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Subterranean clover in W.A.

2. Characteristics required for agronomic success

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Development of subterranean clover varieties is a rapidly changing scene, particularly in terms of farmer acceptance, disease and persistency problems. This is only to be expected, because this is an agricultural plant of only some 50 to 70 years standing, whereas many other pasture plants have been in common use for thousands of years.

In a situation of such rapid change, frequent review of the philosophy behind current selection and development becomes essential.

Subterranean clover’s contribution to the farm system varies widely. In high rainfall non-cropping areas it is essential for high herbage production and maximum profits from animal production. In low rainfall areas its primary role lies in its ability to enhance crop yields. These distinct situations not only demand different clovers but also different proportions of clover in the pasture.

In the agricultural areas as a whole subterranean clover is regarded primarily as a grazing plant. Its contribution to the grazing situation however is not as a single species. One of its most important contributions is its ability to “fix” atmospheric nitrogen and so encourage the growth of various herbs and grasses within a well balanced pasture. A substantial and important part of the herbage production and the animals’ diet arises from these dependent associated species.

A further highly important role for subterranean clover in at least half the agricultural areas of Western Australia is the fixing of atmospheric nitrogen for use by cereal crops. Crop yields in this State are limited by the low soil nitrogen status and there is little doubt that the cheapest nitrogen is that provided by a preceding legume pasture.

In recent years cereal cropping has been so much more profitable than grazing sheep that many farmers see the main benefit from subterranean clover and the other legume pastures coming not through increased and higher quality herbage production but rather from better crop yields. In the cropping areas maintenance of the highest possible clover and minimisation of grasses and herbs (they are weeds in the crop situation) is the current aim.

In both these distinct land use systems there are therefore compelling reasons why the top-growth production of the subterranean clover component of a pasture is not the critical factor. In many, perhaps most situations in Western Australia, it is not the major criterion of its success and herein lies the difference in basic philosophies behind pasture breeding and selection in Western Australia as compared with other parts of Australia and overseas countries, especially those using mainly perennial pasture species.

To fulfil the broad functions outlined above the clover must first persist. The desirable characteristics of subterranean clover can therefore be considered under

- persistence factors and
- characters affecting production patterns of the clovers, such as winter vigour, oestrogenicity, waterlogging and palatability, which usu-
The clover must also maintain soil nitrogen levels in the cropping situation.

Persistence

The characteristics required of subterranean clover varieties vary from district to district. They depend on the type of farm enterprise, the soil type and the climate, but the characteristic common to all is the need for the cultivar to persist in the given environment.

Implied in any definition of persistence is competitive ability either with other varieties or other species. Thus for a clover to persist satisfactorily it must also be competitive. This ability to compete is particularly important in situations where one variety is to replace another, for example, new cultivars to replace oestrogenic cultivars or where varieties are sown on old land with often severe competition from grasses and herbs. Differences in competitive ability and persistence are, as far as we know, largely governed by the same factors and no distinction is made in this article.

Subterranean clover is normally only part of a pasture mixture. It provides the nitrogen for grasses (and herbs) to grow; these in turn furnish the animal with a substantial and important part of its diet. The clover must also maintain soil nitrogen levels in the cropping situation.

The prime requirement is therefore to persist at a high enough density in the pasture to achieve these objectives and to maintain an adequate protein level in dry summer feed.

Cultivars of equal or similar maturity differ only slightly in dry matter production, but in the various farming environments they can differ markedly in persistence. Lack of persistence necessitates expensive reseeding and causes overall loss of productivity as the clover content declines.

Many things influence persistence, but in Western Australia the following seven sometimes interacting major influences are recognised:

- suitable flowering time and seed maturity
- reliability of seed production
- hard seed content
- pasture diseases and insects
- grazing tolerance
- physiological dormancy
- capacity for burr burial.

Flowering time and maturity requirements

Particularly in the lower rainfall areas the clover must flower and mature seed early enough to ensure a reliable seed set. In the early maturing range, varieties like Dwalganup and Northam A flower early and mature very slowly, with an extended flowering period. Others, like Geraldton, start flowering later but nevertheless mature as early because of rapid seed development.

A combination of an early start to flowering and rapid maturation theoretically gives the earliest clovers. Cv. Nungarin is early flowering and intermediate in maturation rate between Northam A (one of its parents) and Geraldton.

