Vegetative propagation of kura clover: A field-scale test

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Baker, J. M. 2012. Vegetative propagation of kura clover: a field-scale test. Can. J. Plant Sci. 92: xxx–xxx. Kura clover (Trifolium ambiguum M. Bieb.) is a potentially valuable forage legume, but it has been underutilized. A major reason is the difficulty of establishing it from seed. Since kura is rhizomatous, there have been attempts to propagate it vegetatively, but no reports of success at the field scale. Two harvesting methods were tested to transplant material from a mature 17-ha field to a newly tilled 17-ha field: a Bermuda grass sprigger that harvests bare rhizome sprigs, and a potato digger that harvests crowns and rhizomes, along with soil. The harvested propagules were distributed over the new field in July 2010 with a manure spreader, then disked and packed. Survival and growth were observed for the remainder of 2010 and through 2011, and recovery of the source field was also monitored. The material harvested with the sprigger did not compete well with weeds and had virtually disappeared by midsummer 2011, but the material harvested with the potato digger thrived, steadily increasing to nearly 80% of the biomass in the new field by the 3rd cutting in summer 2011. Properly done, vegetative propagation is a viable option for kura clover establishment.

Key words: Kura clover, vegetative propagation, sprigging, vegetative establishment


Mots clés: Le trèfle Kura, la multiplication végétative, le flocage, l’établissement végétatif
for white clover, and rhizomes or secondary crowns for kura clover. The thermal time requirement for secondary growth in kura clover (1180°C d) was more than twice that of the other two species (360°C d for rye and 430°C d for white clover). As a consequence, kura clover often fails to establish when planted in mixtures, and sole plantings typically require 2 yr for establishment of a healthy stand, with repeat applications of herbicide and periodic mowing to control weeds. A related impediment has been the scarcity of seed. The slow establishment of kura clover leads to low seed production in the first year (Steiner and Snelling 1994), which, when combined with limited demand, discourages seed suppliers from producing it.

The rhizomatous nature of kura clover suggests an alternative method of establishment: vegetative propagation. Teutsch et al. (2004) conducted a plot-scale test in which they manually scattered kura clover sprigs on mine spoil soils in Kentucky. They compared the efficacy of different incorporation methods and assessed the impact of mulching and of applying mycorrhizal coatings on the sprigs. The results were generally disappointing with only the mulched treatments producing a viable stand after 1 yr. Sheaffer et al. (2008) manually planted bare sprigs on plots in Minnesota, testing the importance of seeding date, rhizome characteristics, and planting density. They found that rhizomes with buds produced better stands than rhizome sections without buds, and also reported that for spring planting, earlier dates (mid- to late April) had higher survival rates and spread further than a mid-May planting. Rhizome planting density was varied over a range from 11 to 178 m⁻², and while subsequent plant populations reflected the initial density differences, by the third year there were no significant differences in dry matter yield, and mean yields on all sprigged plots were similar to seeded plots of similar age. While these proof-of-concept trials have shown that kura clover will spread when vegetatively planted, the techniques used for harvesting, selecting, and planting the sprigs are not practical for field-scale propagation. Our goal was to determine the viability of vegetative harvesting and planting at the scale of a production farm.

**MATERIALS AND METHODS**

The research was conducted at the University of Minnesota’s Rosemount Research and Outreach Center, located 20 km south of St. Paul. The source area was a 17-ha field of Endura kura clover that had been planted in spring 2006. After a 2-yr establishment, it had been managed as a living mulch, with silage maize planted into it in 2008 and 2009, following the methods described by Affeldt et al. (2004). In 2010 no maize was planted and the kura clover was managed as a hay crop. Initial mowing was delayed until June 28, several weeks beyond the typical first cutting date, to maximize belowground carbohydrate reserves. On 2010 Jul. 01, the sprig harvesting and transplanting operation was begun. The target area for transplanting was another 17-ha field, approximately 2 km to the southwest. Both fields are of similar topography and soil type, predominantly Waukegan silt loam (fine, silty, over sandy or sandy-skeletal mixed, superactive mesic Typic Hapludoll). Soil test data for both fields from the spring of 2010 are listed in Table 1.

The target field had been planted in maize the previous year. In spring 2010 it was left fallow, and during the week prior to initiation of the transplant operation it was sprayed with glyphosate to kill all vegetation.

**Sprig Harvest**

Two methods of digging kura clover vegetative material were tested. The first employed a bermudagrass sprig harvester borrowed from the University of Illinois, where it has been used to harvest Miscanthus (Miscanthus giganteus) sprigs. It has rotary tines that resemble those of a rototiller. The tines chop the kura clover rhizomes into pieces and throw them onto a conveyor that unloads them into a trailing wagon for later transfer to a manure spreader. The second approach used a potato harvester to extract kura clover crowns and root fragments and load them on to a conveyor. In this case the conveyor was rotated 90° and the harvested material was dropped directly into the manure spreader, which was being towed by a second tractor. The two harvesting methods differed substantially. The sprig harvester collected bare rhizome sections of variable length, with most less than 10 cm, and very little soil. The potato digger collected a combination of intact crowns, rhizomes and roots, along with a considerable quantity of soil. It has two vertical disks, 50 cm apart, flanking horizontally mounted teeth that lift and undercut the vegetation, much like a sod harvester. The teeth were set to cut to a depth of approximately 5 cm. As the clover was transferred to the manure wagon, the rollers on the conveyor dislodged some of the soil, which was returned to the field, so that the depth of the residual swath was approximately 2–3 cm. The wagons were not weighed, but we estimate that each load filled by the potato digger weighed approximately 2.8 Mg. Loads collected with the sprig harvester were much lighter and contained little soil.

