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Establishment of Kura and Red Clover on a Soil and Mine Spoil

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ESTABLISHMENT OF KURA AND RED CLOVER ON SOIL AND MINE SPOIL

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Numerous benefits result from the addition of forage legumes to livestock diets. Superior nutritive value and intake of legume forage generally increase individual animal productivity compared with grass alone. This is particularly important with tall fescue where dilution of the diet with legumes can partially alleviate toxicosis associated with endophyte fungus infected fescue (Acremonium coenophialum). Unfortunately, short-term persistence of most legumes requires periodic reestablishment, adding to the cost of forage production and complicating pasture management.

Perennial legumes are beneficial to soil development and the revegetation of reclaimed surface mined lands (Ditsch and Collins, 1996). After surface mining, there is little or no organic matter in the soil and symbiotic nitrogen (N_2) fixation by legumes can provide the N to initiate the N cycle. Persistent legumes could increase the overall level of plant available soil N during reclamation as well as improving forage yield and quality where the designated post-mine land use is pasture/hayland or wildlife habitat.

Kura clover (Trifolium ambiguum Bieb.) is a long-lived perennial legume introduced from the Caucasian Region of Russia. Kura clover closely resembles white clover but spreads vegetatively by rhizomes (horizontal underground stems). Kura's persistence is due primarily to it's ability to spread over substantial distances by way of rhizome growth. Researchers have reported kura clover survival after 5 years to be greater than white clover, red clover and alsike clover (Trifolium hybridum L.) In 9-yr-old stands, kura clover plants had spread an average of 23 inches, with the greatest spreading occurring in pastures subjected to higher stocking rates (Allan and Keoghan, 1994).

Low seedling vigor has been identified as a limitation to successful establishment of kura clover (Taylor and Henry, 1989; Caradus, 1994; Ehlke et al., 1994). Failure to effectively inoculate kura clover seed or use of less effective strains of rhizobia may contribute to the observed low seedling vigor of kura clover (Strachan et al., 1994). When inoculant rate was increased to five times the recommended rate, the percentage of kura clover seedlings nodulated increased from less than 10% to more than 60%. Seedling density increased from less than 0.5 plants/ft^2 to more than 2.8 plants/ft^2.

Objectives of this study were to compare seedling growth and stand development characteristics of kura clover with those of red clover on soil and mine spoil and to assess the potential for improvement of kura clover establishment by commercial seed treatments.

MATERIALS AND METHODS

Plot studies were established on a Maury silt loam (Typic hapludult) soil on the Spindletop Research Farm near Lexington, KY and on a coal mine spoil site in the Appalachian coal fields of eastern Kentucky, near Quicksand. The Maury soil had a pH of 6.2, > 200 lbs/acre available P and 281 lbs/acre of exchangable K and received no fertilization during the term of this experiment. Mine spoil material was a mixture of sandstone and shale with a pH of 7.9 and Mehlich III extractable P level of 7 lbs/acre and more than 500 lbs/acre of exchangeable K. This site received 158 lbs/acre P_2O_5 at the time of seeding.

Treatments consisted of Kura clover seed uncoated, coated, or coated plus fungicide and red clover. Seed of 'Rhizo' kura clover was obtained from the U.S.D.A. Natural Resource and Conservation Service, Plant Materials Center in Quicksand, KY. Uncoated kura clover (K) was inoculated with the appropriate strain of Rhizobium (LiphaTech Inc., Milwakee, WI) and refrigerated for 3 days prior to seeding. Portions of the same seed lot were coated with a commerial seed treatment (Rhozo-Kote, Celpril, Manteca, CA) (KC) and the same coating material plus a fungicide, metalaxyl (N-(2,6-Dimethylphenyl)-N-(methoxyacetyl)-alanine methyl ester (KCF). Both coating treatments included the peat based Rhizobium inoculum at a rate of 0.4% w/w. Germination averaged 79, 75 and 76% for uncoated, coated and coated kura clover plus fungicide, respectively, with not more than 5% hard seed. 'Kenstar' red clover had a germination of 95%.

Plots measured 2.6 x 18 ft on the Maury soil site and 5 x 20 ft on the mine site. Each treatment was replicated 6 times on the Maury soil and 4 times on the mine site, in a randomized complete block design. Uncoated kura clover (K) was seeded at a rate of 12 lbs/acre using a small plot drill with a 6 inch row spacing. Seeding rates of KC and KCF seed were increased 1.34 and 1.44 times that of uncoated seed to account for the weight of coating materials.

