially oestrogenic older cultivars, Howard and Tallarook have limited distribution in this State and are mainly confined to pastures grazed by cattle. All the more recent cultivars have much lower formononetin levels, although Meteora has a higher than desirable level while Esperance and Enfield should also be regarded as slightly suspect with respect to clover disease.

In addition to causing clover disease, cultivars with high levels of formononetin, such as Dinninup and Yarloop, have a further disadvantage. In the green stage they have a lower feeding value for sheep than low formononetin cultivars probably because they are less palatable. The precise relationship between formononetin and palatability requires further investigation.

All new crossbreds and selections should be low in formononetin even if their use is intended for cattle country because, under different economic circumstances, sheep may become part of the farm enterprise in such localities. A maximum formononetin
content of 0.20 per cent of the leaf dry weight is used as a guideline in the subterranean clover improvement programme; even lower levels should be easily achieved in future cultivars, as such levels are common to many of the varieties in the subterranean clover collection.

**Diseases and insects**

During most of its history in Western Australia, subterranean clover has been largely free from serious disease and insect problems although both red-legged earth mite (*Halotydeus destructor*) and lucerne flea (*Sminthurus viridis*) have caused significant damage from time to time. However, some major problems have arisen since 1970.

**Clover Scorch**

Serious outbreaks of this disease, which is caused by the fungus *Kabatiella caulivora*, were first reported in 1970 from the Albany and Bunbury areas and this was followed by a severe epidemic in 1971 affecting areas from Bunbury to Esperance. The damaging effects of clover scorch on subterranean clover growth and persistence were well illustrated in the Esperance area where, following the first outbreak in 1971, some pastures deteriorated rapidly and as a result their potential carrying capacity was reduced.

Commercial cultivars differ markedly in their ability to withstand clover scorch (see Table 1). Daliak, Esperance and Meteora all have shown considerable resistance to the disease while Yarloop, Woogenellup and Seaton Park are highly susceptible and can no longer be recommended for clover scorch prone areas. Other cultivars such as Mt Barker, Larisa and Trikkala are intermediate in their response to clover scorch; although moderately susceptible, they are rarely destroyed by the disease.

Although clover scorch has not been as serious as it was in 1971, it is still a major pasture problem in high rainfall areas of Western Australia, South Australia and Victoria, because of its adverse effects on spring growth and seed production.

**Root rots**

Root rot diseases, caused by a number of fungal pathogens including *Pythium* and *Fusarium* species, have seriously affected subterranean clover in high rainfall areas from Busselton to east of Albany. They are probably an important cause of poor persistence of subterranean clover in parts of these areas and hence a contributor to the problem of pasture deterioration. Damage caused by root rots is not always obvious. For instance, they can cause substantial losses of seeds and seedlings during germination and establishment, which in the absence of careful observation, may go unnoticed.

The results of field screening of cultivars for their reaction to the disease, known as “south coast root rot” have shown that Woogenellup and Mt Barker are the most susceptible cultivars and Dinninup and Daliak the most tolerant.

**Blue-green aphid**

Damage to subterranean clover caused by blue-green aphids (*Acyrthosiphon kondoi*) was first reported in 1979. So far they have not caused widespread damage although there have been isolated reports of the collapse of clover swards in spring as a result of aphid attack. Blue-green aphids are a potential threat to the growth and seed production of subterranean clover, although it remains to be seen whether they will become a widespread problem.

Amongst the commercial cultivars so far tested, Dalkeith and to a lesser extent Clare show some tolerance to blue-green aphids while in contrast, Daliak is highly susceptible.

**Other characters**

In addition to the critically important characters outlined above, there are others which need to be considered when selecting a cultivar for a particular situation. In winter waterlogged situations for example, the only cultivars which will grow well are those from the subspecies *yunninicum* namely, Yarloop, Trikkala, Larisa and Meteora.

Clovers from subspecies *brachycalyicum* are well suited to neutral to slightly alkaline
The registered cultivars of subterranean clover

There are 22 cultivars of subterranean clover for which seed has been, is, or probably soon will be, available commercially and most are included in certification schemes. Some are no longer recommended for use. The cultivars are described in order of their flowering time.

Nungarin

Nungarin is a very early maturing cultivar which was developed in the National Subterranean Clover Improvement Programme, run jointly by the Institute of Agriculture, University of Western Australia, and the Western Australian Department of Agriculture. It was registered in 1976. Nungarin is derived from a cross between two locally naturalized varieties, namely, Daglish and Northam A2, and was selected because of its superiority to the existing early cultivar Geraldton in terms of earliness of maturity and hard-seededness. It is low in formononetin and will not cause clover disease.

