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Annual pasture and weed plant ecology

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Ecology is the study of plants and animals in relation to their environment, and is a science not only for the naturalist but also the farmer, the agronomist and others with interests in agriculture, for it applies to pasture plants and weeds as well as to native flora.

The purpose of this article is to outline a few basic principles of pasture and weed ecology with particular reference to seed dormancy mechanisms. These principles apply to many pasture plants and weeds, although their relative importance varies with the particular plants under study.

Winter growing annuals are easily the most successful pasture plants in the agricultural regions of Western Australia, as also are the most "successful" weeds. This is because most of our rain falls in winter and the summers are hot and dry.

The successful establishment and persistence of an annual pasture plant or weed depends on many factors besides climate. If an agriculturist can understand when and how these factors operate he will be able to manage pastures and weeds for maximum overall production. A failure to understand has, in the past, led to many faulty
and wasteful decisions regarding pasture plants and weeds.

The total environment
The environment, or ecosystem, which controls the destiny of annual plants has many components which can be grouped in three main categories—climate, soil and management. With some species and in some situations one or more factors may be decisive, but generally it is a combination or additive effect, or sometimes the absence of a factor, which determines plant growth and persistence.

Climate
Climatic factors include the total, monthly distribution and reliability of rainfall, maximum and minimum temperatures during the growing and dry season, and the day length during the growing season.

Soil
Important soil factors are structure, fertility and microflora population, including legume rhizobia. Topography may also play a part: flat, winter waterlogged areas are suited to only a few species.

Management
The importance of management is often underestimated. The type, quantity and timing of fertiliser applications, the grazing and crop rotational systems and the effectiveness of disease and insect control, may often be critical to the survival of pasture plants and weeds.

With so many controlling or restrictive factors it is not surprising that many plants survive and persist satisfactorily only in narrow geographic areas and within these in specific ecosystems. Some may be well adapted to the climate and soils of a particular district but will not survive the normal management or crop rotational practices. Some of our early maturing subterranean clovers, for example, will not always survive a cropping cycle in the drier wheatbelt. By contrast, the medics come through a cropping cycle very well but they are restricted to the heavy loam and clay soils and cannot colonise the acid, sandy surfaced, sometimes gravelly, soils so common in the region.

The seed phase of the life cycle
A basic requirement for a successful winter growing annual is a capacity to set seed in the spring. If the climate, soil and management do not permit adequate seed set there is little or no hope for the species.

A seed is a living plant in embryo form, whose purpose is to carry the species through time and sometimes space until conditions are suitable once again for continued plant growth. The seed needs an adequate protective or "dormancy" mechanism, for the time lapse may be many months or, where droughts or cropping cycles prevail, even years before conditions are again suitable for a full growth cycle ending in seed production.

When most of our winter growing annuals complete their life cycle in spring the seeds are viable but fully dormant, or in the case of legumes fully hardseeded or impermeable. If placed in cool moist soil these dormant seeds will not germinate. Over the following summer, or sometimes longer, the dormant seeds gradually change to seeds capable of immediate germination. The rate of change with legumes, particularly, is determined by the temperature conditions to which they are exposed rather than the time lapse since seed formation. With grasses this time lapse is the more critical factor.

The length of the dry period from spring seed formation to the following autumn or winter seasonal "break" varies widely from district to district, as also do the summer soil surface temperatures (Figure 1). The seed dormancy mechanism of a species needs to be in balance.

A similar situation applies to some weeds. Paterson's curse, for example, has wide tolerances in terms of climate and soil but will not persist under heavy grazing. By contrast, Cape tulip will withstand heavy grazing, in fact stock will not eat it, but it has real weed potential only in a relatively restricted geographic zone where the growing season and temperature conditions are satisfactory for seed and bulb formation and dormancy.
The drought of 1969 resulted in some unusual pastures in 1970. Grasses, clovers and other pasture species which did not set seed in 1969 and which have little long term seed dormancy tended to be absent. This photograph, taken in July 1970, shows a pasture dominated by capeweed and doublegee at Chapman Research Station.

**Clovers and medics**
The improved pastures of W.A. are based on sowings of annual clovers, mainly subterranean clover on the lighter textured soils and medics on some of the heavier soils. These two species have somewhat similar dormancy mechanisms. Both mechanisms are insensitive to time; the hard or impermeable seeds soften and germinate only after exposure to the daily heating and cooling which they receive on the soil surface during the summer months. The rate of softening varies with the maximum temperature to which the seeds are exposed each day; the higher the maximum the faster the rate of softening.

Medics are much more hard seeded than subterranean clover; a high proportion of medic seeds remain impermeable after the first summer (Figure 2). This impermeable seed reserve remains ungerminated through the winter and allows regeneration after drought and cropping. By contrast, subterranean clover regenerates adequately in the medium rainfall areas where more seed is set and the dry period is shorter and cooler, but often its regeneration is unsatisfactory in the wheatbelt. All or most of the seeds soften and germinate in the growing season after formation, leaving no reserves to survive through drought and cropping years.

