ADF Project No. 20020014: Pasture Renovation with Kura Clover (*Trifolium ambiguum* Bieb.)

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Submitted by
Bruce Coulman and Jim Romo

Abstract/Executive Summary

Legumes are important for profitable grazing management because they fix atmospheric nitrogen and improve seasonal distribution of pasture production. Persistent legumes are the most desirable because they seldom require re-seeding. Kura clover (*Trifolium ambiguum*) is a persistent legume which is able to spread under heavy grazing because of its rhizomatous growth habit. It is considered to be more drought tolerant than other pasture legumes such as birdsfoot trefoil (*Lotus corniculatus* L.) and white clover (*Trifolium repens* L.). Numerous studies in the northern United States and eastern Canada have demonstrated the excellent persistence and high nutritive value of kura clover. Despite these advantages, kura clover has not been widely utilized due to the difficulty of establishing this species and the high cost of seed. Prior to the present study, kura clover had not been evaluated in the semi-arid climate of Saskatchewan.

The overall objective of this study was to evaluate the adaptation, yield and nutritive value of kura clover in mixtures with spring or fall planted perennial grasses at two locations in Saskatchewan.

The study was conducted at Saskatoon under rainfed conditions and at Outlook under irrigation. Two commercially available kura clover cultivars, Rhizo and Endura, were seeded in pure stands and mixtures with smooth (*Bromus inermis* Leyss.), hybrid and meadow brome (*Bromus riparius* Rehm.), and diploid and tetraploid crested wheatgrass (*Agropyron cristatum* L.). The grass and clover mixed stands were either seeded together in the spring, or the grass was fall dormant seeded into spring seeded kura clover. The latter treatment was included to see if kura clover would establish better without the immediate competion of the grass. Trials were seeded in 2003 and data collected in 2004 and 2005. Dry matter yields (two cuts), percent clover in the stand, and concentrations of crude protein (CP), neutral-detergent fiber (NDF) and acid-detergent fiber (ADF) were determined.

Establishment of kura clover was generally good in all treatments at Saskatoon, with the few gaps in the plots filled in by the spreading rhizomes by 2005. At Outlook, establishment of kura clover was poorer; however, by 2005, the kura clover plants had filled in many of the gaps in the plots by spreading rhizomes.

Pure stand dry matter yields of kura clover ranged from 4.5 to 6.7 t/ha, with no differences in yield between the two cultivars. In alfalfa trials of the same age at these sites, mean yields were 6.5-10.1 t/ha at Saskatoon, and 11.1 to 14.4 t/ha at Outlook. Thus, the yield potential of kura clover is considerably lower than that of alfalfa.

For the kura clover-grass mixtures, those seeded together in the spring produced the highest yields. For mixtures in which the grass was dormant seeded into the kura clover in the fall, there was little grass present in the forage in 2004, but grass percentage increased somewhat in 2005. Thus, dormant seeding of a grass into kura clover stands cannot be recommended as stands end up mainly being composed of kura clover. In the spring seeded mixtures, the smooth brome-kura clover and the meadow brome-kura clover mixtures were the highest yielding.

Crude protein concentrations of pure stands of kura clover were highly variable, ranging from 10.9 to 21.2 %, even though all were all samples were similar in maturity. NDF concentrations were also variable, ranging from 20.9 to 37.9 at cut 1 and 22.5 to 33.6 at cut 2. ADF ranged from 15.8 to 20.5 at cut 1 and 17.3 to 23.5 at cut2; these are very low values relative to other legumes.

Kura clover plants were present in the field at Outlook one year after the trial was sprayed with glyphosate, and the area no till planted to durum wheat. Thus, kura clover does show a tendency to persist in cropping systems with minimum tillage. It is known that *Trifolium* clovers are susceptible to 2,4-D, so application of this herbicide may present an effective way of eliminating kura clover.

Based on the results of this study, kura clover is a winter hardy, persistent species in the Dark Brown soil zone of Saskatchewan. It is slow to establish, but its rhizomatous growth will slowly fill in stands. It has a much lower yield potential than alfalfa in the first two years of production of a stand. Kura clover has a high nutritive value, being particularly low in ADF. Kura clover mixtures with meadow or smooth bromegrass produced the highest yields.

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Technical Report

A. Overview

Kura clover (*Trifolium ambiguum* M. Bieb.) was evaluated for its potential as a new forage crop for Saskatchewan. The present studies evaluated forage production and forage quality of two varieties when Kura clover was grown as monocultures or when grown in mixtures with crested wheatgrass, smooth brome, meadow brome or hybrid brome. Below is a review of published, refereed literature to March 31, 2006 that describes the characteristics and culture of Kura clover.

B. Introduction and Review of Literature

Introduction

Kura clover (*Trifolium ambiguum* M. Bieb.), also known as Caucasian clover, honey clover and Pellett clover, is named after the Kura River in Georgia (Speer and Allinson, 1985). This long-lived perennial legume is rhizomatous. The legume is native to Caucasus, an area that includes the Crimea, the Black Sea coast of Ukraine, Eastern Turkey, northern Iraq, northern Iran and Romania (Bryant, 1974; Speer and Allinson, 1985). A valued legume in its native range, Kura clover has been researched for use as a domestic forage and crop for honey production. Several traits of Kura clover make it a legume of interest for researchers including winter hardiness, drought tolerance, resistance to disease and pests, and tolerance to grazing.

Physical Description

Kura clover is a member of the *Trifoliate* section Lotoidea Crantz (Taylor and Smith, 1998). Kura clover has a prostrate growth habit and splitting taproots with many lateral roots and rhizomes (Duke, 1981). Aboveground stems may have some hairs and stipules are broadly ovate and pale (Gillett and Taylor, 2001). The trifoliate leaves are petiolate with obovate to broadly elliptical leaflets that are 1 to 8 cm in length and 0.5 to 5 cm wide in width with a rounded tip and a “V” watermark (Duke, 1981; Taylor and Smith, 1998; Frame, 2005). Each leaflet has a prominent nerve and the upper leaflet has a serrate margin (Gillett and Taylor, 2001). Flowers are white and turn reddish with age (Gillett and Taylor, 2001). Kura clover spreads by seeds and rhizomes (Duke, 1981; Frame, 2005).

Ecology

In its native range, Kura clover occupies many different habitats because of its broad ecological amplitude of tolerance (Seledets, 1979; Abdaladze and Kikvidze, 1991). Kura clover grows at elevations up to 3000 m, excludes other legumes from 3000 to 2200 m, shares habitat with white clover (*Trifolium repens* L.) between 1900 and 2200 m and grows with other legumes below 1900 m (Seledets, 1979; Duke, 1981). Its native habitat includes dry hillsides, scree slopes, margins of forests, stream banks and depressions at lower altitudes (Seledets, 1979; Duke, 1981; Gillett and Taylor, 2001).