During winter, animal production on subterranean clover pastures is limited by the amount of herbage available. For this reason good winter growth is regarded as a valuable character in subterranean clover cultivars. Woogenellup became a widely sown and popular cultivar because it seems to have good winter growth and Yarloop and Trikkala have also been observed to grow vigorously in winter. In contrast, cultivars such as Larisa and Mt Barker appear to make much less growth in winter. While there may be differences between cultivars in winter growth, visual assessment of this character is complicated by differences in growth habits. With respect to the above cultivars, the erect growth habit of Woogenellup, Yarloop and Trikkala gives an impression of more vigorous growth than that in Mt Barker and Larisa which have a much more prostrate habit.

soils. Clare is the only registered cultivar in Australia from this group and because of its relatively late maturity, the opportunities for its use in this State are limited.

In all or most situations, characters such as palatability and winter growth deserve some consideration in cultivar selection. As indicated earlier, cultivars such as Dinninup and Yarloop are relatively unpalatable and in a mixed pasture this results in increased grazing pressure on the non-clover components, which may be part of the reason for the high clover content of pastures based on these cultivars.

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for livestock. Thus, herbage yield was not considered especially important during the selection programme. Nevertheless, under sward conditions, herbage production from Nungarin has at least equalled that of Geraldton.

**Northam**

This is a naturalized variety which was first found near the township of that name in 1931. For many years it was known as Northam A, but in 1976 when it was included in the seed certification scheme the suffix “A” was officially dropped from the name.

Northam is an erect-growing, tall, somewhat “showy” cultivar which is early maturing, low in formononetin and has a reasonably high level of hard-seededness. It has given good results compared to Dwalganup and Geraldton in low rainfall areas.

Northam should replace the highly oestrogenic Dwalganup in districts adjoining the Great Southern railway and in the south-eastern wheatbelt.

**Dwalganup**

Dwalganup, the original “early” cultivar, was discovered by the late Mr P. D. Forrest on his “Dwalganup” property at Boyup Brook where it was thought to have been accidentally introduced as a contaminant of imported seed about 1890. Graded seed was available commercially by 1929 and it was first certified in Western Australia in 1934. It is the most widely established cultivar in Western Australia, accounting for nearly one-third of the total area of improved pasture.

Dwalganup has a high level of oestrogenicity and has caused widespread infertility, particularly in the 400mm to 600mm annual rainfall cereal and sheep districts. As a result it is no longer recommended for use. Daliak is a suitable replacement in the wetter districts while Northam should replace Dwalganup in the drier areas.

**Geraldton**

This naturalized variety was first found in the Geraldton district in 1950 and released commercially by the Institute of Agriculture, University of Western Australia in 1959. It was the main cultivar sown in the cereal and sheep districts from the early 1960s until the late 1970s when Nungarin was released.

Geraldton begins flowering 7 to 10 days after Dwalganup, but because of faster seed development produces mature seed some 10 to 14 days earlier. It has a prostrate growth habit.

The seed yields of Geraldton in districts with less than 375mm annual rainfall are usually higher than those of Dwalganup, but except in good seasons they are not as high as those of Nungarin.

Geraldton has a moderate to high level of formononetin and can cause clover disease. However, in the drier cereal and sheep districts where Geraldton is grown, clover disease has not been as important as in the higher rainfall areas.

**Daliak**

This cultivar was known to have been growing on Mr A. J. Monger’s property “Daliak” at York before 1920. It was sown to a limited extent, mainly on other properties in the York district, during the 1930s. However, it has also been found to be widespread throughout the south-west
Western Australia in 1967. It is virtually free of any oestrogenic activity.

Uniwager is early flowering (similar to Geraldton), and has a prostrate growth habit. It was sown relatively widely in the late 1960s, but became unpopular because it lacked the vigour of its Geraldton “parent”. Freedom from oestrogenic isoflavones did not compensate for lack of vigour.

Uniwager has persisted as well as Geraldton in dry areas and some Uniwager pastures can still be found. However, seed is no longer available commercially.

Yarloop
This cultivar was first found in the Yarloop district in 1935 and by 1939 it had come into prominence as a commercial cultivar. Yarloop is a member of subspecies

Dalkeith
This is a naturalized variety which was first found in the Perth suburb of Dalkeith in 1967. It was registered in 1983 and is the most recent of the registered cultivars.

Dalkeith is characterised by a very low formononetin and total isoflavone content, a high level of hard-seededness (similar to Nungarin), and good burr burial. It is susceptible to clover scorch, but reasonably tolerant of blue-green aphid attack. It begins flowering a little after Daliak and before Seaton Park.

