Thermal time requirements for seedling development of Caucasian and white clovers

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Abstract

A controlled environment study compared the thermal time requirements for seedling development of Caucasian and white clovers. A base temperature of ≤2?C was found for both species. Leaf appearance interval (phyllochron) in days differed across temperatures but was constant at 109?Cd for Caucasian and 94?Cd for white clover. Axillary leaves of white clover first appeared after 439?Cd and stolons appeared after 532?Cd. These compare with 990?Cd for axillary leaves and 1180?Cd for crown shoots of Caucasian clover. As a consequence, white clover shoots had more leaves (16 vs. 5 plant^{-1}) and a faster relative growth rate (0.042 vs. 0.033 mg/mg/d) than Caucasian clover up to 774?Cd. Thus, the slow establishment of Caucasian clover observed in mixed pastures can be explained by its delayed axillary leaf and shoot development, and slow relative growth rate compared with white clover.

Key Words

axillary shoots, pasture establishment, phyllochron, thermal time, *Trifolium ambiguum*, *T. repens*.

Introduction

Caucasian clover is a perennial legume with potential to complement white clover in intensive temperate pastures (2,6). However, slow establishment has limited its commercial use (3,5). Seedling parameters that define 'slow establishment' can provide a basis for understanding the competitiveness of Caucasian clover seedlings in mixed pastures. Specifically, leaf appearance rate (phyllochron) and timing of axillary shoot development are major seedling components that affect canopy expansion, growth and therefore seedling competitiveness. The phyllochron and development of axillary shoots may be quantified in thermal time (Tt). The advantage of this approach is that it provides easily repeatable values that are independent of location and season, and therefore can be transferred from laboratory to field environments.

Thus, the objective of this study was to compare the Tt requirements for seedling development of Caucasian and white clovers using a series of controlled environment experiments.

Materials and methods

In plant growth chambers (Conviron PGV36), three replicates of 'Endura' Caucasian clover and 'Demand' white clover were grown from seed sown at a depth of 10 mm in pots at 7/4, 13/5, 18/10 or 23/15?C with 8 h day/8 h night, and 4 h transitions. There were 10 plants/pot (390 plants/m^2). Air temperature at 10 mm above ground was recorded with a HOBO data logger. The number of emerged leaves/plant was counted daily. The initiation of axillary leaves, stolons or crown shoots, which emerged in the axils of primary leaves, was also recorded. Seedlings were harvested when Caucasian clover plants had five leaves (up to 774?Cd). Leaf area was measured using a LI-COR model LI-3100 leaf area meter. Shoot relative growth rate (RGR = mg/mg/d) was calculated from individual seed weight and final shoot dry weight. The 1000-seed weights were 2.20 g for Caucasian and 0.63 g for white clover.

Leaf appearance interval (days/leaf) was calculated from cumulative primary growing point leaf number over days after sowing. The base temperature (T_b) and Tt requirements for the phyllochron and the initiation of axillary leaves, stolons or crown shoots were defined using a linear model of development rate vs. mean temperature previously described (1,4).

Results

Leaf appearance interval (days/leaf) was greater than 19 days at 5.5?C for both species but decreased exponentially as temperature increased (Figure 1A). A linear (R^2≥0.99) increase in leaf appearance rate (leaves/day) enabled T_b to be estimated at 1?C for both species (Figure 1B). Linear functions (R^2≥0.98) were also found for axillary leaf and stolon initiation of white clover, with a T_b of 1.9?C.

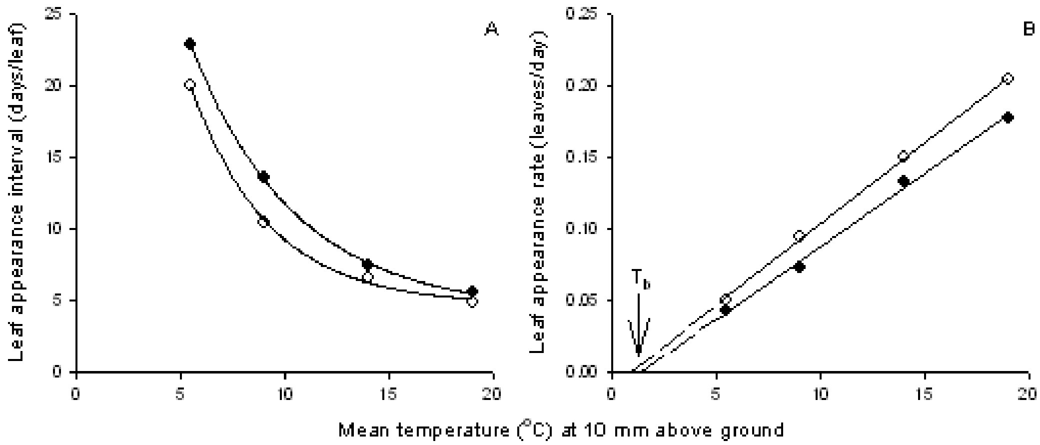

Figure 1. Leaf appearance interval (days/leaf) (A) and leaf appearance rate (leaves/day) (B) from the apical growing point of Caucasian clover (●) and white clover (○) against temperature.

Using a common T_b of 0?C (4), the phyllochron was estimated for Caucasian (109?Cd) and white (94?Cd) clovers. Axillary leaves of white clover first appeared after 439?Cd when seedlings had three primary leaves, and stolons appeared after 532?Cd. No axillary leaves or crown shoots were found in Caucasian clover before the fifth primary leaf emerged which meant at harvest (up to 774?Cd) white clover had 16 leaves/plant compared with only 5 for Caucasian clover. At this time, leaf area averaged 24 cm^2/plant and shoots were 176 mg/plant for both species. Shoot RGR was higher for white clover at 0.042 mg/mg/d compared with 0.033 mg/mg/d for Caucasian clover. A subsequent study at 23/15?C found axillary leaves of Caucasian clover only after 990?Cd and crown shoots after 1180?Cd.

Discussion

The slow establishment of Caucasian clover (3,5) can be explained by its slow relative growth rate and rate of leaf appearance in response to accumulated Tt. In particular, the Tt required to initiate axillary shoots was the major parameter controlling total leaf number and consequently canopy expansion. Therefore, the lack of axillary leaves until 990?Cd and secondary crowns until 1180?Cd after sowing limits the competitiveness of Caucasian clover seedlings in mixed pastures. Other results show axillary leaf and tiller initiation of ryegrass (*Lolium perenne* L.) after only 375?Cd. This compares with 440?Cd for white clover which initiated stolons after 530?Cd. The rapid onset of axillary shoot development of ryegrass confers a competitive advantage over white and particularly Caucasian clovers during pasture establishment when competition for light is intense. The physiological parameters quantified in this study can assist management decisions on time of sowing and compatibility of species within a seed mixture, and could be used in plant breeding to select for rapid leaf initiation in Caucasian clover.

References

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