# WHITE CLOVER (*TRIFOLIUM REPENS*) IN SUB-TROPICAL AUSTRALIA —A REVIEW

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## ABSTRACT

*White clover is widely established along the sub-tropical eastern coast and sub-coastal plateaux of Australia. Its prolific growth, high feeding value and ready acceptance by dairy stock make it by far the most important pasture legume during autumn, winter and spring, in those parts of these regions experiencing suitable moisture and temperatures regimes. Its performance and production, however will generally fluctuate from year to year, because of the unreliable nature of the rainfall during the cooler part of the year.*

*A fuller understanding of the nature and frequency of occurrence of conditions which make for a good clover year would be a considerable help in deciding the true value of the species in south-east Queensland. There is also need for a critical evaluation of cultivars against a ferility gradient with particular regard to phosphorus and sulphur and in relation to soil moisture and shading gradients to determine the full role of the species.*


## INTRODUCTION

White clover (*Trifolium repens* L.) has long been recognised as one of the worlds outstanding temperate pasture legumes. For centuries it has been acclaimed for its ability to maintain heavy production of highly nutritious fodder. This attribute, plus the ability to benefit the growth and quality of associated grasses and to improve soil fertility for cropping purposes, have long been important factors in the economy of many communities.

White clover originated in Europe. For this reason it succeeds best in cool moist climates. It is the most commonly used leguminous constituent of permanent pastures in practically all temperate countries, including Europe, the United States of America, parts of South America and New Zealand. It may however, also be found in many regions outside the temperate zone, where the climatic conditions are mild, without extremes in temperature and precipitation.

White clover makes an important contribution where adapted in the sub-tropics. It is the only temperate trifolium of value so far. Besides lucerne it is the only temperate legume worthy of serious consideration at the present time.

For many years white clover has been widely used in the southern states of Australia. Its use in New South Wales and Queensland has been confined to the more favoured areas in the coastal regions (Winders 1937). In 1969-70 about 13 metric tons of white clover seed was used and over 12,000 hectares of pastures containing clover in their mixtures were planted in Queensland (Anon. 1970).

## ENVIRONMENTAL REQUIREMENTS AND LIMITATIONS

White clover is a perennial, but Hutton (1968) observed that in the sub-tropical environment of Australia it may behave as an annual. Hence cultivars with good seeding ability are needed, in order to maintain clover in pastures.

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Although white clover is a typical temperate species, it can grow under quite high temperatures. Mitchell (1956) states that the optimum temperature for white clover growth is about 24°C (75°F), but growth rates remain fairly constant well below and above this temperature. In most years growth ceases as a result of dry conditions, aggrevated by temperature rises in November, but it may continue until midsummer under cool, moist conditions. In most areas of predominantly summer rainfall, however, white clover is not able to compete with summer growing species. Thus the period in which growth normally can be expected in sub-tropical Australia is predominantly limited to the autumn-winter-spring, but the actual performance within this period is influenced by a number of factors.

Within its normally expected period of growth, white clover growth is probably influenced more by moisture than any other factor (Ostrowski 1969a). Pasture irrigators usually consider that white clover is less tolerant to drought than to heat. A total rainfall of about 300 mm (12 in.) of suitably distributed rain in the May-October period is considered necessary for good clover growth during the cool portion of the year (Winders 1937). Valleys and lower parts of slopes when favoured with better moisture and fertility may permit a somewhat longer growing season.

The incidence of very good white clover years in south-eastern Queensland is about one in every four or five, the good year normally being notable for above normal winter rain and moist, cool early springs (Winders 1937).

White clover grows best on free draining loams, silty loams and clay loams. Alluvial flats adjacent to coastal streams and low lying areas with high water tables are particularly favourable to the shallow rooting system characteristic of white clover (Cassidy 1967), but good results are regularly obtained on a wide range of soil types provided that consideration to fertilizer requirements to correct soil nutrient deficiencies is given. It will also grow well on krasnozem and chocolate soils (Davies and Hutton 1970).

Although fairly frost tolerant, white clover is intolerant of shading.