**Barley and brome grass**
Unlike the clovers, the seed dormancy mechanism of barley and brome grass is almost entirely responsive to time, there being little increase in rate of breakdown of dormancy with exposure to high temperatures, and consequently no major differences between districts in rate of dormancy breakdown. It differs further from the temperature controlled mechanisms of the legumes in that the dormancy breakdown continues into the autumn and winter when temperatures are low. Time lapse mechanisms of this type effectively ensure survival through “false breaks” in the summer and early autumn but they do not necessarily ensure longer term survival through droughts and cropping cycles.

The short term time lapse dormancy mechanisms of these two grasses, with the total germination of each seed crop the following...
season (Figure 3), can cause them to disappear from the pasture after a cropping year provided weed control (including grass control) was adequate before the crop was sown.

An interesting large scale disappearance of grasses from annual pastures took place in 1970 following the 1969 drought. In drought affected areas the grasses set very little if any seed in 1969. There was no reserve of dormant seed from earlier years and the proportion of grasses in the pastures in 1970 was greatly reduced.

Capeweed
Capeweed is a most important pasture species in W.A. In terms of overall stock carrying it would rank second to subterranean clover. Its success is due to a capacity to set seeds quickly and in large numbers even under moisture stress, and also to its efficient seed dormancy mechanism which is correctly in balance with the environment of our medium and low rainfall areas. Like the clovers and medics, it is largely a temperature controlled mechanism and the pattern of breakdown during the summer resembles that of barrel medic. The dormancy breakdown slows with the arrival of the cold autumn and winter, leaving a reserve of ungerminated seeds to regenerate after a drought or cropping year (Figure 2).

Other species
Our annual pastures are composed of a large number of other, somewhat inferior, volunteer, grazing species including wild geranium, Paterson's curse and silver grass. They contain also species which have little if any grazing value and are considered to be mainly weeds. These include dock and various thistles. There are other species which have some grazing value in a pasture but are serious crop weeds. These include annual rye grass, wild turnip and wild radish.

All these plants have efficient seed dormancy mechanisms which are responsive to time, high temperature or both. Their successful colonisation of parts of the agricultural districts and their continued persistence in any district is largely a result of adequate seed production, and seed dormancy mechanisms in balance with the environment.

Pasture management and weed control
An annual pasture or weed situation is the product of its past and present environment. It is the end result of the interaction of a large number of climatic, soil and management factors. Some of these factors can be manipulated in the interests of improving pasture composition, some cannot be altered.

The climate is unchangeable and it is difficult to alter many of the soil factors. Management practices can be adjusted—controlled grazing
Some of the 150 or more very early maturing, high hard seeded, low isoflavone subterranean clover crossbreds growing at the Medina Research Station. One of these may eventually become a new commercial variety for the wheatbelt at certain times of the year, cropping and burning all have marked influences on pasture composition and weeds. This influence is exerted largely on the propagation processes of the plants, the formation of seeds and the seed dormancy mechanisms.

If the botanical composition or production of a pasture is unsatisfactory the reason may not lie in the immediate seasonal conditions. Past seasons and management practices may well be equally or more important. A judgment as to the success or failure of a species should, therefore, not be based on the short term. In a different run of seasons or under different management the situation could be reversed.

Similarly the appearance of a weed may reflect no more than an unusual climate-management association over the previous few years. Most weed species have relatively restricted geographic areas in which they find the environment suitable. In other areas they are able to exist but are easily controlled and are of little consequence. Cape tulip, for example, is a problem weed at Kojonup, but it is not now and never could be a problem at Geraldton. With saffron thistle the position is reversed.

An understanding of a weed life cycle relative to the environment should enable the identification of potential problem plants and provide a basis in some instances for control through management, a far less expensive process than the use of chemical techniques.

**The species climate balance**

The importance of a correct species-climate balance cannot be overstressed. Unlike soil and management factors the rainfall, day length, summer and winter temperatures and other climatic factors cannot be adjusted to suit a particular plant species. With subterranean clover the species-climate balance is satisfactory in the medium and high rainfall zones. Seed formation is adequate and there are few regeneration problems. In the lower rainfall wheatbelt the early maturing subterranean clovers will normally grow and set seed but all too frequently their persistence is not adequate. Only one year in every three or four has sufficient rainfall to ensure a good seed set (300 to 400 kg seed per hectare; 270 to 350 lb. per acre). The hardseededness of the cultivars is insufficient to make best use of this occasional good seed set by providing an extended germination pattern over three or four years. Therefore present subterranean clover cultivars are to some extent out of balance with the environment by comparison with the medics.

If the climate cannot be adapted to suit the species the alternative is to change the species to suit the climate. This is in fact the procedure being adopted with subterranean clover. A cross breeding and selection programme at present in progress as a joint venture between the Department of Agriculture and the University Institute of Agriculture aims mainly at developing earlier maturing varieties capable of producing more seeds in the short growing seasons of the wheatbelt. They are also being selected for improved hardseededness to give a seed dormancy mechanism more in line with that of the medic species.

The selection programme has proceeded to the stage of having about 150 of the better crossbreds growing at the Medina, Merredin and Wongan Hills Research Stations where their maturity is being assessed. Seed samples are also under test for hardseededness. It is likely to be several years before a new variety is released but at this stage it is possible to report some progress with both earlier maturity and hardseededness.