Kura clover has a high below ground to above ground biomass ratio compared to other legumes, especially in the first few years after seeding (Hill and Hoveland, 1993; Abberton et al., 2000). In the first year of growth, about 60% of plant growth is below ground (Genrich et al., 1998). Kura clover has not been widely used outside of its native range because it is difficult to establish (Cuomo et al., 2003; Laberge et al., 2005a). The first three years of Kura clover growth is concentrated mostly below ground (Hill and Mulcahy, 1995). However, over time Kura clover tends to increase canopy cover (Davis, 1991; Cuomo et al., 2003). In an 11 year grazing study of Kura clover and grass, the legume eventually excluded grasses (Virgona and Dear, 1996). Most of this increase is thought to come from vegetative reproduction rather than recruitment of new plants from seeds (Virgona and Dear, 1996; Scott, 2001).

Genetics

Kura clover is highly self-incompatible and it has considerable genetic variation (Kannenberg and Elliott, 1962; Speer and Allinson, 1985; Abberton et al., 2000). Kura clover exists at three main ploidy levels. The diploid (2n = 16) varieties include the varieties 'Summit', 'Forest', and 'Alpine'. 'Treeline' is the only tetraploid (2n = 32) variety, while 'Prairie', 'Monoro', 'Rhizo' and 'Endura' are all hexaploid (2n = 48) varieties (Speer and Allinson, 1985; Taylor and Smith, 1998). 'Endura' had greater forage quality than 'Rhizo' when grown under the same conditions in Minnesota (Seguin et al., 2002). An earlier study reported greater yields for 'Endura' than 'Rhizo' (Genrich et al., 1998). 'Prairie' is reported to spread 30 to 90 cm in the first year and grow larger than 'Summit', 'Forest' and 'Treeline' (Anonymous, 1977). Hexaploid varieties of Kura clover grew most vigorously in Colorado tests (Townsend, 1970). A New Zealand study found no differences in response to phosphorus fertiliser from three different varieties of Kura clover (Davis, 1991). Tolerance to cattle grazing was similar for 'Endura' and 'Rhizo' after the first year of growth (Brummer and Moore, 2000). Kura clover is considered a candidate for cross breeding (Townsend, 1970) and has been used as breeding material, producing acceptable results in the field in the UK (Meredith et al., 1995; Marshall et al., 2003) and in the laboratory (Abberton et al., 2000).

History

Kura clover was first described by Marshall L.B.F. von Bieberstein in 1808 and the perennial legume was first imported to North America in 1911 (Bryant, 1974; Sheaffer and Marten, 1991). In 1941, Frank Pellett of the Pellett Gardens, Atlantic, Iowa attempted to exploit the clover as a honey producing crop because he recognised that the flowers of Kura clover were accessible to bees and the plant is a good source of nectar (Parker and Allen, 1952; Duke, 1981; Speer and Allinson, 1985). Effective nodulation with Rhizobium was one of the earliest challenges to establishing Kura clover outside its native range. Commercial strains of rhizobia do not nodulate Kura clover effectively (Beauregard et al., 2003), but *Rhizobium* spp. from Kura clover nodulate other species of *Trifolium* (Parker and Allen, 1952; Hely, 1957). Kura clover has also been touted as a soil stabiliser where soil fertility is low (Speer and Allinson, 1985), but several studies have shown that Kura clover requires fertiliser to grow well on a low fertility soils (Spencer et al, 1980; Davis, 1991; Scott, 2001).

Pasture

Kura clover is grazed and cut for hay in its native range (Hely, 1957; Bryant, 1974; Spencer et al., 1980). The forage of this legume has high protein content and digestibility when grown in monocultures (Allinson et al., 1985). The legume has also been tested as a companion to grass species because it increases forage quality, persists and can spread (Brummer and Moore, 2000; Mouriño et al., 2003; Laberge et al., 2005b). Alfalfa (*Medicago sativa* L.), white clover and red clover (*Trifolium pratense* L.) produce more dry matter than Kura clover in the first and often in the second and third years after seeding. Persistence and nutritional value of Kura clover is often greater than other legumes (Cuomo et al., 2003). Kura clover averaged 68% of total canopy compared to 21% for red clover in Wisconsin (Mouriño et al., 2003). Kura clover grown with smooth brome (*Bromus inermis* Leyss.) in Iowa accounted for 29% of total dry matter compared to 22% for birdsfoot trefoil and 19% for alfalfa (Moore et al., 2004). Kura clover averaged 45% of total dry matter, red clover averaged 25% and white clover averaged 11% in the second growing season when seeded into existing grass stands in Minnesota and Quebec (Laberge et al., 2005b). Canopy cover of Kura clover averaged 90% compared to 41% for alfalfa, 28% for birdsfoot trefoil and 9% for red clover after 4 years of grazing (Cuomo et al., 2003). Maintenance of a wide belowground to aboveground biomass ratio in the first three years is thought to decrease production compared to other legumes. This same trait allows Kura clover to increase its canopy cover and resist grazing.

Yield

Monocultures of Kura clover produced 8.4 and 4.4 Mg DM ha^{-1} in each of 2 years with 4 cuts compared with 8.5 to 9.6 Mg DM ha^{-1} and 4.5 to 4.7 Mg DM ha^{-1} when Kura clover was grown with grasses in Iowa (Sleugh et al., 2000). In that same study, monocultures of alfalfa yielded 13.5 Mg DM ha^{-1} and 7.5 Mg DM ha^{-1} in 2 years with 4 cuts and 11.2 to 12.7 Mg DM ha^{-1} and 5.6 to 6.8 Mg DM ha^{-1} when grown with perennial grasses. The 3 year average forage yield of Kura clover cut 4 times a year was 5.8 Mg DM ha^{-1} compared to 6.0 Mg DM ha^{-1} for cicer milkvetch (*Astragalus cicer* L.) and 9.0 Mg DM ha^{-1} for alfalfa (Sheaffer and Marten, 1991). Peterson et al. (1994a) reported 8.6 Mg DM ha^{-1} for Kura clover grown in pure stands in Minnesota, while 10.0 Mg DM ha^{-1} were reported from pure stands of Kura clover in Wisconsin (Contreras-Govea and Albrecht, 2005). Herbage yields were 10.7 Mg DM ha^{-1} (Allinson et al., 1985) in Louisiana. Kura clover produced less than 0.1 Mg DM ha^{-1} compared to more than 4.5 Mg DM ha^{-1} produced by white clover in the United Kingdom (Marshall et al., 2003). Forage yields in the seedling year for monocultures of Kura clover were less than 1 Mg DM ha^{-1} and 1 to 5.0 Mg ha^{-1} in the year after seeding (Seguin et al., 1999). Applying phosphorous did not increase dry matter production of Kura clover as much as it did in white clover despite lower phosphorous requirements for Kura clover (Spencer and Hely, 1982). Seed production of Kura clover ranges from 110 to 800 kg ha^{-1} (Seguin et al., 1999).