<table>
<thead>
<tr>
<th>Field</th>
<th>Organic matter (%)</th>
<th>pH</th>
<th>Bray P⁺ (µg g⁻¹)</th>
<th>Potassium⁺ (µg g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>4.7</td>
<td>6.5</td>
<td>79</td>
<td>296</td>
</tr>
<tr>
<td>New</td>
<td>5.2</td>
<td>6.4</td>
<td>45</td>
<td>245</td>
</tr>
</tbody>
</table>

⁺Bray and Kurtz (1945).
field was approximately 2.3 ha, in discrete 0.5-m strips. For 2010, both prior to and after the removal of propagules, the source field was managed for hay. As noted above, it was mowed and baled on Jun. 28, just prior to sprig and crown harvesting, and again in late September.

**Transplanting**

The new field of 17 ha was prepared for transplanting on a “just in time” basis to prevent unnecessary drying of the seedbed. Just prior to the arrival of each manure wagon filled with sprigs and crowns, an appropriately sized portion of the new field was tilled with a tandem disk to break up the surface and the recently killed weeds. This was followed by a field cultivator, which created a surface with small furrows. At this point, the sprieks and crowns were spread from the manure wagon over the prepared soil, followed immediately by a second pass of the tandem disk to partially bury the vegetative material. A final pass was made with a cultipacker (Brillion Farm Equipt., Brillion, WI) to improve contact between vegetation and soil.

The transplanting operation was conducted primarily on 4 d between Jul. 01 and Jul. 20, 2010, roughly one quarter of the field at a time, with timing dictated by weather and the availability of personnel and equipment. On a transplanting day there were typically four people operating equipment: one person pulling the potato digger in the source field, one person conducting tillage and packing operations in the receiving field, and two people shuttling vegetative material in manure spreaders from the source field to the new field. Each spreader load was sufficient to cover an area of approximately 600 m². Due to recurring mechanical problems with the bermudagrass sprig harvester, it only served as the source for two loads, covering approximately 0.1 ha. The remainder of the 17-ha field was planted with material extracted by the potato harvester. The total amount of vegetative material spread on the new field was estimated at 9.2 Mg (dry weight). After each quadrant of the new field was planted, it was irrigated lightly (~8 mm). Following completion of the entire operation, 40 mm of rain fell on Jul. 22, so no further irrigation was necessary.

Only minimal chemical weed control was practiced on the new field after planting— the first planted quadrant (SW quarter of the field) was sprayed with 2,4-DB on 2010 Jul. 20 to control an infestation of pigweed (*Amaranthus retroflexus*). Periodically during the 2 mo following transplanting, stand counts were made to compare plots planted with material from the bermudagrass sprigger with the remainder of the field, which had been planted with material from the potato harvester. Stand counts were done by blindly tossing a large plastic ring (0.95 m i.d.) into a plot, then counting all living clover stems within the ring. At each sampling time, four measurements were made in each of the four quadrants, and four measurements were also made in the two sprigged swaths. The entire field was cut with a flail mower during the first week of September, principally to control weeds.

In 2011, biomass measurements were made at four points in each quadrant of the field, and also on the sprigged plots, just prior to each cutting. Sampling was again done by tossing a 0.95-m plastic ring, then clipping all vegetation within the ring at a height of 3 cm. The vegetation was separated into clover and weeds. Each fraction was weighed, dried for 72 h at 60°C and reweighed. After sampling was complete, the field was cut with a mower/conditioner, windrowed, and subsequently baled when sufficiently dry. At the conclusion of the growing season, below-ground kura clover biomass was measured in the new field, following a method described by Peterson et al. (1994). At eight randomly selected points in the field, a 0.3 m square area was excavated to a depth of 15 cm. Each sample was then washed to remove soil from the roots and crowns, and any non-clover vegetation was also separated and removed. The clover and non-clover fractions were separately dried for 48 h at 60°C and weighed.