Although Dalkeith is similar to Dwalganup in many morphological respects it can be distinguished by its later flowering, less rounded and more indented leaflets, and lack of anthocyanin pigmentation on the leaves. It also has a much lower level of formononetin.

Dalkeith has persisted well in trials over several years in southern and central New South Wales where it is now being recommended as an alternative to Daliak.

Dalkeith, because of its higher hard-seededness and greater tolerance of blue-green aphids, may be useful in Western Australia as an alternative to Daliak in areas where clover scorch is not a problem.

Uniwager
This is a chemically-produced mutant of the Geraldton cultivar which was released by the Institute of Agriculture, University of
yannicum, and like all members of this group can grow successfully on winter waterlogged soils.

Yarloop is an erect and tall growing cultivar which commences flowering about three to four weeks after Dwalganup. For many years it was used mainly on the heavy clay, waterlogged flats west of Waroona, Harvey and Brunswick, where other cultivars failed. Later, it was found to grow well on well-drained soils in medium rainfall districts (400 to 600mm annual rainfall) and many thousands of hectares were sown during the 1950s, particularly in the Esperance, Kojonup and Boyup Brook districts. These large scale sowings of Yarloop in areas used largely for sheep grazing eventually led to serious sheep infertility problems. Later, these were explained on the basis of the high formononetin levels in Yarloop causing marked oestrogenic activity. As a result, Yarloop is no longer recommended for sowing.

The low formononetin cultivar, Trikkala has virtually completely replaced Yarloop.

Seaton Park

The original variety known as Seaton Park was found in 1929 in the Adelaide suburb of Seaton. Recent observations have indicated that the Seaton Park cultivar now grown in Western Australia is similar to, but not identical with, the variety originally collected. The nature and possible reasons for the difference are currently being investigated.

During the 1960s, when it was realised that many of the existing early cultivars were high in formononetin, and thus likely to cause clover disease, a search began for suitable “safe” replacement cultivars. Seaton Park was selected and released in Western Australia in 1967 mainly on the bases of its low formononetin content and good performance in long-term mixture trials.

Seaton Park commences flowering about four weeks later than Dwalganup, has a reasonably good level of hard-seededness and good burr burial. It has been a useful and persistent variety in medium rainfall areas, except on the south coast where, in more recent years, its extreme susceptibility to clover scorch has made it unpopular.

Seaton Park is the most suitable cultivar for the areas from Gingin to Eneabba (400 to 600mm annual rainfall) and most of the annual seed crop of some 400 tonnes is produced and used there.

Trikkala

Trikkala, like Yarloop, is a member of subspecies yannicum. It was developed in the National Subterranean Clover Improvement Programme from a cross (made at CSIRO, Canberra) between the low formononetin, late maturing cultivar, Larisa and the early flowering, highly oestrogenic variety, Neuchatel.

Bred as a low formononetin replacement for Yarloop, Trikkala was released in 1975. It matures a few days later than Yarloop and its winter growth, total herbage production and seed yield are at least equal to those of Yarloop. Trikkala has inherited from its parent Larisa, a degree of tolerance to clover scorch disease. Although not as resistant as Daliak, it is considerably less susceptible than Yarloop. Trikkala has rapidly gained in popularity since its release. Generally it has been grown in the medium and high rainfall areas south of Perth and experience has shown that it is more widely adapted than was originally expected. Trikkala is suited to winter waterlogged soils, but it is also successful in areas that are better drained.

Dinninup

Dinninup was found in 1956 at Boyup Brook where it was common in paddocks close to the township. Certified seed of Dinninup first became available in 1962. Dinninup appears to make relatively slow winter growth, but its spring production is good and often exceeds that of Yarloop and other varieties in the same maturity group.

In Perth, Dinninup flowers at about the same time as Seaton Park. However, its
maturity ranking varies considerably between locations. In warmer areas, such as in the northern agricultural districts, it flowers up to two weeks earlier than Seaton Park, whereas at cooler locations such as around Mt Barker and Boyup Brook it can be as much as 10 days later. Dinninup is a prolific seed-setter, has good burr burial and high levels of hard-seededness and embryo dormancy. It also has good tolerance to root rots.

Dinninup became very popular during the 1960s because of its tendency to become dominant in pastures. It was found subsequently that this dominance was due, in part, to its poor palatability, with sheep tending to select any other clover, grass, or herb for preference. So unpalatable is the cultivar that sheep grazing Dinninup dominant pastures in winter often achieve only very slight gains in weight. Later, Dinninup was found to have very high levels of formononetin and total isoflavones which probably accounted for its low palatability and made it highly oestrogenic.