Mine spoil plots were seeded on 29 April 1994 into a seedbed prepared by using a rotary tine tiller. An earlier seeding on 19 April 1994 on the Maury soil failed due to a series of heary rain events during a 2 week period after seeding, and a second seeding on the Maury soil was made on 24 May 1994. No herbicides were used on the mine site. Methyl bromide (bromomethane) was used over the Maury soil plot area. Red clover shoot growth was removed twice during 1994 by clipping at a 2.5 inch stubble height. Kura clover plots were also clipped but little biomass was removed. Shoot growth was left unclipped on the mine spoil plots in accordance with typical management on such sites.

Seedling density was determined by counting the number of live seedlings in two randomly selected 1 meter (39 inches) lengths of row in each plot. Shoot mass was determined by cutting 10-15 consecutive plants at the soil surface from a randomly selected starting point in each plot. Final stand density determinations and seedling mass samples were collected on 4 and 5 May

1995 from the Maury soil and mine spoil sites, respectively. At the same time, ten whole plants were collected from each plot by digging to a depth of 12 inches. After washing, each plant was separated into below-ground components, which included the root and rhizomes, crown and shoot components. Each sample was dried at 140° F for 72 hr before weighing. Daughter plants (new plants initiated by the original seedling) were counted, removed, separated into shoot, crown and root components, and dried as described above. Grazing damage by wildlife precluded sampling on the mine spoil site.

Location effects were considered fixed and sampling date effects were analyzed as repeated measures (SAS, 1985). Contrasts and multiple comparison test were used to compare coated and uncoated kura clover (K vs. KC) and to compare red clover and kura clover.

RESULTS AND DISCUSSION

Weather Conditions

Precipitation during 1994 was generally below long-term mean levels at both locations, with deficits during 6 of the 8 months between May and December at both locations. July precipitation was 2.4 and 1.6 inches below the long-term mean on the soil and mine sites, respecitively. Mean monthly air temperatures during fall and winter following seeding at the mine site were 3.1 to 10.1° F above normal after being near normal through September. Mean monthly temperatures averaged 3.1° F below normal during Aug. and Sept. on the soil site but were also generally above normal otherwise.

Stand Density

Red clover consistently had greater stand densities than kura clover at both location. (Fig. 1). Maximum red clover stand densities near 18 plants per ft of row at both sites occured within the first and second sampling dates. Maximum kura clover stand densities also occured within the first two sampling dates (2-3 weeks after planting) and ranged between 8 and 11 plants per ft of row at the Maury soil and mine site, respectively. The stand density of 18 red clover seedling per ft of row represents emergence of slightly more the one-half (53%) of the live seeds, based on a 12 lbs/ac seeding rate and 95% germination. At 77% germination and the same seeding rate, a kura clover stand density of 11 plants per ft of row represents only 33% of the live seeds. This difference suggest that low emergence may contribute to delayed or inadequate establishment of kura clover compared with red clover.

By August of the seeding year, red clover stand densities on the Maury soil site had declined sharply to about one-third of peak densities, compared to only a 26% decline on the mine site. Differences in stand reduction between the two sites is likely due to greater competition imposed by the much larger red clover seedlings present on the Maury soil site.

Except for greater seedling stand densities recorded for KCF than for K in August of the seeding year on the mine site, seed coating had no effect on kura clover stand density (Fig. 1). Across coating treatments, an average of 2.8 kura clover seedlings per ft of row were present at the mine site on the last sampling date in the year of seeding. Measured 1 yr after seeding on mine spoil, uncoated kura clover averaged 1.2 plants per ft of row compared to 6.2 plants per ft of row for red clover (Fig. 1). After the same time period on the Maury soil site, uncoated kura clover had 3.1 plants per ft of row compared with 8.3 plants per ft of row for red clover.

Yield Components

Red clover shoot mass, measured in June and August of the seeding year, was significantly greater than that of kura clover at both locations (Table 1). In June, red clover on the Maury soil site averaged 13.6 times more shoot mass that kura clover. On the same date, red clover on the mine site had 4.1 times more shoot mass per seedling than kura clover. Due at least in part to summer moisture stress on the mine site, kura clover shoot mass increased from 6.6 mg per plant in June to 10.9 mg per plant in August. During approximately the same interval at the Maury soil site, kura clover shoot mass increased from 8.9 to 222 mg per plant. Seed coating treatment had no effect on kura clover seedling mass measured the year of seeding.