## HISTORY

In the early years white Dutch clover (common white clover) was used almost exclusively in sub-tropical Australia. Since the introduction of paspalum (*Paspalum dilatatum*) in the 1890's and kikuyu grass (*Pennisetum clandestinum*) in the 1920's, white clover has been planted commonly in association with them along the coast. Coleman (1926) writes that "during the last few years the increase of white Dutch in association with paspalum has been remarked by many, and it is to be noted that this spread of white Dutch has been natural, not the result of seed sown."

English wild white clover was also tried but with much poorer results (Whittet 1925). Its ecotype, Kentish white clover, was also tested but being a shy seeder propagation by vegetative methods was necessary (Coleman 1926).

Ladino white clover has been used since the early 1920s and irrigation white (Victorian irrigation) and New Zealand white, known today as grasslands Huia, have become popular since the 1950's. These three strains were all superior in production under Australian conditions to the European types. In more recent years Ladino and Louisiana, both better adapted to sub-tropical conditions, have superseded all others.

## DISTRIBUTION

The moister coastal and sub-coastal areas within the latitudes of 25°S and 31°S (from Mary River Valley in Queensland to the Macleay River Valley in New South Wales) provide the suitable environment for the successful production of white clover in sub-tropical Australia (O'Brien 1970). This region experiences rather mild summer and winter temperatures. Total yearly rainfall is generally adequate for successful agriculture, but unfortunately it is usually poorly distributed and this fact plus low soil fertility are the major factors limiting regular good clover production. White clover is also found on the moist, elevated tropical tablelands inland from Cairns and Mackay (latitudes 17°S and 21°S) (Davies and Hutton 1970) and on elevated plateaux near Brisbane.

In the tropical upland rainforest areas on the Evelyn and Atherton Tablelands, white clover grown in association with paspalum and kikuyu is important to the dairy industry in seasons of favourable winter and spring rains. On the Eungella Tableland inland from Mackay white clover is scattered throughout paspalum and kikuyu pastures (Bryan 1970).

On the sub-tropical upland rainforest areas on the plateaux of Maleny, Crow's Nest, Beechmont, Mt. Tambourine and Springbrook white clover-kikuyu-paspalum are the most common pastures. On the "Big Scrub" of northern New South Wales (the Richmond-Tweed Region) white clover has been grown with paspalum and kikuyu since the introduction of these grasses (Bryan 1970).

On the sub-tropical lowland rainforest areas such as around Gympie and Cooroy in southern Queensland and along the river valleys in north-eastern New South Wales, white clover may be found in any kind of pasture ranging from native to recently sown tropicals. It is also widely distributed in the sclerophyll forest of southern Queensland and northern New South Wales. These areas are drier than the above mentioned and the growth of clover strongly depends on the available moisture and rainfall pattern. The soil fertility in these areas is generally lower than in rainforest areas. However, if suitably fertilized, they will support white clover satisfactorily.

Since the nutrient deficiencies of the coastal lowland (Wallum) soils became known (Andrew and Bryan 1958) and were corrected, white clover has been widely used in pastures established on these previously unproductive soils.

In most dairying areas planted in the past to pastures based on white clover there has been a serious decline in soil fertility. Restoration of soil fertility and sound management result in prolific clover growth, general improvement of the pastures, and a decrease in the periodic feed deficiencies previously experienced (Bryan and Evans 1971b).

## CULTIVARS AND SELECTIONS

Few comparative data on the various cultivars and selections of white clover under sub-tropical environments have been published. Ostrowski (1972) describes naturalized white clover and five cultivars grown in sub-tropical Australia. The description of various commercial strains may be found also in the Australian Herbage Plant Register (Anon. 1967b, Anon. 1971).

O'Brien (1970) when comparing yields and persistence of a number of commercial cultivars and an ecotype from the Clarence area concluded that in the Clarence basin, Haifa was the most productive cultivar and Clarence was the most persistent type. He speculates that persistence of the Clarence ecotype depended on its high seeding ability, which is an important factor in maintaining white clover stands under conditions at Grafton and in many other situations.

More work is required to find cultivars better suited to the Australian sub-tropics.

## ASSOCIATED SPECIES

Generally speaking white clover will grow well in association with plants that have a low growing habit or are kept low by grazing animals.

