Reestablishing Chicory into Multi-Species Perennial Pastures

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Abstract
Chicory (Cichorium intybus L.) has the potential to provide abundant, high quality forage during periods of drought, but poor persistence limits its usefulness in permanent pastures. This experiment compared the effectiveness of three seeding methods to reestablish chicory into a grazed multi-species pasture where it had previously provided a major proportion of total forage yield. Seedling methods included: frost-seeding in February; no-till seeding in late March; and broadcast seeding followed by hoof incorporation of the seed in May. The three methods did not differ from each other, and all resulted in adequate seedling emergence. However, survival was poor with mortality rates of 77 to 84% by early October of the seeding year. It is likely that greater seeding rates and more vigorous suppression of existing vegetation will be necessary to successfully reestablish chicory into existing cool-season pastures.

Introduction
Chicory has the potential for inclusion in pasture mixtures in the northeastern US because of its reported drought tolerance and high productivity during summer months (2,9,10). Belesky et al. (2) found that chicory was compatible with cool-season grasses and legumes, and could be grown successfully in cool-season based forage systems. Including chicory in mixed swards improved seasonal yield distribution, especially in midsummer when drought reduced productivity of the dominant cool-season forages. Chicory has high feeding value, promotes rapid animal growth, especially during the late summer/autumn period, and reduces problems with internal parasites (1). However, it is recommended that chicory comprise no more than 25% of the total diet for dairy cattle because diets containing only chicory can cause tainting of the milk (1).

A potential drawback to the increased use of chicory is its poor persistence. Herbage production of 7 to 9 tons/ha is common for the first two to three years under grazing, but then decreases significantly as plants age (10). Under high soil fertility, chicory planted as part of a mixed sward declined from nearly a pure stand in the first production year to less than 5% of harvested biomass by the third year (3). Chicory also failed to persist beyond the second production year in grazed multi-species pastures in eastern Pennsylvania (16). Li et al. (11) concluded that a decrease in chicory density under grazing management appeared to be inevitable. The objective of this study was to evaluate several seeding methods to determine if chicory could be re-seeded into an established perennial pasture, eliminating the need to completely renovate the pasture in order to maintain chicory as a component of the pasture mixture.

Pasture History
Four 0.22- to 0.25-acre pastures at the Pennsylvania State University, Hawbecker farm in University Park, PA, were originally no-till seeded in August 2004 with a five-species mixture including: ‘Puna’ chicory (4 lb/acre, 23 seeds/ft²); ‘Tekapo’ orchardgrass (Dactylis glomerata L.) (5 lb/acre, 39 seeds/ft²); ‘Bronson’ tall fescue [Lolium arundinaceum (Schreb.) Darbysh.]
‘Will’ white clover (Trifolium repens L.) (4 lb/acre, 66 seeds/ft²); and ‘Amerigraze’ alfalfa (Medicago sativa L.) (12 lb/acre, 49 seeds/ft²). This project is part of the long-term, multi-location USDA-ARS, Greenhouse Gas Reduction through Carbon Enhancement Network (GRACEnet), which is comparing the greenhouse gas reduction potential of various agricultural systems at 30+ locations across the United States. Even though chicory seeds only comprised 10% of the original mixture, it exhibited vigorous establishment and early growth, contributing 54% of total standing biomass by September 2005. As has been previously observed, the proportion of chicory then steadily declined to 15% in September 2006, 4% in September 2007, and finally to 0% by September 2008. All of the other seeded species remained in the pastures in proportions ranging from 14 to 30% of standing biomass. After the first year, tall fescue and white clover were the predominant components of the mixture, together comprising 52 to 66% of total biomass depending on year and season. In the fall of 2008 the decision was made to try and reestablish chicory into the pastures.