Nitrogen fixation

N_2 fixation by Kura clover ranged from 9 to 25 kg N ha^{-1} yr^{-1} (Seguin et al., 2001) compared to 155 kg N ha^{-1} yr^{-1} in another study in Minnesota (Seguin et al., 2000). Kura clover fixed less N_2 than white clover in laboratory experiments (Abberton et al. 2000). The fertiliser nitrogen replacement value (FNRV) of a Kura clover-grass mixture was between 90 and 250 kg N ha^{-1}, depending on the species of grass; Kura clover provided a greater FNRV than birdsfoot trefoil (Zemenchik et al., 2001).

Nutritive value

Kura clover is palatable to livestock in its native range (Seledets, 1979). Domestically, Kura clover improves all aspects of forage quality when grown with grasses (Zemenchik et al., 2002) and the legume can increase the digestibility of forage more than red clover (Mouriño et al., 2003). Carrying capacity, average daily gain and total gain per hectare of steers were all greater when grazing a Kura clover-grass mixture than a red clover-grass mixture (Mouriño et al., 2003). After three years, dairy cattle grazing a Kura clover-grass produced more milk than dairy cattle grazing birdsfoot trefoil-grass (Zemenchik et al., 2002). Kura clover also maintains higher forage quality than other legumes under adverse conditions (Seguin et al., 2002; Moore et al., 2004). Alfalfa produced more forage than Kura clover, but the forage quality of Kura clover was greater than alfalfa in Iowa (Sleugh et al., 2000). Crude protein of Kura clover grown in monocultures ranged from 17 to 23 % (Allinson et al., 1985; Sleugh et al., 2000) and 25 to 27% (Peterson et al., 1994a; Contreras-Govea and Albrecht, 2005). Kura clover increases the crude protein content of grasses (Sleugh et al., 2000; Contreras-Govea and Albrecht, 2005). Kura clover had among the highest crude protein content of all legumes tested and the greatest in vitro dry matter digestibility (IVDMD) in Minnesota (Sheaffer and Marten, 1991; Sheaffer et al., 1992). The IVDMD of Kura clover monocultures averaged 87% and ranged from 68 to 79% when grown with grasses (Sleugh et al., 2000). Grown in the same conditions and harvested 3 times, Kura clover had greater IVDMD than alfalfa, crownvetch (*Coronilla varia* L.), cicer milkvetch and birdsfoot trefoil (Allinson et al., 1985). Cattle gained most and animal gains were most stable when grazing pastures that included Kura clover (Moore et al., 2004). Lambs grazing Kura clover-grass pastures gained more weight than lambs grazing other legume-grass pastures (Sheaffer et al., 1992).

Grazing management

Kura clover is resistant to trampling by grazers (Seledets, 1979). Kura clover was the only legume that increased under cattle grazing in Minnesota (Moore et al., 2004), and it better resisted grazing by cattle than alfalfa, birdsfoot trefoil and red clover (Brummer and Moore, 2000). 'Endura' Kura clover grown with smooth brome consistently produced more forage than red clover with smooth brome (Mouriño et al., 2003). Kura clover is susceptible to aboveground herbage removal. Root mass of Kura clover decreased by 20% over two years of clipping and grazing (Peterson et al., 1994b). About 3% of lambs grazing pure stands of Kura clover died from bloat (Sheaffer et al., 1992). A similar percentage of cattle died from grazing pure stands of Kura clover in Wisconsin (Mouriño et al., 2003).

Suppression of Perennial Grasses

Forage yield of Kura clover seeded into existing grass stands increases with grass sod suppression (Cuomo et al., 2001; Laberge et al., 2005c). Increasing the density of grasses and therefore increasing competition can limit growth of Kura clover (Hill and Hoveland, 1993; Hill and Mulcahy, 1995). Adding nitrogen fertiliser when sowing legumes into grasses can also increase the competitiveness of grasses to the detriment of Kura clover (Laberge et al., 2005b). Decreased fertility and infrequent defoliation favour Kura clover in grass-Kura clover mixes (Hill and Mulcahy, 1995). Production of Kura clover was greater in Kentucky bluegrass (*Poa pratensis* L.) than in smooth brome in Quebec and Minnesota (Laberge et al., 2005b). Red clover sown into existing stands of grass yielded 2.7 Mg DM ha^{-1} compared to 1.5 Mg DM ha^{-1} from white clover sown into grass and 1.2 Mg DM ha^{-1} from Kura clover sown into grass in Quebec and Minnesota (Laberge et al., 2005b). By contrast Kura clover was more competitive with grasses than birdsfoot trefoil in Minnesota (Cuomo et al., 2001). Annual grasses can be established in Kura clover without using herbicides or fertilisers (Contreras-Govea and Albrecht, 2005).

Inoculation

The literature from Russia does not note any trouble nodulating Kura clover for nitrogen fixation (Hely, 1957), but western researchers have had difficulty nodulating Kura clover. The bacteria required to inoculate Kura clover appear species specific (Hely, 1972; Abberton, et al., 2000; Seguin et al., 2001). *Rhizobia* species chosen specifically for Kura clover inoculation significantly increase dry matter and nitrogen yield of the legume compared to inoculation with rhizobia that are commercially available (Laberge et al., 2005a). Some rhizobia species from Turkey increased production of Kura clover (Hely, 1957). Other rhizobia species native to North America increased dry matter production of Kura clover, but never more than when 100 kg N ha^{-1} fertiliser was applied (Beauregard et al., 2003). Limited nitrogen fixation by Kura clover, low dry matter yield, and poor establishment of the legume may have exaggerated ineffective nodulation. Ineffective nodulation may also be mistaken for late nodulation (Evans and Jones, 1966).

Winter Hardiness

Kura clover is considered winter hardy (Anonymous, 1977; Spencer et al., 1980). Kura clover had greater winter survival than red clover and white clover in Quebec and Minnesota (Laberge et al., 2005b). However, Kura clover was the most frost sensitive of several clover species tested; poor seedling vigour may have contributed to frost sensitivity (Caradus, 1994).

Drought

Kura clover survived and increased during two droughts that were sufficient to kill white clover in Australia (Spencer and Hely, 1982). New Zealand researchers also reported considerable drought tolerance in Kura clover (Davis, 1991). Kura clover was more tolerant of drought than birdsfoot trefoil and white clover (Hill and Hoveland, 1993). Kura clover was not permanently damaged by a 3 to 4 week drought (Hill and Mulcahy, 1995).

Conclusions

Pastures or crop rotations would benefit from the traits reported for Kura clover. The long-lived legume persists under grazing while other legumes do not. Because of its rhizomatous growth habit, Kura clover is able to spread after planting and under heavy grazing pressure. Nutritional value of this plant is excellent and often higher than other legumes. Kura clover may also be more tolerant of drought than white clover or birdsfoot trefoil.