Although Dinninup is undoubtedly one of the better cultivars for total production and adaptability, it cannot be recommended for general planting because of its high oestrogenic activity and susceptibility to clover scorch. However, it may have a place on some of the drier sandy or gravelly soils in the dairying districts where other cultivars will not grow successfully and where oestrogenicity is not of economic significance.

Enfield
Enfield was first observed in 1973, growing on the roadside near Kilmore in Victoria. Following a recommendation by the Victorian Department of Agriculture it was registered as a cultivar in 1982.

In Perth, Enfield begins flowering about 12 days earlier than Woogenellup and about one week after Seaton Park. It is more tolerant to clover scorch than Woogenellup, but much less so than Daliak or Esperance. Formononetin level is low to moderate. Enfield has weak burr burial and a low level of hard-seededness (less than that of Woogenellup).

In Victoria, Enfield is reported to be highly productive in the autumn-winter period, and it is recommended for sowing as an alternative to Woogenellup where clover scorch is severe.

Enfield has not been tested (as at 1983) in the field in Western Australia and no recommendation regarding its use has been made. However, in medium to high rainfall areas where Enfield might be considered, its very low level of hard-seededness may be a disadvantage, particularly if cropping is part of the farm enterprise.

Esperance
Esperance was registered as a cultivar in 1978. It is derived from a cross between Bacchus Marsh and Daliak and is the first cultivar selected specifically for resistance to clover scorch.

Esperance closely resembles Daliak in appearance, except for slightly paler calyx pigmentation and a tendency to produce the occasional leaf with four leaflets. It also has the fine growth and compact growth habit of Daliak.

However, Esperance is at least three weeks later in flowering than Daliak and generally is intermediate in maturity between Dinninup and Woogenellup. In this respect it is suitable as an interim cultivar for most of the clover scorch affected south coast areas.

The level of hard-seededness in Esperance is similar to that in Daliak and slightly higher than that in Woogenellup. Esperance has a low to moderate level of formononetin and so is slightly suspect as a cause of clover disease.

Clare
This cultivar originated from South Australia where it was reported to have been growing on a property near the township of Clare since about 1921. The first commercial seed was certified in South Australia in 1950.
Woogenellup

The exact origin of Woogenellup is obscure, but it was first noticed growing vigorously on an old Group Settlement property at Manjimup about 1951. Some of the seed for pastures established on these properties originated from a property at Elgin, where Woogenellup was subsequently found growing. This was probably the site of its first establishment in Western Australia. Certified seed first became available in 1959.

Woogenellup first came into prominence in the 1950s when its ability to produce a good bulk of forage in winter and its persistence made it popular in the medium to high rainfall zones (500 to 800mm annual rainfall) of the entire southern agricultural areas of the State. It became the basic pasture species on the south coast in particular and also on many newly-cleared areas of the south-west and west coast districts. During the 1960s over one million hectares were sown in Western Australia, and large areas were sown in other southern States and overseas.

Woogenellup matures about 4 to 6 weeks later than Dwalganup. It appears to be vigorous growing in the vegetative stage, but is not a prolific seed-setting cultivar.

Clare is one of only two varieties of the subspecies *brachycalycinum* to have been found in Australia. Varieties in this group characteristically develop long thin peduncles which push the burrs along the soil surface until they find protection in a soil crack or under a stone. In their natural habitat in the Mediterranean region they are usually found on soil types which are neutral to slightly alkaline in reaction.

Clare commences flowering about the same time as Woogenellup, but takes 1 to 2 weeks longer to complete seed formation. Its oestrogenic potency is low and it has some tolerance to clover scorch.

The performance of Clare under grazing in Western Australia has not been as good as that of Woogenellup; in fact its performance under heavy grazing has generally been poor and it is not grown on a large scale. However, Clare can grow well on neutral and slightly alkaline soils making it suitable for the tuart sands south of Perth and the limited areas of limey soils along the south coast.

During the late 1960s Clare was in strong demand on the seed export market and many of the Clare pastures in Western Australia were originally established specifically to service that market.

**Fig. 2 — The agricultural area of Western Australia divided into zones for which recommendations are made. (See Table 2.)**
and normally most of the burrs are formed above the soil surface. It has a low to moderate level of hard-seededness and is highly susceptible to clover scorch disease.

Although the total isoflavone content of Woogenellup is reasonably high its formononetin level is relatively low and field evidence suggests it does not cause the infertility in sheep sometimes associated with the Dwalganup and Yarloop cultivars.