One year after seeding, kura clover treatments on the Maury soil site had greater total- seedling, crown, shoot and root/rhizome masses than those on the mine site (Fig. 2). Although red clover from the Maury soil site also tended to have greater component and total plant masses than that from the mine site, the difference was much less than for kura clover. One-year-old red clover seedlings on the Maury soil site were 1.8 times heavier than those from mine spoil, but kura clover plants were nearly 16 times heavier on the soil site.

Slow stand development may also be related to the tendency of kura clover to partition photosynthate preferentially to root and rhizome tissues compared with other legumes (Strachan et al., 1994). We found that 1-year-old kura clover on the mine site contained 49 to 58% of its total mass below ground compared with only 28% below ground for red clover from the same site. Both species had lower proportions of their total mass below ground on the Maury soil site than on the mine site (Table 2).

Two-year-old kura clover parent plants on the Maury soil site averaged 2.4, 1.1 and 2.9 g per plant for shoot, crown and root tissue, respectively (Fig. 3). No coating or fungicide effects were found for kura clover plant component weights measured 2-yr after seeding. Red clover was omitted from this sampling due to thin stands. On average, 8.9 daughter plants had been initiated on each parent plant, each with an average of 0.37 g of shoot mass. The small mass of root tissue found on daughter plants suggests that the parent plants may still play an important role in daughter plant survival.

Rhizome Number and Size

Moorhead et al. (1994) measured rapid kura clover rhizome growth on an acid, low-P soil using a strip tillage planting method. Within 5 months after seeding, 75% of kura clover plants had rhizomes averaging 0.82 inches in length. In the our study, two-year-old kura clover plants had an average of 12.5 rhizomes per plant with average lengths of 6 inches per rhizome (Fig. 3).

Conclusion

Kura clover dry matter production during the seeding year was much less than red clover at both locations. However, red clover seedling density declined more rapidly than kura clover at both locations during this same period suggesting greater kura clover persistence. These data also indicate that low kura clover dry matter yields, compared to red clover, may be related to greater below ground growth, particularly on mine spoil where frequent periods of moisture stress are common. In general, seed coatings had no effect on growth and persistence of kura clover at both locations.

Greater kura clover persistence along with the potential for higher dry matter production over time, compared to red clover, are encouraging results, particularly for use on reclaimed surface mined land. However, more research is needed to identify management strategies that increase the rate of establishment and seed mixtures that are compatible to the slow development of kurá clover.

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Table 1. Shoot dry weight of kura and red clover seedlings sampled during the year of seeding.

Location	Seed coating/species	June	August
		....mg/seedling....	
Mine Spoil	Kura (K)	8.0 b[†]	9.2 b
	Kura-coated (KC)	6.7 b	13.8 b
	Kura-coated + fungicide (KCF)	5.2 b	9.7 b
	Red clover (RC)	27.1 a	83.2 a
Maury silt loam soil	Kura	12.7 b	249 b
	Kura-coated	5.6 b	143 b
	Kura-coated + fungicide	8.5 b	273 b
	Red clover	121.3 a	1901 a

[†]Means within a column and location followed by the same letter are not significantly different at the 0.05 level based on the LSD test.

Table 2. Plant component yields of kura and red clover one year after seeding.

Location	Treatment	Plant Component			
		Shoot	Crown	Root	Total
		...............% of Total...............			lbs/ac
Mine Spoil	Kura (K)	26.3 b†	15.9 b‡	57.8 b‡	107.4 b‡
	Kura-coated (KC)	30.3 b	13.6 b	56.2 b	130.4 b
	Kura-coated + fungicide (KCF)	34.7 b	16.1 b	49.2 b	137.5 b
	Red clover (RC)	45.4 a	26.4 a	28.3 a	2368.2 a
Maury silt loam soil	Kura	42.2 b	22.2 a	35.5 a	3805.9 b
	Kura-coated	42.5 c	21.3 b	36.2 bc	2008.4 c
	Kura-coated + fungicide (KCF)	44.3 c	21.1 b	34.6 c	1914.6 c
	Red clover (RC)	56.4 a	20.6 a	23.0 ab	5499.1 a

†Means within a column followed by the same letter are not significantly different at the 0.05 level based on the LSD test.
‡ Means within a column and location, followed by the same letter, are not significantly different at the 0.05 level based on the LSD test.