Chicory Reestablishment and Monitoring Procedures

In preparation for chicory reestablishment, pastures were grazed from 27-31 October 2008 then mowed to a uniform 4 inch stubble height. Residual biomass after mowing was 945 lb/acre. Each of the original pastures was divided into three equal sections which were randomly assigned to one of three seeding procedures including: (i) frost seeding; (ii) seeding with a no-till drill; and (iii) broadcast seeding with hoof incorporation of the seed. All plantings were at 8 lb/acre (46 seeds/ft²). Seeding rate was not adjusted for reported germination percentage of the seed lot, which was 84%. Frost seeding occurred on 13 February 2009, when seeds were broadcast using a handheld cyclone seeder. Snow had melted off the plots about one week prior to seeding and the soil surface had thawed. The soil refroze, thawed and froze again before permanently thawing the first week of March. The no-till seeding occurred on 25 March 2009. Seeds were planted at a depth of about ¼ inch into slightly dry surface soil. The pasture was just beginning to green up at the time of sowing. The final planting occurred on 18 May 2009 when seeds were again broadcast using the cyclone seeder. Standing biomass at the time of seeding was 2700 lb/acre. Grazing began immediately after seeding and plots were grazed to a residual biomass of 1780 lb/acre. Hoof action during grazing incorporated seeds into the soil.

On three dates, 27 April, 24 June, and 2 October 2009, seedling establishment was monitored by counting the number of chicory seedlings in a 20 × 20-inch frame placed at approximately 15-ft intervals moving diagonally across each plot. A total of five frames per plot were counted. Means and standard errors were calculated for each treatment × counting date. The final count occurred just prior to the October grazing event, at which time a 4 × 39-inch section of each plot was clipped to ground level, and harvested material was separated by species, then dried and weighed to determine individual species contributions to total biomass. Biomass data were analyzed as a randomized complete block design with four replications.

Chicory Emergence, Survival, and Contribution to Total Biomass

To account for differences in the amount of time since sowing for the different treatments, chicory seedling numbers are plotted vs. the number of accumulated growing degree days since planting, calculated with a base temperature of 7°F (12). Initial emergence was about 5 to 6 seedlings/ft² or 11 to 13% of sown seed (13 to 15% of live seed) (Fig. 1). No significant differences were found among treatments for initial emergence rates. Mortality was high and by the end of the summer the number of seedlings had decreased to 1.3 ± 0.5 seedling/ft² under frost seeding, 1.1 ± 0.3 seedlings/ft² under no-till, and 0.5 ± 0.2 seedlings/ft² in the broadcast treatment. There was no difference between frost and no-till seeding but seedling numbers in the fall were reduced...
to less than half when seeds were broadcast just prior to the initial grazing period in May. It is possible that high standing biomass at the time of the third seeding interfered with seed incorporation, resulting in more seedlings germinating at the soil surface where they were susceptible to desiccation and death.

Fig. 1. Effect of sowing method on seedling numbers for chicory sown into established multi-species pastures. Growing degree days are calculated as the mean daily air temperature (based on measurements made every 20 min) minus a base temperature of 7°F. Negative values were considered to be zero. Error bars represent ± 1 SE.

Moisture was plentiful and temperatures were relatively cool during the summer of 2009 (Table 1). Mean monthly temperature ranged from 0.1 to 3.8°F below average, and monthly precipitation was near or above average from May through August before becoming relatively dry in September. The combination of adequate rainfall and low temperatures meant drought stress was practically non-existent during the summer. These favorable conditions were reflected in pasture yield which averaged 4856 ± 1273 lb/acre, and was greater than any of the four previous years since the pastures were established (average 3804 lb/acre). Pastures were grazed five times during the year from mid May through early October. Mean standing biomass when cows were put into the pastures to graze was 1923 lb/acre, whereas residual biomass following harvests was 952 lb/acre. Weather conditions that were favorable for pasture growth would also have been favorable for chicory seedling emergence and survival. However, competition from existing plants experiencing greater than usual productivity would have had a detrimental effect on chicory growth and survival.
Table 1. Mean monthly air temperature and total monthly rainfall for University Park, PA from May-September, 2009. Mean temperatures are based on 30-year means from 1961 to 1990. Mean rainfall amounts are based on 103 years of data from 1896 to 1998.