Since 1970, following severe outbreaks of clover scorch disease, Woogenellup has lost much of its popularity on the south coast and in the south-west. It is no longer sown to any major extent in these areas although it is still popular in the higher rainfall west coast districts north of Perth.

Howard

This cultivar was developed at CSIRO in Canberra from a cross between Northam and the clover stunt virus resistant cultivar, Tallarook. It was first certified in Western Australia in 1964.

Howard is variable with respect to the time of commencement of flowering (with a range of up to six weeks between plants) with the latest plants completing seed formation at about the same time as Woogenellup. It has a high level of formononetin which could cause infertility in sheep.

Howard has not been sown as a pasture in Western Australia although a few areas were established during the early 1960s specifically for seed production. Howard's main merit lies in its high degree of resistance to the aphid-transmitted, clover stunt virus; but as this is not a disease of any significance in Western Australia there appears to be a little place for the cultivar.

Bacchus Marsh

Bacchus Marsh was first observed at Myrniong near Bacchus Marsh, Victoria in 1929. It was first certified in Victoria in 1937 and in Western Australia in 1947. Bacchus Marsh normally matures a few days later than Woogenellup. It gives good growth in the spring and is very palatable both in the green and dry stage. It is not a prolific seed-setting cultivar and usually all its burrs form above the soil surface. Formononetin level is low and it has never been associated with infertility in sheep.

Bacchus Marsh was extensively planted in the late 1950s particularly at Esperance, but in many instances proved disappointing. It has a major disadvantage

Table 2. The distribution of existing subterranean clover cultivars in Western Australia and current recommendations for cultivar selection.

<table>
<thead>
<tr>
<th>Zone, rainfall and main establishment period</th>
<th>Approx. area of subterranean clover (ha)</th>
<th>Main existing cultivars</th>
<th>Current recommendations</th>
</tr>
</thead>
</table>
| 1. Old south-west zone 800 to 1500mm 1820 to 1950 | 750,000 | Mt Barker  
Woogenellup  
Yarloop | Larisa for general sowing in mixture with Trikkala. Esperance to be included on gravelly hills where clover scorch is a problem; replace with Woogenellup if scorch risk is low. Mt Barker can be used where root rots are not prevalent. Meteora alone or with Trikkala along the south coast for hay production. |
| 2. New west coast zone 500 to 800mm 1865 to 1975 | 250,000 | Seaton Park  
Daliak  
Dwalganup  
Woogenellup | Seaton Park for general sowing with Woogenellup in the higher rainfall areas and Daliak or Northam in the drier areas. Trikkala on waterlogged soils. |
| 3. Intermediate lateritic zone 500 to 800mm 1930 to 1970 | 750,000 | Woogenellup  
Dinninup  
Dwalganup  
Yarloop  
Seaton Park | Woogenellup and Seaton Park for general sowing with Daliak on drier margins. Trikkala should be included in higher rainfall areas and particularly on areas subject to winter waterlogging. Esperance should be used in the pasture mixture where clover scorch has been a problem. |
| 4. Old Dwalganup zone 400 to 500mm 1935 to 1975 | 2,500,000 | Dwalganup  
Geraldton  
Daliak | Northam for general sowing, but Daliak or Seaton Park for the south-western edge and Nungarin for the eastern edge of the zone. |
| 5. Dry wheatbelt zone 300 to 400mm 1950 to 1970 | 500,000 | Geraldton  
Dwalganup | Nungarin on all light soils. Northam should be used as an alternative in the higher rainfall and more southerly parts of this zone. |
| 6. New south coast zone 400 to 700mm 1950 to 1970 | 750,000 | Woogenellup  
Yarloop  
Seaton Park  
Daliak  
Dinninup | Esperance and Trikkala mixture with Daliak included in the drier areas. Woogenellup can be included if clover scorch has not been severe. |
| 7. South-eastern wheatbelt zone 300 to 500mm 1940 to 1970 | 700,000 | Dwalganup  
Geraldton  
Daliak | Northam/Daliak mixture for the western area. In the east, include Nungarin in a mixture with Northam and Daliak, particularly if cropping is frequent. |
in being extremely soft-seeded with most of the seeds being capable of germination by February each year. This resulted in many regeneration failures following "false breaks" and led to a decrease in the area sown. Bacchus Marsh is moderately susceptible to clover scorch disease. Because of these disadvantages, Bacchus Marsh is no longer an important cultivar in this State. Seed supplies are rarely, if ever, available.

