VARIABILITY FOR BIOMASS PRODUCTION AND PLANT COMPOSITION
IN SERICEA LESPEDEZA GERMPLASM

Final Report on a Field and Laboratory Research Program
for the Period September 30, 1990, to December 31, 1991.

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May 1993

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under

Subcontract 19X-SG301V

Research supported by
Biofuels Systems Division
Office of Transportation Technologies
Activity No. EB 24 13 01 0

Prepared for

Biofuels Feedstock Development Program
Environmental Sciences Division
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
Managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U. S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-84OR21400

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TABLE OF CONTENTS

LIST OF TABLES	v
LIST OF FIGURES	vii
ABSTRACT	ix
INTRODUCTION	1
MATERIAL AND METHODS	3
RESULTS AND DISCUSSION	3
LITERATURE CITED	21
APPENDIX	22

LIST OF TABLES

Table 1. Biomass yield of 81 sericea lespedeza genotypes in the year of establishment (1986) and subsequent years.	5
Table 2. Mean, standard deviation, minimum, and maximum biomass yield (Mg ha^{-1}) obtained from 81 sericea lespedeza genotypes.	8
Table 3. Biomass yield and crude protein, NDF (neutral detergent fiber), ADF (acid detergent fiber), lignin, hemicellulose, cellulose, and holocellulose content of the 16 highest yielding sericea lespedeza genotypes.	10
Table 4. Pearson correlation coefficient among quality traits . . .	19
Table 5. Genetic variance and broad sense heritability of crude protein, NDF, ADF, hemicellulose, lignin, cellulose, and holocellulose (sum of hemicellulose and cellulose) content in the biomass of 81 sericea lespedeza genotypes.	19

LIST OF FIGURES

Fig. 1. Mean biomass yield of 81 genotypes and yield of three selected genotypes.	9
Fig. 2. Distribution of sericea lespedeza genotypes for ADF, NDF, and crude protein.	16
Fig. 3. Distribution of sericea lespedeza genotypes for lignin, cellulose, hemicellulose, and holocellulose.	17

ABSTRACT

Mosjidis, J.A. 1993. Variability for Biomass Production and Plant Composition in *Sericea Lespedeza* Germplasm. Final Report on a Field and Laboratory Research Program for the Period September 30, 1990, to December 31, 1991. ORNL/Sub/19X-SG301V. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Sericea lespedeza [*Lespedeza cuneata* (Dumont de Courset) G. Don.] is a deep-rooted legume that can be established successfully on eroded and depleted croplands. It is tolerant of drought, high levels of aluminum, and low soil fertility; environmental conditions found throughout the southeastern region of the USA. *Sericea lespedeza* is capable of improving soil by increasing its organic matter and nitrogen content rapidly. A field with a four year stand of *sericea lespedeza* grown for soil conservation or biomass production may have over 7 Mg ha⁻¹ of residues on the surface. Once established, *sericea lespedeza* maintenance costs are relatively small compared to other plants. While most herbaceous plants require nitrogen fertilization, *sericea lespedeza* fixes its own. Compared to most other crops, relatively few diseases and insect problems are associated with *sericea lespedeza*. A field experiment aimed at measuring biomass yield of 81 genotypes of *sericea lespedeza* over time and variation in biomass composition was conducted. Results indicated substantial differences for biomass yield among *sericea lespedeza* genotypes. However, dry matter percentage was the same. Genotype R194-79-290-9 had the highest mean biomass yield and, consistently, ranked among the top four during the years that this study was conducted. Other genotypes that also had a good performance over the four years are the cultivar Serala and the breeding line 75-2-3. These results suggest that *sericea lespedeza* genotypes with a consistently high biomass yield can be selected. No significant differences were found among genotypes for percentage of crude protein content. Crude protein contents were found to be substantially lower (about 25%) than those previously reported by other researchers. There were significant differences among genotypes for neutral detergent fiber (NDF), hemicellulose, and holocellulose content. There were not significant differences among genotypes for acid detergent fiber (ADF), lignin and cellulose content. In short, there is variability for biomass yield and for some quality traits that are considered important for biofuel production. Thus, it is possible to select *sericea lespedeza* genotypes within the breeding lines tested that would be particularly adapted for some methods of biofuel production. Further testing of the best genotypes should be conducted at several locations to determine the genotype to be released for the specific purpose of biomass production. Screening of accessions from the Plant Introduction System should be conducted to determine their variability for lignin and crude protein content. If accessions with lower levels are found, recombination, using genetic procedures, could be carried out to obtain plants with reduced content of lignin and crude protein.

INTRODUCTION

Sericea lespedeza [*Lespedeza cuneata* (Dumont de Courset) G. Don.] is a deep-rooted legume that can be established successfully on eroded and depleted croplands, provided that its seedbed preparation and seedling requirements are met. *Sericea lespedeza* is tolerant of drought, high levels of aluminum (Al), and low soil fertility. Thus, it is well adapted to the acid, eroded soils found throughout the southeastern region of the USA. The badly eroded soils of this region are very deficient in organic matter. *Sericea lespedeza* is capable of improving soil by rapidly increasing its organic matter and nitrogen content. In good stands, *sericea lespedeza* sheds the lower leaves during the growing season to form a protective mat on the soil surface. This leaf litter decomposes to form a valuable source of organic matter. A field with a four year stand of *sericea lespedeza* grown for soil conservation or biomass production may have over 7 Mg ha⁻¹ of residues on the surface (Kalburtji and Mosjidis, 1991, personal communication).