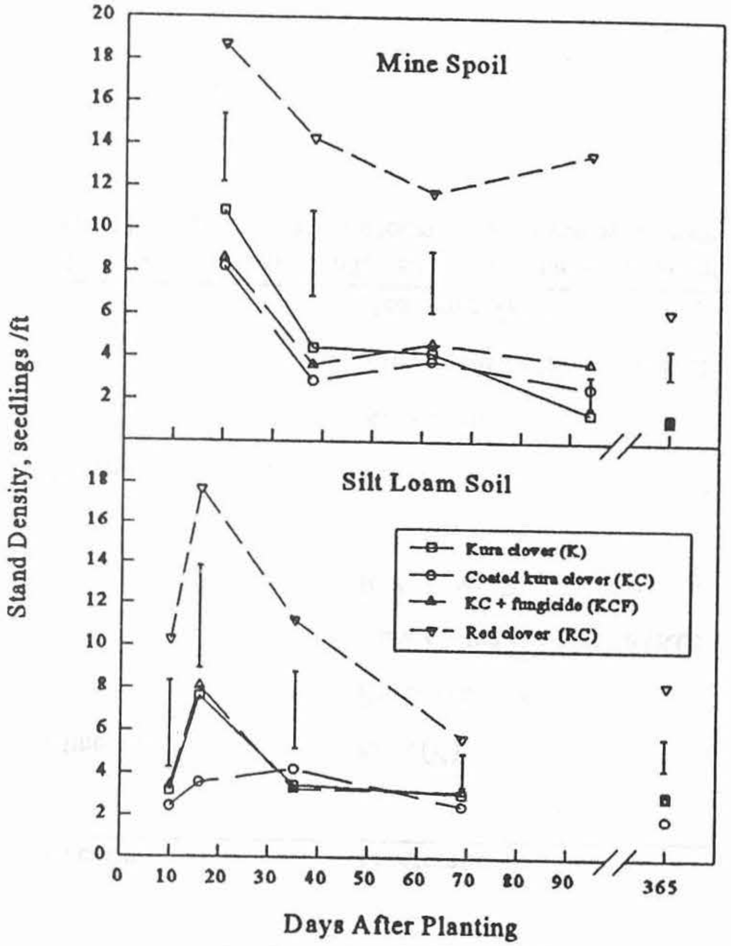

Figure 1. Stand density of spring seeded kura and red clover on mine spoil and silt loam soil. Vertical bars represent LSD values for comparison of means within a given location and date.

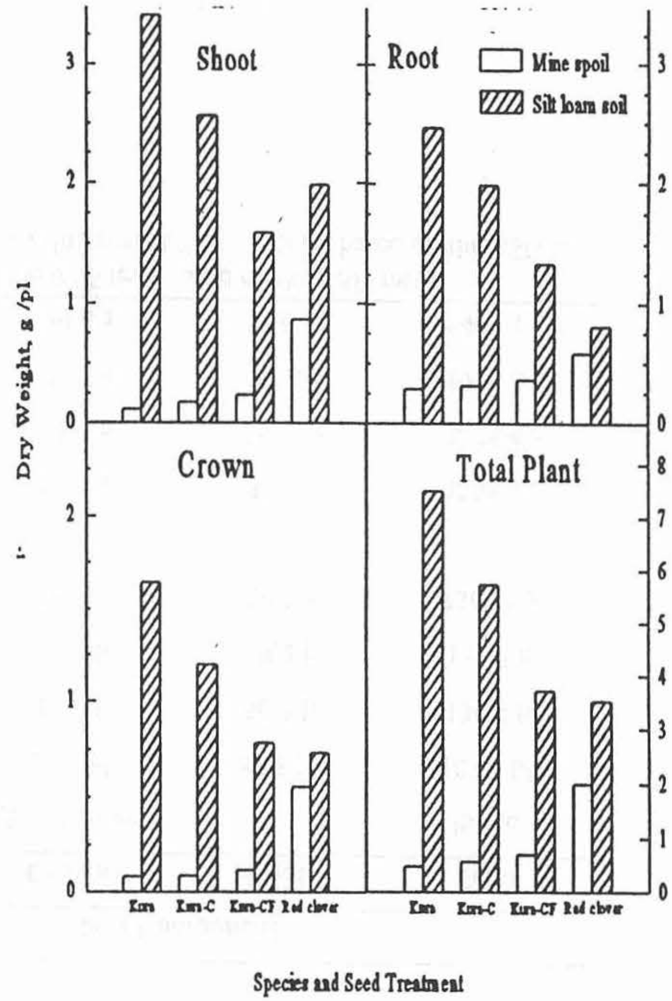

Figure 2. Plant component weights of kura and red clover one year after seed on surface mine spoil or silt loam soil.