**Mt Barker**

This cultivar was first observed at Mt Barker, South Australia in 1889 and it subsequently became the first variety to be cultivated in Australia.

Mt Barker was first introduced into Western Australia in the early 1900s. During the 1920s it was extensively planted in the high rainfall areas of the south-west as well as in adjacent drier districts. It is still perhaps the main pasture legume of the lower south-west.

Mt Barker was referred to for many years as "midseason"; it flowers and matures some 5 to 7 weeks later than Dwalganup and a week or so after Woogenellup. It is a very leafy cultivar and makes excellent growth in spring. Its winter growth appears to be rather poor and for this reason it tended to be less popular than Woogenellup. However, more recently it has regained popularity because of its better tolerance to clover scorch disease.

Formononetin level is very low in Mt Barker and there is little likelihood that it will cause infertility in sheep.

**Larisa**

Larisa is a member of subspecies yanninicum. It was collected in northern Greece in 1965 as part of a programme to produce a low formononetin cultivar suitable for waterlogged situations. Registered in 1975, it was first released to farmers in 1977.

Larisa is identical to Trikkala in appearance, but is four weeks later in maturity. It commences flowering a few days after Mt Barker and in small-scale experiments has shown moderate tolerance to clover scorch disease and south coast root rots. Its winter growth, like Mt Barker, appears to be slow, but spring growth is good. Larisa has low oestrogenic activity and has performed well under grazing. However, because of its late maturity its use is restricted to high rainfall districts.

**Fig. 3 -- Illustration of the botanical terms used in the text.**
Nangeela
This cultivar originated from Victoria where it was first discovered near the township of Nangeela in the early 1930s. It has been commercialised to a limited extent in both Victoria and South Australia and has also been sown in Oregon and California in the United States of America. In Western Australia, so far as is known, it has been deliberately sown on only a few hectares east of Donnybrook. However, there are several Nangeela pastures in the Manjimup district which appear to have been established for many years. None of the present owners have any knowledge of the origin of these pastures.

Nangeela is late flowering and has low oestrogenic activity, but is relatively susceptible to clover scorch disease. It probably has little potential for direct use in Western Australia although, because of its distinctive leaf markings and vigorous growth, it has been used as a parent in a number of crosses made in the National Subterranean Clover Improvement Programme.

Meteora
Meteora originated from northern Greece and is the second subspecies *yanninicum* cultivar, following Larisa, to come from the collection made in 1965. It was registered and released in 1981.

Meteora is late-flowering, about 7 to 10 days later than Mt Barker, and in Western Australia needs a growing season of at least nine months for satisfactory persistence. It has an unusually high level of hard-seededness for its maturity which, under cool summer conditions, may result in thin stands in the second year. Like the other subspecies *yanninicum* cultivars, Meteora is tolerant of waterlogging.
Formononetin level is a little higher than that considered desirable and Meteora should be regarded as slightly suspect as a cause of clover disease.

Meteora has considerable resistance to clover scorch and some tolerance to south west root rots. In this latter regard it is clearly better than Woogenellup and Mt Barker.

Meteora's outstanding attribute is its exceptional spring growth and this, together with its tall habit and resistance to clover scorch, makes it particularly useful for hay production. Meteora should be well suited to the high rainfall areas on the south coast where cattle production and fodder conservation are part of the farming system.

**Tallarook**

This naturalized variety was discovered near Tallarook, Victoria in 1928. It is the latest maturing of the commercial cultivars, and does not commence flowering until about mid-October. It was first certified in 1935 in Tasmania and in 1943 in Western Australia.

Although Tallarook was introduced into Western Australia as early as about 1940 it has been grown only to a very limited extent, mainly in the very high rainfall districts of the lower south-west. It is a leafy cultivar which appears to make little growth until spring and it is used mainly in combination with earlier maturing types such as Woogenellup or Yarloop. It has moderate tolerance to clover scorch. Tallarook contains a high level of formononetin and although it is likely to cause infertility in sheep, this is of little consequence as dairying and beef cattle production are the main enterprises in districts where Tallarook is grown.