<table>
<thead>
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<th>Month</th>
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<th>Rainfall (inches)</th>
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By early October 2009, seedlings sown in the spring had matured to the point where they could contribute to harvestable biomass. Chicory biomass at the October harvest was 55 lb/acre, which accounted for 4.6% of total standing biomass. No difference was detected among seeding methods for either chicory biomass ($P = 0.36$) or percent of total yield ($P = 0.43$). Tall fescue and white clover each contributed about 40% of standing biomass, whereas, orchardgrass, alfalfa, and weeds contributed about 5% each. The dominance of white clover and tall fescue was greater than in previous years when, with the exception of 2005 when chicory dominated, they contributed from 52 to 66% of total yield (unpublished data).

Some information is available about chicory germination and establishment in pure stands but little is known about establishment in mixtures. Smith and Capelle (17) found that percent germination in a pot study ranged from 18 to 36% with the greatest germination occurring when rocks or clods were placed on the soil surface. When conditions were similar to agricultural soils, germination was 18 to 10%. They also found that 23 to 30% of emerged seedlings had died by 35 days after planting. Sanderson and Elwinger (13) also found that emergence percentage of ‘Puna’ chicory was about 18% after a September planting, but increased to 40% when planted in July. They attributed the greater emergence in July to the more favorable moisture condition during July of that year. In both the cited examples, seeds were sown into bare soil so there was no competition with existing vegetation. When chicory was sown in multi-species mixtures, its contribution to first year yield was much higher than would be expected by the relative proportion of chicory seeds sown (15). However, no direct information was collected in that study on seedling emergence or survival.

The little information that exists on emergence and survival of chicory when sown into established stands has not been particularly encouraging. Volesky (18) observed new chicory seedlings in the spring and fall of the second year following establishment, but reported that most did not survive. Li et al. (11) also reported two failed attempts to over-sow chicory into established stands, although they did not specifically define what constituted failure. They concluded that the persistence of chicory in a stand depends mainly on the survival of the original plants.

Previous experience had suggested that chicory seedlings can be highly competitive, at least during initial pasture establishment (14,15), contributing two to three times as much biomass as would be expected from the proportion of sown seeds. In the current study, the chicory was reseeded at twice the rate used in the original planting yet by the end of the summer only about 1 to 3% of sown seeds had produced viable plants which contributed 5% of total biomass at the October harvest. The rapid decrease in seedling numbers during the summer confirms the difficulty of over-sowing chicory into established pastures. However, it should be remembered that these were not degraded pastures and that competition with existing biomass was high.

The ability to reestablish any chicory at all into well-established, vigorously growing pastures suggests that under appropriate conditions chicory establishment could be successful following its disappearance from pasture.
mixtures. A potential limitation to establishment in this study could have been the relatively low seeding rate. Frost seeding studies with red clover and other species have used rates as high as 81 seeds/ft² (5) or 139 seeds/ft² (4) compared with the rate of 46 seeds/ft² used in this study. In both previous studies plant density increased with seeding rate and maximum dry matter yield and economic return was achieved at red clover seeding rates between 84 and 112 seeds/ft² (4). Casler et al. (5) found that red clover produced 0.55 seedlings for each additional 10 seeds sown. Thus, increasing seeding rates could improve chicory establishment.

Competition from existing vegetation could also have played a role in limiting chicory establishment. Guretzky et al. (7) found that legume emergence and survival increased as sward height decreased when a mixture of legume species was sown into an existing cool-season grass pasture. Jung et al. (8) also found that legumes could easily be introduced into mixed swards when warm-season grasses provided less than 75% of ground cover, but over-seeding was not successful with thick stands of warm-season grasses. Cuomo et al. (6) obtained similar results when they sowed legumes into existing cool-season grass pastures and concluded that the overriding factor in the ability to establish legumes into established pasture was the suppression of existing vegetation during establishment. Although vegetative cover was not assessed in the current study, yield was higher than average suggesting the competition was also high. Residual biomass was particularly high following the May grazing. Closer grazing in May and shorter intervals between subsequent grazing events might have opened up the canopy and permitted greater seedling emergence and survival.

Recommendations

Results suggest that adequate chicory seedling emergence into mixed-species pastures can be obtained using any of the three methods examined in this study. However, successful re-establishment of chicory as a significant contributor to total standing biomass will probably require seeding rates greater than 8 lb/acre (46 seeds/ft²). Closer and more frequent grazing, perhaps combined with mowing, will probably also be necessary to reduce competition with existing vegetation.

Literature Cited