In sub-tropical Australia, white clover is mainly associated with paspalum and kikuyu. These two grasses provided the initial base for the dairy industry. Both grasses require better quality soils and good moisture conditions, which are also basic requirements of white clover.

As a result of intensive utilisation and poor management, especially inadequate maintenance fertilizers, paspalum and kikuyu pastures deteriorated over the years and were invaded by mat grass (*Axonopus affinis*). Today the majority of these old pastures consist of a mixture of mat grass, paspalum, kikuyu and white clover, (Bryan 1967, Cassidy 1971), the botanical composition being related to the fertility status of the soil and management practised.

On some coastal flats under mat grass-paspalum-white clover pastures, lespedeza (*Lespedeza striata*) becomes firmly established. Miles lotononis (*Lotononis bainesii*) also may be found in association with white clover. On better drained, lighter and shallow soils white clover is frequently associated with blue couch (*Digitaria didactyla*) and green couch (*Cynodon dactylon*).

White clover combines well with most of the temperate grasses. In sub-tropical environments however, these are mostly grown with supplementary irrigation. White clover combines reasonably well with a number of tropical grasses. The management of white clover in these pastures is, however, more difficult because of the tall growing habit of tropical species (Ostrowski 1969b).

## RHIZOBIUM

The genus *Trifolium* was not present in Australia before European settlement. Its *Rhizobium* must have been brought in as a contamination by early settlers (Norris 1970). Since then, white clover has become acclimatised in many parts of Australia and now occurs in a naturalised form. The spread of appropriate *Rhizobium* followed naturally. These naturally occurring *Rhizobium* strains are generally effective (Vincent 1954).

Nodulation is influenced by a number of factors. Two of them, acidity of the soil and deficiency of molybdenum, have an important bearing in the sub-tropical region of Australia on growth of clovers. Both have to be corrected to obtain successful results. It has been found, however, that lime is needed mostly to promote nodulation (Bryan and Andrew 1955) and that once the clover is well nodulated it may grow on quite acid soils. Norris (1959) stated that *Rhizobium* requires calcium in trace amount only, and that it has an essential need of magnesium. Lime pelleting of inoculated seed can greatly improve nodulation on these acid soils (Norris 1967) and may be a good substitute for costly liming. Molybdenum deficiency may be corrected by using molybdenised superphosphate (Norris 1970).

## NUTRITION

The soils in sub-tropical eastern Australia are generally low in nutrients and a fertilizer programme is necessary to facilitate establishment and persistence of this legume (Ostrowski 1969a). Much research has been conducted to determine deficiencies in various soils in relation to white clover requirements.

Andrew and Bryan (1955) established that on the low humic soils white clover has responded to phosphorus, calcium, potassium, copper, zinc, molybdenum and boron in decreasing order of importance. Maximum plant growth could only be obtained if all these nutrients were supplied. Furthermore, a critical percentage of 0.23% phosphorus (Andrew 1960), 1.0% potassium (Andrew and Robins 1969) and a tentative percentage of 1.0% calcium (Andrew and Norris 1961) was established. A combined influence of these elements on the growth and chemical composition and deficiency symptoms of white clover grown on these soils was also described (Andrew 1960). Andrew and Bryan (1958) also determined the nutrient deficiencies and established fertilizer recommendations for lateritic podzolic soils in the same region.

Chester, Marriott and Harvey (1957) reported increase of white clover up to 33% of ground cover on grey-brown loam soil, when lime was applied in addition to superphosphate. Truong, Andrews, and Skerman (1967) working on low fertility solodic soils found that white clover responded to phosphorus, molybdenum, calcium carbonate and sulphur, but that application of small amounts of molybdenum eliminated the need for calcium carbonate.

Ostrowski (1969a) investigated the effect of major and minor elements on the yields of white clover in the establishment period on a number of soil types and sites in south-east Queensland. A response to superphosphate on all but one site was obtained. Response to lime occurred only on some sites. No response to potassium chloride was evident, with the exception of an old cultivation. Very little response occurred to trace elements.

White clover responds markedly to addition of copper on copper deficient soils (Andrew and Bryan 1958), although it is less sensitive to copper deficiency than *T. alexandrinum* and *Stylosanthes guyanensis* (Andrew and Thorne 1962). The symptoms of copper deficiency are described by Andrew (1963). White clover has some tolerance to excess of manganese (Andrew and Hegarty 1969) and aluminium (Andrew 1966).