Many challenges facing Kura clover utilisation in North America have not been eliminated. Kura clover is slow to establish perhaps because of a wide below ground to above ground biomass ratio and the requirement of species specific rhizobia. In the first few years of growth, Kura clover expends most of its energy producing roots and rhizomes to the detriment of its ability to capture sunlight aboveground. Although it is not know for certain, Kura clover's ability to spread may also create ecological problems should it escape cultivation. Nitrogen fixation by Kura clover is equal or less than alfalfa. Seed production of the legume is also limited, but is increased by providing pollinators. Kura clover is inferior in dry matter yield to alfalfa in the first three years of the stand, but in older stands may outyield alfalfa. Making full use of this legume would require committing many years in crop rotations and accepting limited production during establishment. Kura clover has been described as a legume that is somewhat widely adapted to different growing conditions but with "limited agriculture potential" (Taylor, 2003). Until basic problems of establishment, seed production, dry matter yield and nitrogen fixation are solved, Kura clover will remain a legume that is promising.

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C. Objectives

The overall objective of this study was to evaluate the adaptation, yield and nutritive value of kura clover (*Trifolium ambiguum* Bieb.) in mixtures with spring or fall planted perennial grasses at two locations in Saskatchewan.

D. Methodology

<u>Locations</u>: The study was conducted at two locations: 1) The University of Saskatchewan Horticulture Research Farm in Saskatoon; and 2) The Canada-Saskatchewan Irrigated Crop Diversification Centre in Outlook. Site 1 was a clay loam soil that was not irrigated, while site 2 was a sandy loam soil that was irrigated. A trial was also seeded at the Seager Wheeler Farm in Rosthern, but this failed to establish.

<u>Treatments:</u>

Kura clovers cultivars (2); Rhizo, Endura

Perennial grass species/cultivars (5): Signal smooth bromegrass (*Bromus inermis* Leyss.), Paddock meadow bromegrass (*Bromus riparius* Rehm.), AC Knowles hybrid bromegrass (*B. riparius* X *B. inermis*), AC Parkland diploid crested wheatgrass (*Agropyron cristatum* L.), Kirk tetraploid crested wheatgrass (*A. cristatum*). Grasses were mixed with each of the two kura clover cultivars.

Seeding time of perennial grasses (2): Spring, late October (dormant).

Experiments and Design: Experiments were seeded in late-May of 2003 at Saskatoon and Outlook on summerfallow. Dormant seedings of perennial grasses were carried out on 18 November, 2003 at both locations. Trials were arranged in a modified factorial randomized complete block design with four replications. The clover cultivars were seeded in both pure stands and mixtures, while the grasses were only seeded in mixtures. For the October seeding, the grasses were seeded directly into the spring seeded plots of the clovers. Plot size was 1.2 X 6.0m. consisting of four rows seeded 30 cm apart. The seeding rate was 100 seeds per linear meter with 50 seeds of each species in the mixtures. Seeding depth was approximately 1.25 cm.

Plot management: Trials received 12 kg of N and 55 kg of P in the late fall in 2002, 2003 and 2004. No herbicides were applied during the course of the experiments although weeds were problematic, particularly in the establishment year. Hand weeding and clipping of plots was done to reduce weed competition in the establishment year. At Saskatoon, weeds were not a serious problem in the years following establishment. At Outlook, weeds such as foxtail barley and green foxtail were problems and these were hand weeded.

Data collected:

Dry matter yield: Trials were cut twice at each location in 2004 and 2005. The first cut was done during the third week of June when the kura clover was in full flower and the grasses were fully headed. The second cut was done between Aug 10 and 15 when the clover was again in full bloom. The entire plot was cut and weighed and a subsample taken which was dried and weighed to permit the calculation of dry matter yield.

Plant composition: Random samples from several areas in the plots were taken just prior to harvest. These were separated into component species and dried at 60° C and weighed. The percentage of kura clover in mixed plots was determined.

Forage nutritive value: The dried samples collected for plant composition were ground and analyzed for crude protein (CP), acid-detergent fiber (ADF) and neutral-detergent fiber (NDF). A Leco nitrogen analyzer was used for CP, and an Ankom fiber analyzer for NDF and ADF. Individual mixture components were analyzed and then a whole plot value calculated by using the percent of each component.

Statistical analysis: An analysis of variance (ANOVA) was carried out. Due to significant interactions involving locations and years, separate analyses were done and summarize over years and locations. When F tests were significant ($p<0.05$), least significant differences (LSD) were determined.

E. Results and Discussion

a. Dry matter yield:

Kura clover pure stands: As there were generally no significant differences in dry matter yield between the kura clover cultivars and there were no significant grass by clover cultivar interactions (Table 1), data for Endura and Cossack were combined. Thus neither cultivar was superior to the other in pure or mixed stands. Overall yields were 4.5 t/ha in 2004 and increased to 6.7 t/ha in 2005 (Table 2). Total seasonal yields were more consistent from year to year at Saskatoon, around 5 t/ha (Table 3). Pure stand yields were generally much lower than those for kura clover grass mixtures, when the grass was seeded at the same time as the kura clover in the spring. For comparison, mean yields of 2003 established pure alfalfa (*Medicago sativa* L.) trials conducted in the same years at these locations were 6.5 and 10.1 t/ha at Saskatoon and 14.4 and 11.1 t/ha at Outlook in 2004 and 2005. The hay yield potential of kura clover in Saskatchewan appears to be considerably lower than alfalfa. These results are similar to those previously found in the northern United States.

Effect of grass seeding date: Dry matter yields were considerably greater for mixtures in which the grass was seeded in the spring with the kura clover (Tables 2 and 3). The grasses established well in the spring, producing high yields in the year following seeding.

The fall (dormant) seeded grasses were slow to develop in the year following seeding and had to compete with the already established kura clover. Establishment of the dormant seeded grasses was more successful at Outlook, so yields of these mixtures improved markedly in 2005. This was not the case at Saskatoon, where grass establishment was poor.

Effect of perennial grass species: For mixtures established in the spring, at Outlook (Table 2) the overall yields were numerically highest for the Paddock meadow brome-kura clover mixture in both years. This mixture was significantly higher yielding than the Kirk crested wheatgrass-kura clover and AC Parkland-kura clover mixtures in 2004 and higher than the AC Knowles hybrid brome-kura clover mixtures in 2005. At Saskatoon (Table 3), the Signal smooth brome-kura clover mixture was significantly higher yielding than the Kirk-kura clover mixture in 2004, while there were no significant differences among the spring established mixtures in 2005.

For the mixtures where the grass was seeded in the fall, there were no differences among mixtures in either year at Saskatoon (Table 3). At Outlook, there were no differences in 2004, but in 2005, the Kirk-kura mixture was significantly lower yielding than the other mixtures (Table 2).

