New Clovers for the New Millennium

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If the dying years of the twentieth century are any indication, the twenty-first century will see ever increasing pressures towards the greening of agriculture. Sustainable, environmentally friendly ways of production are likely to grow in response to public pressure, legislation and, perhaps above all, economics. Food safety, the BSE crisis and environmental pollution are already at the forefront of the public mind. Costs of oil-based inputs, including those for nitrogenous fertilizers, will likely rise to levels where their use gives increasing cause for concern. In this context, the increased use of white clover in conjunction with grass as the basis of pastures in the sheep, beef and dairy sectors represents a considerable double whammy. Not only is white clover nutritious, with a high protein content reducing the need for concentrates, but, in symbiosis with the bacteria (Rhizobia) in root nodules, it also has the capability to fix atmospheric nitrogen, so reducing the level of fertilizer nitrogen needed in mixed swards.

New varieties

In recent years, plant breeders at IGER have produced new varieties of white clover with increased winter hardiness and rapid growth in early

Figure 5.1 *Interspecific hybrids between* Trifolium repens *and* T. nigrescens. *Plants of* T. repens *(bottom left),* T. nigrescens *(bottom right), F1's (three plants, middle row) and backcross1 (top) hybrids at the onset of flowering.*

Figure 5.2 *Interspecific hybrids between* Trifolium repens *and* T. ambiguum. *Plants of stoloniferous* T. repens *(bottom right), rhizomatous* T. ambiguum *(bottom left) and the F1 hybrid (centre) which is stoloniferous and rhizomatous.*

spring. Major progress has been made in persistence and reliability, problems that bedevilled white clover in the eyes of some farmers, particularly where pasture management is matched to the white clover variety or blend sown. The new varieties, finished and marketed by the Germinal group of companies, represent a considerable success and have gone a long way towards producing white clover varieties flexible enough to survive under cutting or grazing by sheep or cattle. However, there are still opportunities for progress. Exciting developments, resulting from novel germplasm developed at IGER, may be contemplated in three areas:- (1) stress and grazing tolerance, (2) disease resistance and (3) seed production.

Interspecific hybrids

At IGER, a new approach to the assembly of desired traits has been developed that offers potential improvements in all these areas. Hybrids between white clover (*Trifolium repens* L.) and two other species of the *Trifolium* genus have been produced. The first involves *Trifolium nigrescens* (Figure 5.1), a diploid annual species, and a near relative and possible ancestor of the tetraploid perennial white clover.

This species crosses naturally with white clover but is much more profusely flowering. It also produces volatile insect attracting compounds thought to be more effective at luring pollinating bees than those

Figure 5.3 *Six uniform inbred lines of* Trifolium repens *showing the stable variation in size, morphology and development.*

produced by white clover. The hybridisation programme aims to produce plants resembling white clover in everything except these improved reproductive traits. The F1 hybrids are annual but repeated backcrossing to the white clover parent has produced plants that resemble white clover but with increased flowering. This may increase the production of white clover seed crops in the UK rather than in the warmer climes currently used.

Trifolium ambiguum (Figure 5.2) is less closely related to white clover and a cross between these species requires the intervention of ovule culture for success. It is a very persistent species with good drought tolerance but is much slower to establish than white clover. It produces rhizomes for growth and storage below ground rather than the above ground stolons (horizontal stems) of white clover. These rhizomes may confer improved persistence in terms of increased tolerance of cold, grazing and drought. F1 hybrids and a range of backcrosses using white clover as the recurrent parent have been produced and by the third generation of backcrossing, plants that are essentially white clover but with rhizomes as well as stolons have been produced. *T.ambiguum* is also resistant to several viral diseases of white clover. The backcrossing programme is capable of introducing the genes responsible for this resistance into white clover. Currently, all the hybrids are undergoing field trials, to assess their agronomic potential.

Inbred lines

A further exciting development is the production of inbred lines of white clover (Figure 5.3). These lines are very uniform and enable specific morphological characters to be fixed.

This material will facilitate more efficient physiological and morphological as well as molecular studies which hitherto have been difficult in conventional white clover. They are also an

Figure 5.4 *Variation for nitrogen fixation between inbred lines. Inbred line A showing normal fixation and inbred line D which exhibits no-fixation. Both lines grow normally with nitrate.*

Figure 5.5 *Hybrid vigour in* Trifolium repens. *F1 hybrid (centre) demonstrating superior growth compared with its inbred parents P1 and P2.*

effective tool in exploiting rare traits, by releasing and then capturing hidden recessive variation (Figure 5.4). For pasture species like white clover, a breeding programme based on inbreeding methods could, in the future, be a more efficient strategy than conventional breeding methods (Figure 5.5).

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