## ESTABLISHMENT

Establishment methods in the Australian sub-tropics are similar to those in temperate countries, but no original work has been done in this environment. Ostrowski (1972) describes the establishment methods usually accepted in Queensland. Local research is needed on this aspect.

## MANAGEMENT

A very important factor in maintaining a satisfactory proportion of clover in a grass-legume sward is the light relationship. Under conditions of heavy grass growth and consequent low light intensity at the clover canopy, a marked reduction in both the number of clover plants and yield of clover occurs (Stern and Donald 1962). In a grass-clover pasture the grass component must be kept very short in autumn to obtain a good clover regeneration and subsequent grazing or mowing management designed to maintain a desirable grass-clover ratio.

The application of white clover seed and the necessary nutrients to a run-down paspalum-kikuyu-mat grass pasture at Maleny resulted in a marked change in botanical composition, very noticeable being a considerable increase in the white clover content (Bryan 1967); about half of this was attributable to overseeding and half to fertilizer. There was much more clover in the open paspalum sward and establishment was quicker than in dense kikuyu. Most of the increase in white clover was at the expense of paspalum. The content of mat grass was also reduced, but to a smaller extent.

Clover may appear in tropical grass-legume pastures, provided they are kept reasonably short. With an improved phosphate level in the soil, white clover, even if not included in the original mixture, appears spontaneously from seed brought in by cattle or from persisting original clover (Ostrowski 1969b).

White clover is more adapted to continuous grazing at high stocking rate than most temperate and tropical legumes. The effects of close grazing of pastures in which white clover was included or invaded are shown by Jones *et al* (1968), Whiteman (1969) and Bryan and Evans (1971b). Frequent grazing gives the best use of white clover and also keeps the associated grass at a younger, more nutritive stage (O'Brien 1970).

Naturalized white clover can withstand close grazing quite well, while Ladino, on the other hand, if kept closely grazed will soon disappear (Midgley 1938). Severe overgrazing, especially if repeated, will quickly deplete plant vigour, resulting in poor regrowth and a marked drop in production. At the same time undergrazing can also be harmful. Undergrazing a grass-clover pasture may allow the grass to completely suppress the clover, a condition that can occur during autumn, when most of the grasses are still actively growing.

## FEEDING VALUE AND YIELDS

In recent years little attention has been given in sub-tropical Australia to feeding value of white clover, probably because its high value has been taken for granted. The only digestibility figure that could be found was 76% dry matter digestibility (DMD) (Minson 1967), which in temperate experience would be a reasonable figure. By contrast, the DMD of seven tropical legumes (Milford 1967) ranged from about a 42% to 69% with mean values largely between 50% and 60% for leafy stands. The superiority of white clover is apparent.

The high protein content and high voluntary intake and digestibility of white clover make it a very useful component of sub-tropical pastures which otherwise are low in protein for long periods in the year and hence have lower voluntary intake and digestibility (Milford 1960).

The contribution of white clover during the time when sub-tropical species are at their lowest feeding value is of great significance and its value as a supplement in the pasture at such times is higher than its direct feeding value (Milford and Minson 1966). Yabsley (1971) stated that on irrigated farms on the Atherton Tableland, clover dominant pastures which form the basis of grazing from June to December, contribute to yields of up to 36 kg milk per cow per day from grade cows. The same author states that in the Moreton district daily milk yields of 14 kg and 18 kg have been obtained from paspalum, kikuyu and white clover, grown without irrigation.

White clover is reported to have contributed high amounts of nitrogen in New Zealand (Sears 1953) and other temperate countries. Nitrogen production from white clover based pastures in Australia would probably be about 110 to 220 kg per ha per year (Anon. 1967a).