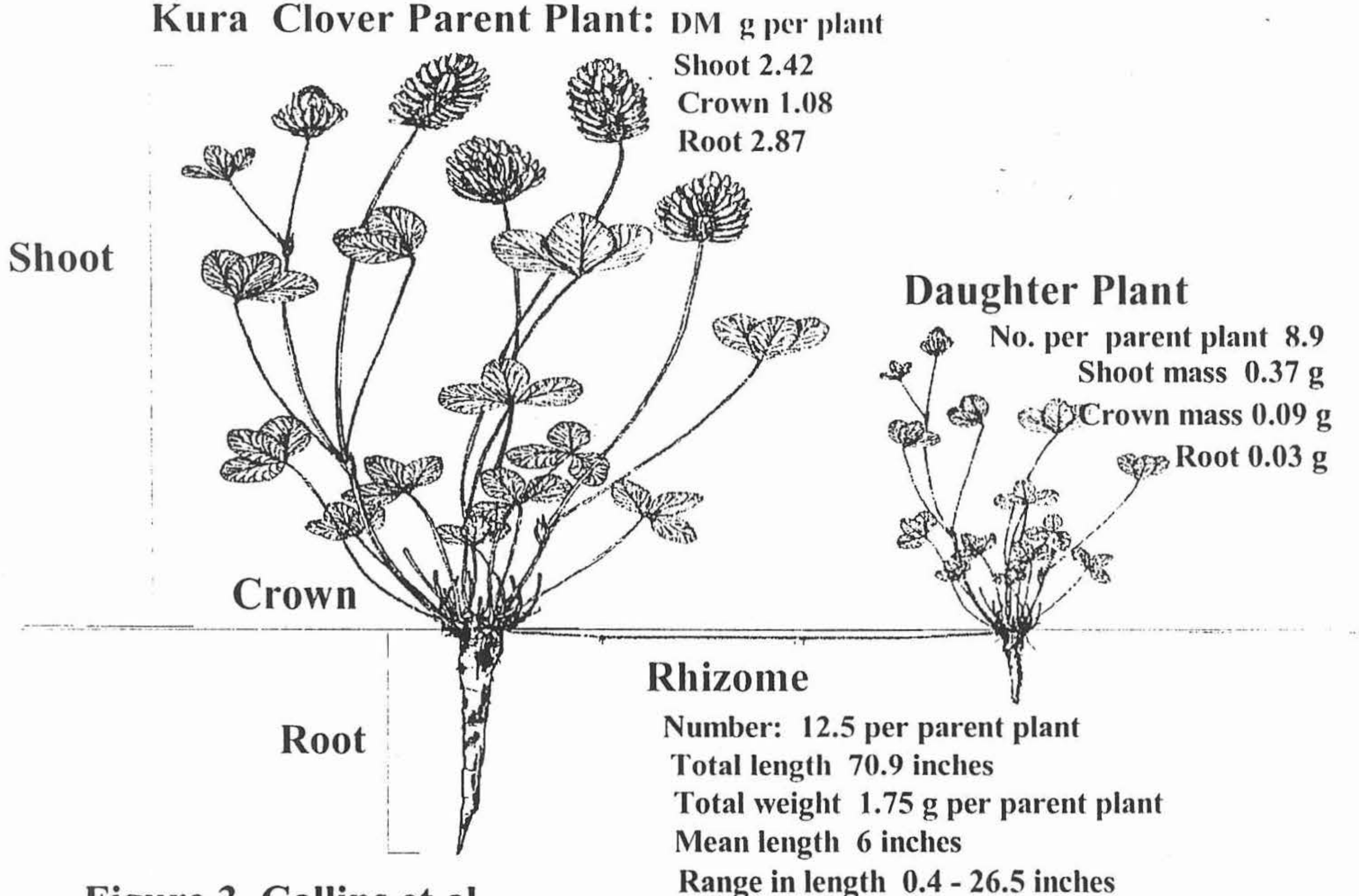

Figure 3. Collins et al.

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