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**Table 3. Key for the identification of the registered cultivars**

<table>
<thead>
<tr>
<th>Trifoliate leaf</th>
<th>Petiole</th>
<th>Stipule</th>
<th>Runner</th>
<th>Flower</th>
<th>Seed</th>
<th>Other distinctive features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf markings</td>
<td>Upper surface hairiness</td>
<td>Petiole hairiness</td>
<td>Stipule pigment-ation</td>
<td>Runner hairiness</td>
<td>Calyx pigment-ation</td>
<td>Seed colour</td>
</tr>
<tr>
<td>Nungarin</td>
<td>B2</td>
<td>3</td>
<td>1</td>
<td>S1</td>
<td>2-3</td>
<td>Cx4</td>
</tr>
<tr>
<td>Northam</td>
<td>B1</td>
<td>3</td>
<td>1</td>
<td>S1</td>
<td>2-3</td>
<td>Cx4</td>
</tr>
<tr>
<td>Dwalganup</td>
<td>C2 A1</td>
<td>3</td>
<td>2</td>
<td>S1</td>
<td>2-3</td>
<td>Cx1</td>
</tr>
<tr>
<td>Geraldton</td>
<td>B1</td>
<td>2-3</td>
<td>2</td>
<td>S1</td>
<td>2</td>
<td>Cx5</td>
</tr>
<tr>
<td>Daliak</td>
<td>(C1)</td>
<td>2-3</td>
<td>1</td>
<td>S2-3</td>
<td>2</td>
<td>Cx1</td>
</tr>
<tr>
<td>Dalkeith</td>
<td>C2 A1</td>
<td>3</td>
<td>2</td>
<td>S1</td>
<td>3</td>
<td>Cx1</td>
</tr>
<tr>
<td>Uniwager</td>
<td>Nil</td>
<td>2</td>
<td>2</td>
<td>S0</td>
<td>3</td>
<td>Cx0</td>
</tr>
<tr>
<td>Yarloop</td>
<td>A1</td>
<td>0</td>
<td>0</td>
<td>S2-3</td>
<td>0</td>
<td>Cx1-2 Amber Elongated calyx lobes, brown pigmentation often along lower midrib of leaf</td>
</tr>
<tr>
<td>Seaton Park</td>
<td>C3 A2</td>
<td>1</td>
<td>1</td>
<td>(S1)</td>
<td>3</td>
<td>Cx0</td>
</tr>
<tr>
<td>Trikalla</td>
<td>C2 A1-2</td>
<td>0</td>
<td>0</td>
<td>S1-2</td>
<td>0</td>
<td>Cx0</td>
</tr>
<tr>
<td>Dinninup</td>
<td>C3-4 (A1)</td>
<td>0</td>
<td>2</td>
<td>S1-2</td>
<td>2-3</td>
<td>Cx2-3 Black Elongated calyx lobes</td>
</tr>
<tr>
<td>Enfield</td>
<td>C3 (A1)</td>
<td>1</td>
<td>1</td>
<td>S1</td>
<td>2-3</td>
<td>Cx0</td>
</tr>
<tr>
<td>Esperance</td>
<td>(C1)</td>
<td>2-3</td>
<td>1</td>
<td>S2-3</td>
<td>2</td>
<td>Cx5</td>
</tr>
<tr>
<td>Clare</td>
<td>C3 A2-3</td>
<td>0</td>
<td>0</td>
<td>S2</td>
<td>0</td>
<td>Cx0</td>
</tr>
<tr>
<td>Woogenellup</td>
<td>C2 A2-B1</td>
<td>0-1</td>
<td>1</td>
<td>S2-3</td>
<td>0</td>
<td>Cx0</td>
</tr>
<tr>
<td>Howard</td>
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<td>S0</td>
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<td>Cx1</td>
</tr>
<tr>
<td>Bacchus Marsh C3-B2</td>
<td>2</td>
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<td>S0</td>
<td>2-3</td>
<td>Cx0</td>
<td>Black Elongated calyx lobes</td>
</tr>
<tr>
<td>Mt Barker</td>
<td>C3</td>
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<td>2</td>
<td>S2-3</td>
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<td>Cx4</td>
</tr>
<tr>
<td>Larisa</td>
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<td>S1-2</td>
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<td>Cx0</td>
</tr>
<tr>
<td>Nangeela</td>
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<td>S2</td>
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<td>Cx0</td>
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<tr>
<td>Meteora</td>
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<td>S2-3</td>
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<td>Cx0</td>
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<tr>
<td>Tallarook</td>
<td>C1-2 A1</td>
<td>1</td>
<td>2</td>
<td>S0</td>
<td>3</td>
<td>Cx0</td>
</tr>
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</table>

* Pale green arms
  ( ) = Variable, ranging from 0 to 1
Current distribution of cultivars in Western Australia

Within the agricultural districts of the State there are now clearly defined zones in terms of the subterranean cultivars which have been sown in the past. These zones are depicted in Figure 2, and the main cultivars in each zone are shown in Table 2.