## IRRIGATION

White clover is the main legume species used in irrigated grass-legume pastures in the sub-tropics (Jones *et al* 1968). Under irrigation its distribution reaches further inland, where the occurrence of clover is limited by low rainfall. Grasses associated with these pastures usually include Grasslands Manawa—(*Lolium perenne* × *L. multiflorum*) and Kangaroo Valley (*L. perenne*) ryegrasses, Priebe prairie grass (*Bromus unioloides*), Australian phalaris (*Phalaris tuberosa*), Demeter fescue (*Festuca arundinacea*), reed canary grass (*Phalaris arundinacea*) and occasionally sub-tropical grasses like paspalum and setaria (*Setaria sphacelata*). Rapid decline in growth rate of temperate grasses occurs when the temperature reaches 30°C (85°F) (Mitchell 1956). In many instances they fail to survive more than one summer though this partly may be attributable to management.

For irrigated conditions Ladino and Louisiana are the cultivars chosen almost exclusively. Ladino in particular has a high degree of heat tolerance (Grof personal communication) combined with high production and good compatibility with vigorous growing grasses. It is widely used in irrigated pastures, especially in Central Queensland, where it maintains vigorous growth all-the-year-round. Annual yields of 22,400-24,000 kg/ha of dry matter were recorded at Biloela from Ladino—reed canary grass pasture (Grof personal communication). Cameron (1969) however, pointed out that there are some difficulties in finding a suitable grass which will associate successfully with white clover in this environment. If grass species are used which compete too strongly with clover, the overall production will fall (Jones *et al* 1968). Louisiana has a better winter performance.

A major problem with irrigated temperate mixed pastures in the sub-tropics is the maintenance of a desirable grass-legume ratio. Despite such measures as manipulating the sowing rates, times of sowing, strategic application of nitrogen fertilizer to stimulate grass growth etc., usually white clover becomes dominant by the end of the second year. Grass-clover ratio may be regulated to some extent by management methods. Increase in frequency of grazing will increase the clover percentage, while decrease in grazing frequency will favour grass and decrease the clover percentage (Schroder 1961, Kleinschmidt 1964).

The invasion of weeds results in poor utilisation of the pasture and a decline in productivity with time (Schroder 1961). The productive life of clover-based irrigated pasture is about 3 to 4 years (K. Lowe pers. comm.). Under good management, some pastures may persist for upwards of eight years. Very high yields have been recorded from irrigated pastures (Schroder 1963, Jones *et al* 1968) the actual yields depending on environment, mixture used and management practice. Pasture without white clover on Gatton Research Station in Queensland, produced 33 tons (metric) material per ha in 13 months. In the same period the same grasses grown alongside but with white clover produced 124 tons (Schroder pers. comm.). Large differences in pasture growth rate and in botanical composition between summer and winter may occur (Jones *et al* 1968). Good, clover pasture may support 5 milking cows to the hectare.

## BLOAT, PESTS AND DISEASES

A clover dominant pasture is a potential bloat hazard to ruminants. Rudder (1959) described ways of reducing the incidence and severity of bloat. There are various commercial preparations which may be applied to the pasture as a spray (Bentley and Rudder 1964) or fed to the cattle as additives to feed or in their drinking water (Hutchings 1961).

Insect pests rarely become very serious in clover pastures. In some areas, however, Amnemus weevil (*Amnemus quadrituberculatus*) (Braithwaite, Jane and Swain 1958) may cause substantial damage.

Diseases of white clover in sub-tropical environment are also of minor economic importance (Anon. 1964). The following more common diseases occur:— fungal diseases—two species of rust (*Uromyces trifolii* and *U. nerriphilus*), damping-off of seedlings, rot (*Sclerotina*), anthracnose (*Colletotrichum trifolii*) and burn (*Pseudoplea trifoli*); viral diseases—rugose leaf curl (Grylls and Day 1966), mosaics, virescence, little leaf virus (Hutton and Grylls 1956), and nematode diseases—caused by root-knot nematode (*Meloidogyne* spp.) (Colbran 1966) or stem nematode (*Ditylenchus dipsaci*).

Some non-parasitic diseases also occur. They are usually induced by an excess or deficiency of some factor in the environment.

## ACKNOWLEDGEMENTS

Thanks are due to Dr. J. P. Ebersohn, Queensland Department of Primary Industries and Dr. W. W. Bryan, C.S.I.R.O. Division of Tropical Pastures for helpful criticism of the manuscript.

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(Accepted for publication April 2, 1972)