**RESULTS AND DISCUSSION**

**Weather**

Figure 1a depicts cumulative growing degree days for the 2010 growing season at Rosemount, superimposed on plots of the warmest and coolest growing seasons within the past 15 yr. Figure 1b is a similar plot of moisture status: cumulative precipitation minus cumulative potential evapotranspiration. In general, the early summer preceding transplanting was somewhat cooler and drier than normal, but the period after transplanting was both wetter and warmer than normal, providing favorable growing conditions. First frost occurred on 2010 Oct. 29, followed by a winter that was both colder and snowier than normal, with the last frost recorded on 2011 May 03. The succeeding spring and early summer in 2011 experienced below-normal temperatures and above-normal precipitation, followed by near-normal midsummer temperatures, with no extended dry periods until late summer-early fall 2011. Clover ceased photosynthesizing on or about 2010 Oct. 14 and resumed in the spring of 2011 on or near Mar. 21. (Note that this is 10 wk prior to the final recorded hard frost; the cold tolerance of kura clover is one of the features that makes it an attractive candidate for companion cropping with maize, a cold-sensitive species.)

**Kura Clover Growth in the New Field**

Stem counts in the new field during the initial weeks following transplanting in 2010 are shown in Fig. 2. The dug clover apparently survived the shock of the mechanical transplanting operation much better than the sprigged clover. This is likely due to a combination of two factors. First, the potato digger extracted intact crowns, while the sprig harvester chopped both crowns...
and rhizomes into small pieces. Second, the vegetative material removed by the potato digger had a substantial amount of soil adhering to it, while the material taken up by the sprig harvester was essentially bare, and thus more susceptible to desiccation. Of course the soil removed by the potato digger resulted in much heavier loads, and more visible disruption to the source field. However, the more vigorous initial growth of the material appears to have been an important advantage in coping with the weed pressure that developed in the target field. This is particularly evident in the biomass data collected during the subsequent growing season in 2011 (Fig. 3). At the initial cutting on Jun. 06, weeds comprised nearly half of the biomass for both propagation methods, but with much less total vegetation in the plots planted with material from the bermudagrass sprigger. The clover fraction steadily increased after each cutting for the dug clover, which comprised the bulk of the field. At the second cutting on Jul. 11 mean clover fraction was 66%, and by the time of the third

Fig. 1. Top: Cumulative growing degree days (3.5°C base) for 2010 (solid line). The dashed lines show the two most extreme of the past 15 yr, and the shaded bar delimits the period during which transplanting took place. Bottom: Similar plot of available water, presented as the cumulative difference between precipitation and potential evapotranspiration. Dashed lines denote the wettest and driest of the past 15 yr, while the solid line denotes 2010.
cutting, on Aug. 09, the mean above-ground ratio of clover to weed biomass was 78:22, confirmation that kura clover, once it is established, competes effectively with weeds (see photograph in Fig. 4). By contrast, the clover in the sprigger plots declined in vigor, was dominated by weeds by the time of the second cutting in 2011, and had virtually disappeared by the third cutting. We surmise that the preservation of intact crowns during harvest by the potato digger confers an important competitive benefit to transplanted kura clover relative to bare sprigs.

The 2011 clover biomass data from the new field are also useful for assessing the impact of transplanting date (Fig. 5). The first quadrant had been planted on 2010 Jul. 01/C1 02, the second on 2010 Jul. 09, the third on 2010 Jul. 16, and the final quadrant on 2010 Jul. 20. There...
were no significant differences among the four quadrants in total 2011 clover production, suggesting that transplanting could probably have been done even later than Jul. 20. The significance of this is that a later planting can more easily accommodate a prior cash crop such as peas, spring oats, or winter wheat, preserving income during the transplanting year while still producing harvestable clover the following year.

The below-ground kura clover biomass measurements near the conclusion of the 2011 growing season (2011 Oct. 11) are shown in Table 2. The mean of eight samples for the new field was 4.82 Mg ha$^{-1}$, with a rather large standard deviation of 1.98 Mg ha$^{-1}$. For reference, the mean value reported by Peterson et al. (1994) for a mature stand was 7.14 Mg ha$^{-1}$.

**CONCLUSIONS**

These results demonstrate that kura clover can be successfully propagated vegetatively at the field scale, thus providing an alternative means of establishment if seed is not available. An advantage of this approach is that it can potentially be done late in the growing season following an early crop to prevent complete loss of income during the establishment year, while still producing harvestable forage the following year. Additionally, the more rapid initial production should provide superior erosion protection during the establishment year relative to a seeded crop. The principal disadvantage is the lack of specialized equipment and techniques for harvesting the vegetative material and for planting it. Propagules obtained with a commercial bermudagrass sprigger, which were primarily small sections of bare rhizome, did not produce a healthy stand and were crowded out by weeds. By contrast, material harvested with the potato digger, a mixture of intact crowns and larger rhizome segments with soil attached, readily took root and spread in the new field. The primary drawback of this approach is that it required a substantial amount of both manpower and horsepower, and probably removed more soil than...
necessary from the source field. One alternative is to start plants from seed in a nursery or hoop house, and then plant the seedlings with a mechanical transplanter of the sort used for vegetable crops (Bruce Gelinas, personal communication). Regardless of the method, the initial cost of vegetative establishment will likely exceed that of seeding, but the difference may be trivial when amortized over the lifetime of a stand, particularly when weighed against the benefits of rapid establishment and lower weed pressure.

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