Over both sites and years, the smooth brome and meadow brome-kura mixtures were the highest yielding of the five mixtures in spring established stands (Table 4).

b. Percent kura clover:

Visual observations on the establishment of kura clover were made in each year of the trial (data not shown). Establishment was generally good in all treatments at Saskatoon, with the few gaps in the plots filled in by the spreading kura clover rhizomes by 2005. At Outlook, establishment of kura clover was poorer. However, by 2005, the kura clover had filled in many of the gaps in the plots by spreading rhizomes. Our observations matched findings in the literature which indicated that kura clover is slow establishing, but even a sparse population can greatly increase ground cover after a few years. The present study was carried out only over three years, thus it could not be determined whether the kura clover would eventually out complete the grass as has been reported in the literature for stands of ten years or older.

The percent kura clover in the stands at harvest was measured to assess the success of establishment and persistence in mixtures with grasses (Tables 2 and 3). There was usually a higher percentage of kura clover in the mixture at the second cut. The grasses produce high biomass in the spring growth, but regrow relatively slowly, resulting in the kura clover being a higher percentage of the forage in the second cut.

Effect of grass seeding date: At Outlook (Table 2), there was very little kura clover in the spring growth of the spring established mixtures in 2004 due to poor establishment and slow growth. Kura clover percentage increased in cut 2 of that year and at both cuts in 2005, indicating that the kura clover is filling in as the stand ages. There was a much higher percentage of kura clover in the stands of mixtures with dormant established grasses due to slow grass growth in 2004; however, kura clover percentages declined somewhat in 2005 as the grasses became better established and more vigorous.

At Saskatoon (Table 3), kura clover percentages were also very low for the spring established mixtures in cut 1 in 2004, but improved in cut 2 and at both cuts in the following year. For the dormant seeded grass mixtures, grass establishment was very poor at this location, with no grass present in either the first or second cut in 2004. There was more grass in the forage in 2005, but the kura clover still predominated.

The dormant seeded treatment was included in this study to assess the efficacy of allowing the kura clover to establish without competition in a spring seeding and then seed the grass directly into the kura clover. This did not work well under the non-irrigated conditions at Saskatoon, as little grass established. More grass became established from the dormant treatment at Outlook, as irrigation water was available in early May and the kura clover stands were not as thick as at Saskatoon. It appears that this method of establishing kura clover mixtures is risky on non-irrigated soils, as the result will often be close to a monoculture of kura clover. We have found similar poor establishment in trials of dormant seedings of other perennial grass species, including ryegrasses (*Lolium* spp.) and tall fescue (*Festuca arundinacea* Schreb.).

Effect of perennial grass species: At Outlook (Table 2), the Kirk-kura clover mixture had the highest or close to the highest percentage of clover for all cuts. This was particularly evident at cut 2, perhaps indicating the slower regrowth of this cultivar of crested wheatgrass. At Saskatoon the only significant difference among grass species in the spring seeding was that Signal-kura clover had a higher percent clover in cut 2 of 2004. However, the Signal and Paddock-kura clover mixtures usually had a lower percentage of clover than other mixtures.

For the mixtures in which the grass was dormant seeded, there were no clear trends in percent kura clover in the various species/varieties.

c. Crude protein concentrations

There were no significant differences in crude protein (CP) concentration between Cossack and Endura kura clover and there was no interaction between kura cultivar and grass species cultivar in mixtures (Table 1). Consequently, data for Endura and Cossack were combined (Tables 5 and 6). Thus, neither cultivar was superior to the other for CP in pure or mixed stands. CP of pure stands of kura clover ranged from 10.9 to 21.2 % at cut 1 and 11.1 to 16.4 % at cut 2. The reason for this high variation is unknown since date of harvest and maturity were similar from year to year at each location. The values at the low end of the range are quite low compared to those reported in the literature.

Effect of grass seeding date: CP was generally higher for mixtures in which the grass was seeded in the fall than those established in the spring. This was especially true for 2004 as stands were largely kura clover which was higher in CP than the grass. Differences were smaller or non existent between the two dates in 2005 since the grass plants were more developed and made up a greater portion of the forage.

Effect of grass species: Mixtures with a lower percentage of kura clover were usually also lower in CP. Thus, the Signal and Paddock mixtures generally had the lowest CP for the spring seeded mixtures and the crested wheatgrass mixture tended to be the highest in CP. For mixtures in which the grass was seeded in the fall, differences among mixtures in CP were generally smaller and often not significant.

d. Neutral-detergent fiber concentrations

There were significant kura clover by grass interactions at cut 1 in 2004 and cut 2 in 2005 at Outlook (Table 1). Consequently, data for NDF are reported individually for Cossack and Endura pure stands and mixtures (Tables 7 and 8). In pure stands of kura clover, NDF ranged from 20.9 to 37.9 at cut 1 and 22.5 to 33.6 at cut 2. Again, this wide variation is surprising given the similarities in harvest date and maturity.

Effect of grass seeding date: NDF was generally lower for mixtures in which the grass was seeded in the fall than those established in the spring. This was especially true for 2004 as stands were largely kura clover. Legume species are usually considerably lower in fiber than grasses due to higher leaf/stem ratios. This is especially true for NDF. Differences were smaller or non existent between the two dates in 2005 since the grass plants were more developed and made up a greater portion of the forage.

Effect of grass species: Mixtures with a lower percentage of kura clover would be expected to be higher in NDF. Thus, at Outlook, the Signal and Paddock mixtures generally had the highest NDF for the spring seeded mixtures and the crested wheatgrass mixtures tended to be the lowest in NDF. No clear trends were found at Saskatoon over the years and cuts. For mixtures in which the grass was seeded in the fall, differences among mixtures in NDF were generally smaller and rankings changed over years and cuts, so no clear trends were seen.

e. Acid-detergent fiber concentrations

There were significant kura clover by grass interactions at cut 1 in 2004 and cut 2 in 2005 at Outlook (Table 1). Consequently, data for ADF are reported individually for Cossack and Endura pure stands and mixtures (Tables 9 and 10). In pure stands of kura clover, ADF ranged from 15.8 to 20.5 at cut 1 and 17.3 to 23.5 at cut 2. This is a low concentration of ADF compared to other legumes such as alfalfa at comparable stages of growth.

Effect of grass seeding date: ADF was generally lower for mixtures in which the grass was seeded in the fall than for those established in the spring. This was especially true for 2004 as stands were largely kura clover. Legume species are usually considerably lower in fiber than grasses due to higher leaf/stem ratios. Differences were smaller or non existent between the two dates in 2005 since the grass plants were more developed and made up a greater portion of the forage.

