A New Era for White Clover

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The twin problems of low yield and unreliability

The traditional use for white clover over the past century has been as a ‘driver’ of low input, but low output livestock enterprises. It had been used, typically, to improve the herbage quality and save on nitrogen fertiliser costs of upland and sometimes lowland beef and sheep systems. Dry matter yields from these clover-based swards typically ranged from 3 t/ha in adverse upland conditions, to 7 to 8 t/ha in more favoured lowland sites. Apart from a few, but often successful, enthusiasts, and the nascent organic sector, it did not have any widespread use in UK dairy farming. Despite this, during the 1960s until the early 1990s, seed sales of white clover in the UK remained at around 700 to 800 tonnes per annum. This amount in mixture with grasses is sufficient to re-sow around 400,000 hectares of land per annum.

The impression has arisen, therefore, that although clover has been extensively used, its performance has been poor. This argument is flawed for two reasons. Firstly, often clover may have been used in seed mixtures where it was not required and where subsequent management (e.g. high nitrogen fertiliser inputs) resulted in the reduction or even loss of clover content. Secondly, inappropriate varieties may have been used, which were not matched with prevailing climatic and soil environments or with other suitable species, and may have given unreliable performance and poor persistency over...
years. This situation was compounded by the fact that, during the 1960s to mid-1980s, one variety accounted for about 80% of seed sales. A single variety, however good, cannot be well adapted to the wide range of climatic, edaphic and biotic conditions encountered in the UK. (Unfortunately, several improved varieties of white clover, bred at the Welsh Plant Breeding Station, were not available to farmers until the mid-1980s because little or no seed was produced.)

Clover rarely contributed more than 15% of sward annual yields and was often patchy and generally regarded as unreliable from year to year. By contrast, a plethora of studies and anecdotal experience indicate that the benefits of clover are optimised when it is present at about 30% of annual yield. These factors led to the general view that clover was unreliable.

Although the oil and energy crisis of the 1970s stimulated interest in the use of legumes, more recent events have forced a re-evaluation of the benefits of clover. The severe economic pressure in livestock agriculture resulted in the need to reduce input costs. In addition, a concern for the environment, the need to source ‘home grown natural protein’ following the BSE crisis and the strong development of organic livestock farming have all contributed to the increased use of white clover.

The basis of the problems – and their solution by breeding

The success of white clover in a mixed sward depends on its reaction not only to climatic and soil conditions but also on its complex biological interactions with the type of grazing animal/defoliator, the insect pollinator for seed production and with symbiotic soil microorganisms (e.g. Rhizobium). Our studies over the last 25 years have allowed us to identify the basis of unreliable clover performance, largely centred around its intolerance of grazing and cold- and fertiliser N-induced stresses. Simple breeding models have been utilised to overcome these problems.

White clover is a potentially long-lived perennial which survives grazing and is able to over-winter by means of a network of horizontal stems, called stolons. These stolons are the site of new leaf production and a storehouse of carbohydrates and protein necessary for survival and the generation of new leaves following defoliation or after winter. Little attention had been given to the role of stolon characters in yield and survival until the late 1970s. Prior to that, emphasis had been placed on breeding for large leaves in the hope that this would confer increased ability to compete with tall grass. This theory was based on perfectly good research, but on an annual legume where vegetative survival was not a factor. We also demonstrated in older varieties that there was a negative relationship between stolon density and yield of leaf material. Subsequently, and crucially, we were able to partially break this relationship through breeding.

Since then, studies have demonstrated a positive linear relationship between stolon density and both spring growth and subsequent annual yield. Up to a certain range (and including most grazed swards), stolon density is the major factor limiting yield. Only beyond this range do other traits, such as leaf size and rate of leaf appearance, assume greater importance. From extensive investigations we were able to define the ideal characteristics that clover should possess: an appropriately high density of stolon of high unit weight (associated with rapid leaf expansion following defoliation) and good cold hardiness to ensure high levels of stolon survival over winter.
**New varieties**

The important characteristics described above have been used in our breeding programme as a framework on which to build in other important physiological traits to produce new varieties, some of which are outlined below.

**AberHerald (medium leaved) and AberCrest (small leaved)**

These varieties were bred for different livestock systems but with the same basic concept; to improve overwintering combined with high rates of leaf growth at low temperatures. The consequences of combining these traits in improving clover yield are clearly demonstrated in Table 4.1.

**AberConcord (medium leaved)**

This variety has been developed to produce high yields under zero nitrogen inputs but also to tolerate applications of moderate levels of nitrogen fertiliser (Table 4.2). Although of medium leaf size it produces yields approximating to those of large leaved varieties. These attributes are of importance to all livestock sectors, both where N is used to increase DM yields at certain times of the year or in zero N and organic systems where the build up of fixed N can otherwise lead to large cyclical fluctuations in grass and clover content.

**AberDai (medium leaved)**

A variety bred to give greater flexibility in use than was possible from older varieties, which confined the farmer to a tight straitjacket of management practices (Table 4.3). AberDai possesses both good overwintering attributes and high yield across a wide range of defoliation systems, from continuous sheep grazing to cutting for silage.

**AberAce (small leaved)**

This new variety has exceptionally small leaves yet is more productive than the larger leaved Kent Wild White and, unusually, has greater stolon density and ground cover under hard grazing. AberAce will be an important variety in eliminating crashes in clover content during hard continuous sheep grazing, the one management system where this is a relatively common phenomenon. The variety has also been bred to tolerate the soil and climatic conditions typical of upland farms.

The breeding programme has also generated three additional listed varieties, AberBonus, AberDale and AberVantage.

**Agronomic performance of clover varieties – a new era**

As a matter of course, varieties, potential varieties and their progenitors in our breeding programme are evaluated under relevant grazing managements - a procedure we consider to be of utmost importance.
The results of major farm scale experiments and farmer experience verify the findings of our own grazing evaluations.

Three aspects in particular lead us to believe that our modern clover varieties can be used with confidence as the necessary cornerstone of low input sustainable agriculture.

1. Annual clover contributions of 30% or even greater, are now commonplace, thus optimising its nutritional and N saving benefits (Tables 4.4 and 4.5). This is reflected in monitored, on-farm performance as well as experimentally.

2. Our new medium leaved clovers are compatible with very tall-growing, productive grasses such as Tetraploid Hybrid and Italian ryegrasses, thus giving high sward yields of up to 13t/ha/annum without the use of N fertiliser (Table 4.4). Similarly, they are also highly productive with modern high yielding perennial ryegrasses (Table 4.5). This takes clover into a new era where it can be used as the basis of low input, but medium to high output systems.

3. Results from long-term experiments indicate that our clovers are maintained in effective amounts in the sward for many years. For example, in long term evaluations of our new varieties under sheep grazing, clover contents have been reliably maintained at approximately 25% with 250kg fertiliser N. Where no N fertiliser was applied, clover contents in excess of 40% were maintained. These high clover contents have been maintained while providing overall yields of 10 to 11+ t/ha/annum.

**Conclusion**

Many improvements have emerged over the past 15 years in the reliability and performance of new varieties of white clover. For the medium term future, prospects also look bright with exciting developments in the form of improved stress tolerance from hybrid clover varieties. In particular, breeding methods now in progress will improve drought tolerance and allow the development of very productive large leaved varieties with excellent tolerance of hard grazing. The precision and speed of breeding will also be enhanced with the imminent introduction of marker-assisted selection.

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*Dr Ian Rhodes retired from IGER in March 2001*