Although flowering time in subterranean clover may be influenced by several factors, including day length and cold requirements, cold requirement probably plays the greatest role in Western Australia. Later varieties have a much higher cold requirement for flowering but even amongst early varieties there is evidence of substantial differences in cold requirement. Geraldton, for instance, is relatively much earlier in colder inland environments than Northam A.

Varieties best suited where there is likely to be a large premium on earliness, such as in the northern wheatbelt, may well have to be of the Northam A type because higher cold requirement types like Geraldton may not flower early enough to ensure consistent seed production. Conversely, as has been shown in many flowering date trials, higher cold requirement types flower less erratically. They do not flower prematurely in seasons which begin with rains in late summer or early autumn, as does the Carnamah variety.

Flowering date alone is not necessarily the best final index of ultimate maturity because some cultivars mature seed and burrs faster than others.

In short seasons and where the ending is abrupt due to drought and increasing temperatures, a quick-maturing cultivar is likely to be best suited. In colder southern areas with milder springs the same does not apply and it may well be an advantage to remain partly vegetative to provide for additional periods of green feed, as do Dwalganup and Northam A when moisture conditions allow. Geraldton in the same conditions can die off as much as two weeks earlier despite a later start of flowering.
It may be argued that earliness involves loss of dry matter production and perhaps lower quality of dry feed due to complete maturing of the plant under moist conditions. While this may be so the balance between seed production and hence persistence must be considered. At least in the light rainfall areas consistent production and legume density are more significant than the occasional benefit a later variety might give in good seasons when, in fact, such extra production will generally go unused by the grazing animals.

The maturity range of available clovers is now virtually complete (see Table 1). Tallarook, the latest, overlaps into the perennial clover districts where annual clovers run into a “wet barrier”. Any later maturing clover would probably be less useful or persistent than perennials such as white clover at this end of the scale. The new early cultivar Nungarin is earlier than other current cultivars. It appears capable of growing in 250 mm rainfall and very close to the dry margins for agriculture in Western Australia.

Reliability of seed production
Seed production governs a clover’s ability to persist. However, while there is evidence that some varieties are inherently better seed producers than others, environment is by far the main cause of variation.

Adaptability to the environment, involves a complex in which maturity, burr burial capacity, and ability to set seed above the soil surface are overriding features. Within maturity groups some varieties have tended to prove more reliable than others. Geraldton has proven superior to Dwalganup in dry areas and Daliak is generally better than Yarloop under similar dryland conditions, whilst Dinninup, and to a lesser degree Woogenellup, show out amongst the later cultivars for their seed setting ability.

As well as its importance for regeneration and persistence, reliable seed production is of course important in commercial seed harvesting and in the final price of seed to the farmer.

Hard-seededness
Hard-seededness, or seed coat impermeability, is a valuable charac-
Esperance, for instance, that Wood-disease susceptible Yarloop and more severely reduced in clover genellup-based pastures have been losses of seed production in one or beneficial in disease-prone areas, greater productivity of later varieties like Mt Barker, Bacchus Marsh and Clare are regarded as inadequate. Woogenellup, on the other hand, seems to have sufficient hard seed for the environment in which it is grown in Western Australia and this degree of impermeability could be regarded as a reasonable minimum for high rainfall areas.

There are no other reasonably hard-seeded commercially available cultivars in the late maturity range, a deficiency which will be rectified by current clover breeding and selection programmes. Hard seeds should allow a later maturing variety to grow in a shorter or less desirable clovers and grass and herbs, to predominate. Nevertheless, the inherent impermeability levels of varieties like Mt Barker, Bacchus Marsh and Clare are regarded as inadequate. Woogenellup, on the other hand, seems to have sufficient hard seed for the environment in which it is grown Western Australia and this degree of impermeability could be regarded as a reasonable minimum for high rainfall areas.

A high hard seed bank is also beneficial in disease-prone areas, enabling the clover to survive severe losses of seed production in one or more years. There is evidence at Esperance, for instance, that Woogenellup-based pastures have been more severely reduced in clover density by Kabatiella (see below) than the harder-seeded, but equally disease susceptible Yarloop and Seaton Park cultivars.

In the drier, more difficult, wheat-belt environment the situation is quite different. Cropping is frequent and due to its current profitability the intensity of cropping is increasing. Annual medics, which have about 75 per cent of their seed “hard” at the break of the season, can easily persist through two (or more) crops. If this is taken as a guideline, then Geraldton with 20 per cent (in the wheatbelt) falls well below requirements, and there is an urgent need to replace this cultivar with harder-seeded selections.