Effect of grass species: Mixtures with a lower percentage of kura clover would be expected to be higher in ADF. Thus, at Outlook, the Signal and Paddock mixtures generally had the highest ADF for the spring seeded mixtures and the crested wheatgrass mixtures tended to be the lowest in ADF. There was also a trend for the brome mixtures to be highest in ADF at Saskatoon For mixtures in which the grass was seeded in the fall, rankings of ADF changed over years and cuts, so no clear trends were seen.

f. Potential weediness of kura clover:

This study has shown that kura clover is a winter hardy species that increases it ground cover as the stand ages. Given that it is a rhizomatous species, there is a possibility that kura clover could become a weed in subsequent crops on the same area of land. In the present experiment, the stands were sprayed with Glyphosate in the fall of 2005 and lightly cultivated. At Outlook, a crop of durum wheat was no-till planted on the land and the herbicides Refine XTRA and Puma Super used. Kura clover plants were seen in the field in late August 2006 following the harvest of the durum wheat (Photo 1 and 2). At Saskatoon, the test was sprayed with Glyphosate in the fall of 2005 and was fallowed in 2006, being cultivated several times. No kura clover plants were seen in the fall of 2006.

Based on our experience in this study, kura clover does show a tendency to persist in cropping systems with minimum tillage. It is known that *Trifolium* clovers are susceptible to 2,4-D, so application of this herbicide may present an effective way of eliminating kura clover.

Personnel

	PY	% from grant
Nadia Mori	0.33	100
Numa	0.25	100
Bin Xu	0.58	100
Sheng Li	1.58	100
Andrew Pantel	0.17	100
Zhaohui Wei	0.17	100
Dong Wang	0.08	100
Yu Rong Wu	0.08	100
Shaochang Li	0.08	100
Matthew Braun	0.17	100
Julie Bergen	0.08	100
Total	3.57	

Equipment

No equipment was purchased during this project.

Project Developed Materials

None developed during this project.

Project photos

Photo 1. Kura clover persisting one year after stand elimination following a crop of durum at Outlook. (attached file)

Photo 2. Kura clover persisting one year after stand elimination following a crop of durum at Outlook. (attached file)

Acknowledgement

No presentations were given, nor papers written, so there were no opportunities to acknowledge Saskatchewan's support for this research. It is anticipated that one or two scientific manuscripts will be submitted, and results will be written up in popular articles and/or presented at field days. Saskatchewan will be prominently acknowledged in all of this publications/presentations.

Table 1. F values from the ANOVAs carried out on data collected from pure stands and mixtures of kura clover
at Outlook and Saskatoon in 2004 and 2005.

NDF

	Outlook				Saskatoon			
	2004		2005		2004		2005	
Source of variation	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**
kura	0.0258	0.0734	0.9365	0.1209	0.0009	0.5615	0.1948	0.4168
grass	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
date	<.0001	<.0001	<.0001	0.0001	<.0001	<.0001	<.0001	<.0001
kura*grass	<.0001	0.8008	0.8773	0.0224	0.0774	0.0733	0.3790	0.3696
kura*date	0.1585	0.9278	0.3568	0.2319	0.3655	0.0082	0.9046	0.5952
grass*date	0.0048	0.1616	0.1807	0.2358	0.4981	0.4984	0.4996	0.7613
kura*grass*date	0.0002	0.4330	0.3887	0.1970	0.0409	0.3975	0.2402	0.6271

ADF

	Outlook				Saskatoon			
	2004		2005		2004		2005	
Source of variation	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**
kura	0.0563	0.1697	0.9025	0.0753	0.0491	0.0382	0.6139	0.3909
grass	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
date	<.0001	<.0001	<.0001	0.0009	<.0001	<.0001	<.0001	<.0001
kura*grass	0.0001	0.9253	0.9816	0.0094	0.3197	0.1111	0.4480	0.4322
kura*date	0.4462	0.9330	0.6443	0.4573	0.3173	0.0063	0.5971	0.2068
grass*date	0.0019	0.0986	0.2415	0.3210	0.4121	0.3959	0.7233	0.6795
kura*grass*date	0.0147	0.5431	0.7191	0.1684	0.1205	0.2637	0.5490	0.8949

Crude protein

	Outlook				Saskatoon			
	2004		2005		2004		2005	
Source of variation	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**	**Cut 1**	**Cut 2**
kura	0.3058	0.1424	0.1427	0.2468	0.0519	0.0896	0.6182	0.1856
grass	<.0001	<.0001	<.0001	0.0268	<.0001	0.0863	0.1521	0.7740
date	<.0001	<.0001	<.0001	0.0363	<.0001	0.0001	<.0001	0.0005
kura*grass	0.4834	0.2070	0.5673	0.1339	0.9947	0.7049	0.2504	0.4825
kura*date	0.0118	0.0151	0.7112	0.9418	0.2072	0.0290	0.7980	0.0308
grass*date	0.1872	0.3209	0.0007	0.5497	0.8902	0.3971	0.8784	0.0751
kura*grass*date	0.2657	0.2008	0.8355	0.9404	0.6426	0.9519	0.8413	0.5905

Dry matter yield

	Outlook		Saskatoon	
	2004	2005	2004	2005

Source of variation	Cut 1	Cut 2	Cut 1	Cut 2	Cut 1	Cut 2	Cut 1	Cut 2
kura	0.9263	0.6130	0.3666	0.3247	0.0218	0.6262	0.4266	0.4072
grass	0.0069	0.3756	0.0042	0.0811	<.0001	0.0011	<.0001	0.2093
date	<.0001	0.0110	<.0001	0.0802	<.0001	<.0001	<.0001	0.0294
kura*grass	0.8917	0.6284	0.6256	0.7651	0.7992	0.9746	0.3433	0.3055
kura*date	0.0826	0.5844	0.8611	0.6630	0.3272	0.6177	0.2275	0.0044
grass*date	0.1884	0.2116	0.1688	0.0504	0.0008	0.9798	0.8266	0.9095
kura*grass*date	0.9572	0.7011	0.9990	0.3523	0.7097	0.6238	0.7766	0.0704

Table 2. Dry matter yields (kg/ha) and % clover of kura clover mixtures and pure stands seeded at Outlook in 2003.