The distribution of cultivars between the various zones, is, to some extent, a reflection of climatic boundaries, but it also reflects past history. Most clearing and pasture development in the various districts occurred at clearly defined times and the cultivars selected for sowing were those thought best at the time, to suit both soil type and rainfall.

Selection of suitable cultivars for sowing

The cultivars currently recommended for sowing in the various zones are shown in Table 2. These recommendations are under regular review as experience is gained with newer cultivars and additional ones become available.

As more cultivars are developed to meet special needs, cultivar selection for specific sites may become more complex. However, the need to choose types of a suitable maturity for an area will remain basic to any selection considerations. This is not simply a matter which can be decided by rainfall or length of growing season.

Climate mainly determines what can be grown, but soil type and topography determine to what extent the climatic potential can be realised. An extreme example of soil type playing a dominant role is found at Perth where, in a rainfall of 900mm, the only cultivars persisting on the rapid-drying coarse sands are early maturing types such as Dwalganup. Similarly, in any district it is reasonable to expect gravelly hills and sandy surfaced soils to dry out some three weeks before the better soils, and allowance should be made for this in selecting suitable cultivars.

Identification of the registered cultivars

There are several visible characters that can be used to distinguish subterranean clover cultivars. However, some of these vary markedly with plant growth stage, soil type, fertiliser treatment, grazing management, degree of competition from other plants and various environmental influences. For example, Bacchus Marsh has distinctive brown flecking on the upper leaf surface when grown as spaced plants in test rows, but under normal pasture conditions this flecking may not be present. Another example is in Dinninup where in the early growth stages the leaves develop strong brown pigmentation in the midrib and around the border of the leaf mark. However, from the beginning of flowering onwards this pigmentation is much less pronounced and may be completely lacking.

As far as possible, cultivar identification is based on characters which are not too much affected by the plant's environment. Nevertheless, the observer should be aware that some variation in the expression of these characters is likely to occur. There may be variation both within and between plants of the same cultivar at one location and also in the same cultivar grown at different locations.

Terms used

The plant parts used for identifying cultivars are shown in Figure 3. Identification is based on variation in attributes of the leaf, petiole, stipule, runner, flower and seed, together with data on the time of flowering.

The categories of variation and their ratings are illustrated in Figure 4. The ratings for the registered cultivars, based on these categories are shown in Table 3.

To identify a plant, its characters as determined from Figure 4 should be related to the data of Table 3. To confirm the identification, the specimen should be compared to the colour plates included in the text.

The early flowering stage is the most suitable time to attempt identification. Before flowering, identification is not easy and often impossible.

The characters used for identification are briefly described below:

- Trifoliate leaf markings
  Most cultivars have some type of marking on the upper leaf surface other than the variable red or brown flecking. Commonly the mark consists of a pale green centre with white (or occasionally green) “arms” extending from the edge of the central area to the leaflet margin. In some cases the mark consists solely of a pale green band extending across the leaflet. The various markings are illustrated in Figure 4.

- Leaf, petiole and runner hairiness
  In Figure 4 the degree of hairiness is divided into four categories — no hairs,
few hairs, hairy and very hairy. Because the division between the groups is somewhat subjective the differential degree of hairiness is not used as primary means of cultivar identification unless a cultivar has one or more plant parts which are completely hairless.

- **Stipule pigmentation**
  Stipule pigmentation is usually fully expressed in a dense vigorous sward by the time of early to mid-flowering. It fades to varying degrees as plants mature. Four categories of pigmentation are illustrated in Figure 4 ranging from completely pale green through to a red flush covering half or more of the stipule surface.

- **Calyx pigmentation**
  This is one of the most important characters for distinguishing between cultivars. Six levels are defined in Figure 4 ranging from no pigmentation, i.e. pale green as in Bacchus March and Woogenellup, through to pigmentation on three-quarters or more of the calyx tube, as in Daliak.

- **Time of flowering**
  The time of commencement of flowering for a cultivar will vary depending on location and the time of germination and so is not a completely reliable guide for cultivar identification. However, at times it is useful and for this reason the normal expected time of first flowering has been included in Table 1.

- **Seed colour**
  Seed colour is only useful for distinguishing the subspecies *yanninicum* cultivars, Yarloop, Trikkala, Larisa, Meteora (which all have amber seeds) from the other registered cultivars. Mt Barker frequently has a purplish seed and Clare has a relatively large unusually flat seed, but in neither instance is the colour or shape sufficiently distinct to be used for identification.

**Bibliography**


Quinlivan, B.J. and Francis, C.M. (1977). Registered cultivars of subterranean clover in Western Australia — their origin, potential use and identification. Bulletin No. 4012, Western Australian Department of Agriculture.
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