### Clover diseases and insects

Diseases may greatly weaken plant growth and in turn persistence. This is well illustrated at Esperance, where, since the first outbreak of clover scorch (Kabatiella caulivora) in 1971 pastures have deteriorated rapidly, and potential carrying capacity has been greatly reduced. Resultant low seed yields threaten to destroy the clover seed industry in the area and clover seed production has fallen from some 3000 tonnes each year to less than 700 tonnes.

There is a wide difference in ability of the cultivars to withstand the disease (Table 2). Cultivars like Daliak are only slightly affected. Mt Barker and Larissa show a substantial degree of disease escape, and are rarely destroyed by the disease. Yarloop, Woogenellup, Seaton Park and probably Dininup are highly susceptible and can no longer be recommended for clover scorch-prone areas.

Clover scorch is now the major pasture problem in high rainfall areas of Western Australia, South Australia and Victoria, not only because of its effect on seed production and persistence, but also because it seriously reduces spring growth.

A series of root rot diseases have affected sub. clover in W.A. Dininup has shown tolerance to one of these (known as “south coast root rot”) in the field, while Larissa appears less affected than Woogenellup or Yarloop. Root rot is insidious and may cause losses at seedling and pre-germination stages and so be often unrecognised. It is, however, certainly a cause of pasture deterioration and lack of persistence in some areas of this State.*

There is some evidence that clover cultivars such as Daliak and Dininup are less susceptible to the effects of attack by red legged earth mite (Halotydeus destructor Tuck) (Nicholas and Hardy, private communication). Mite attack can reduce clover growth and kill germinating seedlings. Where the replacement of an old cultivar with a new selection is the aim, such differences in susceptibility could be important.

### Grazing tolerance

Heavy grazing situations require suitable types of subterranean clover and there is evidence that some varieties predominate under heavy grazing. Upright types like Clare and other members of T. brachycalyx are suspect under heavy grazing pressure, whereas prostrate, densely leafy cultivars like Daliak, Seaton Park, Dininup and Geraldton are well proven under high grazing pressures. Where grazing pressure by sheep is high and particularly in mixtures with competing varieties, even such “field proven” varieties as Yarloop and Dwalganup, both semi upright types, are less successful than varieties like Daliak and Seaton Park.*

With cattle, on the other hand, there is some evidence that long petiole varieties suffer little or no disadvantage and in fact in conditions where hay production is part of the system, tall growing stands are an advantage.

A specific situation where grazing tolerance is needed (perhaps better defined as ability to recover after heavy grazing) often occurs at the break of the season. During this period total pasture growth is limited and varieties with better ability than others to recover from the resultant high grazing pressures may thus be favoured if the situation occurs frequently in particular areas. Such adaption may be related to dense swards of prostrate seedlings rather than large, less densely distributed upright types.

### Physiological dormancy

Physiological dormancy gives protection against premature summer germination.*

It has been shown that where hard seed develops quickly, as in dry summer areas, dormancy is not an effective mechanism. On the cool, damp south coast, however, it may be a month and more before seed moisture content falls to levels which enable expression of the hard seed characteristics.
In this situation physiological dormancy is a useful mechanism and it is likely to be of real value in the later maturing cultivars of the cool coastal areas of high early summer humidity.

The importance of burr burial
The ability to bury burrs in the soil is a feature of subterranean clover.

In all of some 30 members of T. subterraneum studied, buried seed was larger, more viable, and "harder" in terms of seed coat impermeability than unburied seed. Buried seed also germinates more evenly with higher seedling survival than unburied seed.

Despite the "need" to bury seed, sub. clover varieties vary greatly in their propensity to do so. Later maturing varieties such as Mt Barker, Woogenellup and Bacchus Marsh, have rather poor burial capacity relative to varieties like Dwalganup, Daliak and Geraldton. The disadvantage of non-burial must vary greatly according to the ambient temperature and humidity. Unburied seed in the south coast areas may for instance be little disadvantaged, but in drier, hotter spring conditions, as in the wheatbelt, poor quality seed almost invariably results.

Soil texture greatly influences burial and on sandy soils such as at Esperance there is less need for strong burial types, particularly as this is also in the cool early summer zone. Thus it is that Woogenellup, a weak burier, has been a most successful cultivar in the area.

On many soils however, such as the mallee wheatbelt soils, the surface sets hard early in the spring, and even cultivars with strong burr burial capacity, like Geraldton, are prevented from burial. In the absence of cropping similar situations often arise after many years of compaction by animals. In some traditional stock areas therefore, lack of burial undoubtedly contributes to deterioration of the sub. clovers in such localities.