		2004					2005				
	Date of	Cut 1		Cut 2		Total	Cut 1		Cut 2		Total
Mixture	Seeding	% Clover	Yield	% Clover	Yield	Yield	% Clover	Yield	% Clover	Yield	Yield
Paddock + Clover	spring	0	6387	20	3306	9693	20	5666	35	3425	9091
Signal + Clover	spring	0	5915	37	3052	8967	10	5237	21	3224	8461
AC Knowles + Clover	spring	0	5211	27	3162	8373	17	3949	53	3091	7039
AC Parkland + Clover	spring	2	3422	29	4145	7567	28	3982	39	4219	8202
Kirk + Clover	spring	6	2927	67	4038	6965	28	4127	46	3784	7911
Clover	spring	100	1105	100	3428	4533	100	3033	100	3714	6747
AC Parkland + Clover	fall	62	1004	63	3135	4139	39	3608	52	4087	7694
AC Knowles + Clover	fall	75	993	82	3169	4162	51	2837	57	3971	6808
Kirk + Clover	fall	63	858	77	2824	3682	46	2430	73	3365	5795
Paddock + Clover	fall	82	600	88	3058	3658	30	3160	43	3828	6988
Signal + Clover	fall	83	590	78	2898	3488	43	3176	53	3835	7010
Mean		**43**	**2637**	**60**	**3292**	**5930**	**37**	**3746**	**52**	**3686**	**7432**
C.V.		**57**	**80**	**40**	**18**	**36**	**37**	**26**	**35**	**17**	**16**
LSD (.05)		**17**	**2065**	**24**	**582**	**2137**	**14**	**956**	**18**	**632**	**1182**

Table 3. Dry matter yields (kg/ha) and % clover of kura clover mixtures and pure stands seeded at Saskatoon in 2003.

		2004					2005				
	Date of	Cut 1		Cut 2		Total	Cut 1		Cut 2		Total
Mixture	Seeding	% Clover	Yield	% Clover	Yield	Yield	% Clover	Yield	% Clover	Yield	Yield
Signal+ Clover	spring	13	8942	63	4289	13231	18	9401	26	857	10258
Paddock + Clover	spring	0	7898	22	3716	11614	21	9307	29	982	10289
AC Knowles + Clover	spring	16	7094	31	3987	11081	27	9243	25	1229	10472
AC Parkland + Clover	spring	17	6470	28	4251	10721	27	8570	26	1251	9821
Kirk + Clover	spring	4	6295	43	4199	10494	33	7883	29	1252	9135
Clover	spring	100	3041	100	2346	5387	71	4279	92	831	5110

Signal+ Clover	fall	100	2585	100	2841	5426	70	4809	84	782	5591
Kirk + Clover	fall	100	2584	100	2711	5295	100	4166	88	963	5129
AC Parkland + Clover	fall	100	2414	100	2502	4916	72	4280	79	884	5164
AC Knowles + Clover	fall	100	2409	100	2557	4966	67	4151	79	957	5108
Paddock + Clover	fall	100	2252	100	2405	4657	66	4116	79	827	4943
Mean		**59**	**4726**	**70**	**3255**	**7981**	**52**	**6382**	**58**	**983**	**7365**
C.V.		**31**	**20**	**39**	**23**	**32**	**37**	**22**	**31**	**49**	**45**
LSD (.05)		**18**	**943**	**27**	**733**	**1610**	**18**	**1525**	**18**	**477**	**2880**

Table 4. Mean dry matter yields (kg/ha) of kura clover mixtures and pure stands over two sites and two years

Mixture	Date of Seeding	Yield
Signal + Clover	1	10229
Paddock + Clover	1	10172
AC Parkland + Clover	1	9078
AC Knowles + Clover	1	9241
Kirk + Clover	1	8626
AC Parkland + Clover	2	5478
Signal + Clover	2	5379
Clover		5444
AC Knowles + Clover	2	5261
Paddock + Clover	2	5062
Kirk + Clover	2	4975
Mean		**7177**
C.V.		**31**
LSD (.05)		**984**

Note: Site/years used as reps in the ANOVA

Table 5. Crude protein percentage (DM basis) of kura clover mixtures and pure stands seeded at Outlook in 2003.
Protein

Mixture	Date of Seeding	2004 Cut 1	2004 Cut 2	2005 Cut 1	2005 Cut 2
AC Parkland + Clover	2	18.5	12.3	12.7	13.1
Clover		18.3	16.4	15.9	11.1
Kirk + Clover	2	16.9	12.8	15.1	13.2
AC Knowles + Clover	2	16.5	14.0	14.8	13.7
Paddock + Clover	2	16.5	13.6	11.5	12.1
Signal + Clover	2	16.2	13.6	13.8	13.2
Kirk + Clover	1	14.9	11.9	12.1	12.0
AC Parkland + Clover	1	13.7	11.3	13.3	11.5
AC Knowles + Clover	1	12.9	10.6	9.8	14.3
Signal + Clover	1	11.6	11.6	9.7	11.6
Paddock + Clover	1	10.4	10.8	10.1	11.0
Mean		**15.1**	**12.6**	**12.6**	**12.4**
C.V.		**15.0**	**16.0**	**14.0**	**17.0**
LSD (.05)		**2.3**	**2.0**	**1.8**	**2.1**

Table 6. Crude protein percentage (DM basis) of kura clover mixtures and pure stands seeded at Saskatoon in 2003.

Mixture	Date of Seeding	2004 Cut 1	2004 Cut 2	2005 Cut 1	2005 Cut 2
AC Parkland + Clover	2	22.7	15.0	13.3	14.2
Signal + Clover	2	21.6	16.0	13.2	13.5
Clover		21.2	14.1	10.9	13.0
Paddock + Clover	2	21.0	14.0	12.8	13.9
AC Knowles + Clover	2	20.8	15.6	14.6	13.7
Kirk + Clover	2	20.8	15.0	15.3	14.8
AC Parkland + Clover	1	16.3	10.7	10.8	11.4
Kirk + Clover	1	15.2	11.2	11.8	12.0
AC Knowles + Clover	1	14.9	14.5	10.2	13.3
Signal + Clover	1	14.9	13.5	9.7	13.6
Paddock + Clover	1	13.7	12.6	9.1	12.2
Mean		**18.5**	**13.8**	**12.0**	**13.2**
C.V.		**11.0**	**15.0**	**20.0**	**11.0**

LSD (.05)	**1.9**	**2.1**	**2.4**	**1.6**

Table 7. Neutral-detergent fiber percentage (DM basis) of kura clover mixtures and pure stands seeded at Outlook in 2003.