A further characteristic related to burial may be of value in these situations in that some cultivars are much better than others in their ability to set good quality seed above the ground. In this context the varieties Daliak and Midland B have shown superiority to most other varieties (Collins, Francis and Quinlivan, unpublished results). Daliak is particularly interesting because the improved above ground seed setting ability is certainly not at the expense of an otherwise efficient ability to bury when conditions allow, so that selection for both characteristics is feasible.

Characteristics affecting production patterns of subterranean clover
Low oestrogenic activity
Subterranean clover has often been associated with sheep infertility and lambing percentages of 20 per cent or less both experimentally and on a farm scale are common. Serious infertility problems have been encountered with the Yarloop, Dwalganup and Dinninup cultivars. Geraldton has also been implicated in less spectacular cases. The other potentially oestrogenic cultivars, Howard and Tallarook, have a very limited distribution in this State and have been largely confined to pastures grazed by cattle.

The plant oestrogens, formononetin, genistein and biochanin A, have been found in subterranean clover in large quantities and of these formononetin was found by workers at the Institute of Agriculture to be the one responsible for most of the oestrogenic activity in clover leaves.

All new crosses and selections should be low in formononetin even if perhaps their ultimate use appears destined for cattle country, because changing economic circumstances may sometimes demand that sheep form part of the farm enterprise in such localities. A maximum of 0.20 per cent of the dry weight may be used as a guideline, but even lower values can be achieved in most new cultivars, as such levels are common amongst the many hundreds of varieties now available in our collections.

Soil type, pH and drainage
Certain environments are flooded or sodden for a large part of the growing season. In such localities Yarloop, Trikkala and Larissa as representatives of a group called T. yanninicum are tolerant of flooded conditions and are the only cultivars likely to persist in such situations. Clare, a member of T. brachy-calycinum, is better adapted to neutral or slightly alkaline soils, particularly if these set fairly hard or crack during spring. It has special burr development characteristics, including a long sarmentous peduncle (slender, horizontal flowering runner) of value in such environments, which however are rare in Western Australia.

Palatability
A number of cultivars, especially Yarloop, Dinninup and Dwalganup, tend to maintain a higher-than-average clover percentage in mixed pastures. (D. A. Nicholas, unpublished results). They have been observed to be relatively unpalatable in pure swards as compared with palatable varieties like Northam A, Seaton Park and Uniwager.

Unpalatability of the clover, with the consequent increased grazing pressure on grasses, is undoubtedly part of the reason for the high clover content of some pastures. This may be linked with isoflavone content.

A degree of unpalatability may be a distinct advantage to persistence of subterranean clover and if this can be related to total isoflavone rather than any individual isoflavone, then it should be possible to select types very high in isoflavones other than formononetin and thus retain a degree of unpalatability if the situations where this would be desirable are definable.

Winter growth and resistance to heavy winter grazing pressures
The much discussed "improved winter growth" is a characteristic long sought and discussed by researchers and farmers alike. Morley has shown differences between cultivars and a variety x temperature interaction. In the field however, particularly in Western Australia, the position is complicated by incipient waterlogging—sodden paddocks are common so that growth is restricted not only by temperature but also waterlogging. This may explain why Yarloop, which can grow normally in wet soils, shows better "winter growth" than other cultivars.

Woogenellup also stands out in field trials and there is no doubt that some cultivars have greater apparent winter dormancy than
others. For example, Larissa, from cold areas in Greece, makes little winter growth (Nicholas, unpublished.) However, further factors must be considered before winter growth is made a major criterion for selection. Firstly, at the low growth rates often obtained (as low as 1 000 kg per ha in two months) will even 20 per cent improvement make much difference to animal production? Willoughby showed at Canberra that when pasture available was below 1 400 kg/ha, sheep production dropped because the animals could not get at the plants. In practice, it is likely that early winter production of a mixed pasture depends more on growth of the grass component than on the less available and perhaps slower-growing clover. The early winter "deferment" of grazing of clover that results from the sheep's preference for grass is to the clover's advantage, allowing rapid late winter and early spring growth of the legume after a grassy early winter phase. In spite of this, clover pastures are often very heavily grazed in early and mid winter and differences in the ability to recover from heavy grazing are important. Such differences must be considered in conjunction with winter growth because the two may in fact be antagonistic: rapidly growing types with leafy growth may not recover as well as other types and may persist less well in mixed pastures.

References