Outlook		2004		2005	
Mixture	Date of Seeding	Cut 1	Cut 2	Cut 1	Cut 2
Cossack + Signal	1	62.5	54.6	54.5	47.3
Endura + Signal	1	62.0	52.9	56.0	47.8
Cossack + Paddock	1	60.1	52.3	52.9	46.1
Endura + AC Knowles	1	59.7	55.0	46.6	34.5
Endura + Paddock	1	59.5	52.6	49.9	45.5
Endura + Kirk	1	58.8	50.0	49.0	41.8
Cossack + AC Knowles	1	57.2	46.4	53.0	43.8
Endura + AC Parkland	1	57.0	50.5	50.6	45.5
Cossack + AC Parkland	1	56.0	49.6	48.4	42.6
Cossack + Kirk	1	54.6	45.4	47.7	41.0
Endura + Kirk	2	47.3	38.9	41.3	35.9
Endura + AC Knowles	2	43.5	35.1	41.5	34.5
Endura + AC Parkland	2	38.7	45.6	46.6	42.8
Cossack + Signal	2	36.9	37.1	44.2	40.8
Cossack + Paddock	2	32.9	33.3	45.9	42.8
Cossack + AC Knowles	2	29.5	36.3	37.5	36.2
Cossack + AC Parkland	2	27.1	38.6	43.2	36.6
Cossack + Kirk	2	25.0	34.3	40.5	32.6
Cossack		24.3	30.9	37.9	30.7
Endura + Paddock	2	23.6	37.0	47.8	42.5
Endura		23.4	31.5	32.4	33.6
Endura + Signal	2	22.6	36.9	41.2	36.1
Mean		**43.7**	**42.9**	**45.8**	**40.3**
C.V.		**11.6**	**14.2**	**12.3**	**13.9**
LSD (.05)		**7.0**	**8.6**	**8.0**	**7.9**

Table 8. Neutral-detergent fiber percentage (DM basis) of kura clover mixtures and pure stands seeded at Saskatoon in 2003.

Saskatoon		2004		2005	
Mixture	Date of Seeding	Cut 1	Cut 2	Cut 1	Cut 2
Cossack + AC Parkland	1	63.1	48.9	48.9	44.3
Endura + Signal	1	62.6	54.3	54.3	41.9
Cossack + Signal	1	62.3	56.5	53.3	42.1

Endura + Kirk	1	62.1	53.8	48.1	45.5
Endura + Paddock	1	60.3	53.8	52.0	44.5
Cossack + Kirk	1	60.2	47.4	47.5	43.9
Cossack + AC Knowles	1	60.2	48.7	48.2	42.3
Cossack + Paddock	1	59.5	50.9	51.4	39.9
Endura + AC Knowles	1	58.6	51.4	52.7	45.0
Endura + AC Parkland	1	56.3	55.8	51.3	48.1
Cossack + Signal	2	28.0	28.9	29.9	28.5
Cossack + Kirk	2	27.7	28.4	30.3	31.6
Cossack		27.4	28.2	21.6	26.6
Cossack + AC Parkland	2	27.2	26.6	35.5	30.9
Cossack + AC Knowles	2	27.0	28.4	37.6	29.2
Cossack + Paddock	2	26.6	26.7	38.3	29.5
Endura + Paddock	2	26.1	28.3	38.4	30.8
Endura + Signal	2	25.7	26.2	43.5	31.9
Endura + AC Parkland	2	25.2	28.3	34.8	34.1
Endura		25.2	26.6	20.9	22.5
Endura + AC Knowles	2	24.8	24.9	38.4	33.5
Endura + Kirk	2	24.5	25.0	26.9	25.0
Mean		**41.8**	**38.5**	**41.3**	**36.0**
C.V.		**5.0**	**9.5**	**13.6**	**15.0**
LSD (.05)		**2.9**	**5.2**	**3.9**	**7.7**

Table 9. Acid-detergent fiber percentage (DM basis) of kura clover mixtures and pure stands seeded at Outlook in 2003.

Outlook		2004		2005	
Mixture	Date of Estab.	Cut 1	Cut 2	Cut 1	Cut 2
Cossack + Signal	1	35.4	30.7	31.2	26.7
Endura + Signal	1	34.8	30.4	32.2	27.2
Cossack + Paddock	1	33.5	31.4	31.3	27.8
Endura + AC Knowles	1	33.4	31.3	29.1	22.1
Endura + Paddock	1	33.0	31.7	29.7	26.1
Endura + Kirk	1	32.0	29.1	28.5	25.0
Cossack + AC Knowles	1	31.0	28.4	30.1	25.4
Endura + AC Parkland	1	30.7	28.7	28.9	25.9
Cossack + Kirk	1	30.6	27.7	28.0	24.5
Cossack + AC Parkland	1	29.4	29.4	28.2	25.7
Endura + Kirk	2	25.4	24.4	24.4	22.4
Endura + AC Knowles	2	25.2	24.3	24.4	25.2
Cossack + Signal	2	22.6	25.7	26.2	24.8
Endura + AC Parkland	2	22.5	27.5	26.7	24.8
Cossack + Paddock	2	20.1	23.4	27.2	26.1
Cossack + AC Knowles	2	19.3	24.6	23.4	22.8
Cossack + AC Parkland	2	18.4	25.8	25.4	22.9
Cossack + Kirk	2	17.7	23.7	24.2	24.8
Cossack		17.5	22.4	18.7	21.8
Endura + Paddock	2	17.3	25.2	28.7	26.1
Endura		17.1	23.5	15.9	21.9
Endura + Signal	2	16.5	25.0	25.0	22.2
Mean		**25.6**	**27.0**	**26.7**	**24.6**
C.V.		**9.4**	**9.1**	**11.9**	**9.0**
LSD (.05)		**3.4**	**8.6**	**4.5**	**3.1**

Table 10. Acid-detergent fiber percentage (DM basis) of kura clover mixtures and pure stands seeded at Saskatoon in 2003.

Saskatoon	2004	2005

Mixture	Date of Estab.	Cut 1	Cut 2	Cut 1	Cut 2
Cossack + Signal	1	35.3	32.2	30.9	24.2
Endura + Signal	1	35.3	29.8	31.8	24.2
Endura + Kirk	1	35.2	30.3	27.9	25.2
Cossack + AC Parkland	1	34.7	27.9	28.2	23.8
Cossack + Kirk	1	34.1	28.7	28.7	24.6
Endura + Paddock	1	34.0	30.8	30.0	25.3
Endura + AC Knowles	1	33.5	28.9	31.3	25.4
Cossack + AC Knowles	1	33.3	28.7	28.3	24.8
Cossack + Paddock	1	33.3	30.4	30.4	24.7
Endura + AC Parkland	1	31.6	30.9	29.1	25.3
Cossack + Signal	2	21.1	21.3	22.1	21.0
Cossack + Kirk	2	20.6	21.3	22.2	21.3
Cossack + AC Knowles	2	20.5	21.6	24.5	21.3
Cossack		20.5	21.3	15.8	20.0
Endura + Paddock	2	20.5	20.2	24.5	20.5
Cossack + AC Parkland	2	20.2	21.3	24.1	21.9
Endura + Signal	2	19.9	19.2	26.3	20.6
Cossack + Paddock	2	19.7	20.1	25.4	20.8
Endura + AC Parkland	2	19.6	20.2	22.8	22.1
Endura		19.4	19.6	16.0	17.3
Endura + Kirk	2	18.8	19.1	19.8	18.4
Endura + AC Knowles	2	18.7	18.7	24.4	21.1
Mean		**26.3**	**24.6**	**25.7**	**22.5**
C.V.		**5.5**	**7.4**	**10.5**	**11.1**
LSD (.05)		**2.0**	**2.6**	**3.9**	**3.5**