Once established, *sericea lespedeza* costs are relatively small compared to other plants. While most herbaceous plants require nitrogen fertilization, *sericea lespedeza* fixes its own. Compared to most other crops, relatively few diseases and insect problems are associated with *sericea lespedeza*.

Sericea lespedeza has been used as a forage crop for grazing or hay, or as a soil conservation plant. It is one of the most commonly used species for plantings made on strip mine spoils, roadbanks, and other disturbed or eroding areas. Recent reports (Bransby et al., 1989) indicate that *sericea lespedeza* could be grown for the production of ligno-

cellulosic biomass. In those tests, sericea lespedeza was harvested as a hay crop. Ansley (1960) reported that maximum biomass yield of this crop is obtained when it is cut only once during the growing season.

Biomass production of sericea lespedeza has been studied in only a few cultivars. Work conducted at Auburn University (J.A. Mosjidis, 1990, unpublished data) indicated a substantial variability for biomass production among sericea genotypes. Sericea lespedeza has the advantage over other herbaceous species that biomass can remain in the field during a good part of the winter, i.e., it does not require storage facilities.

Conversion of plant biomass to biofuels depends on the conversion process as well as on the composition of the feedstock. Composition of sericea lespedeza biomass has been reported for plants that have been managed for forage production. A study of the composition of sericea lespedeza biomass cut only one time late in the season was conducted because it can provide us with more realistic information from the standpoint of synthetic fuel production. For example, nitrogen content is known to decline as plant tissue matures. Conversely, ligno-cellulosic compounds increase as plant matures. Furthermore, plant composition can have a strong genetic component. Different genotypes may have different composition.

The objectives of this research were to determine the variability for single-harvest biomass production and plant composition among 81 entries of sericea lespedeza.

MATERIAL AND METHODS

A collection of 81 entries of sericea lespedeza were planted in a randomized complete block design with three replications at Tallassee, Alabama, in May 1986. This experiment was located on a Bassfield loamy fine sand (coarse-loamy, siliceous, thermic, Typic Hapludults) soil. The plots were single rows 7.6 m long, planted 0.91 m apart. The year of establishment and subsequent years, sericea lespedeza plants were cut only once at the end of the growing season (October). Seedling height has been found to be closely correlated to seedling dry wt. in sericea lespedeza (Qiu and Mosjidis, 1991, personal communication), thus, plant height was measured in three places in the plot before cutting in 1986 and 1990. Total biomass yield and percentage of dry matter were measured in 1986, 1988, 1989, and 1990. In 1990, biomass sample were taken, dried at 60 C for 48 h, ground to pass a 1 mm screen, and analyzed for nitrogen content with a LECO combustion analyzer, neutral detergent fiber (NDF), acid detergent fiber (ADF), and permanganate lignin using the methods described by Goering and Van Soest (1970). Hemicellulose content was estimated by the difference between NDF and ADF.

RESULTS AND DISCUSSION

Analysis of variance on the combined data for biomass yield of four years (1986, 1988, 1989, and 1990) indicated a significant genotype-environment interaction. Biomass yield per genotypes for years 1986, 1988, 1989, 1990, and their mean yield are presented in Table 1. Yields during the year of establishment (1986) were expected to be low compared to yields of mature plants. Genotype R194-79-290-9 had the highest mean yield

and, consistently, ranked among the top four throughout the years in which this experiment was conducted. Other genotypes that also had a good performance over the four years are the cultivar Serala and the breeding line 75-2-3. Although these results give precise information on genotype performance at Tallassee, it is not possible to decide which of the best 16 genotypes (top 20%) is the best for Alabama or the southeast region because this study was conducted in only one location. However, it is clear that it is possible to select genotypes of *sericea lespedeza* with a consistently high biomass yield.

Mean biomass yield of the 81 *sericea lespedeza* genotypes showed a steady decline from 1988 to 1990 (Table 2). However, a closer look at some statistics on the yield data shows that there was a decline in the higher yields whereas the lower yields remained constant in 1989 and 1990. Factors that are likely to have had an influence on the observed yield decline are a reduction in plant stand and in plant height that were observed over the years. Although biomass yield of all genotypes declined over time, there were differences among genotypes on the type of reduction. For instance, genotypes R194-79-290-9 and Serala had a yield reduction that paralleled the change in mean yield of the 81 genotypes whereas yield reduction in 73-167-12 was more abrupt (Fig. 1). These observations indicate that there were differences in yield stability among genotypes that need to be considered in a breeding program.

No significant differences were found in percentage of dry matter of the biomass among genotypes. The average dry matter over the four year period was 46%. Different genotypes had different canopy heights,

Table 1. Biomass yield of 81 sericea lespedeza genotypes in the year of establishment (1986) and subsequent years.

Genotype	1986	1988	1989	1990	Mean Yield	
					Four † Year	Three ‡ Year
	----- Mg ha ⁻¹ -----					
R194-79-290-9	1.8	16.5	11.6	8.6	9.0	12.2
73-34-7	1.6	13.2	9.9	7.0	7.9	10.0
Low-tan Synth. (C-Blck.)	1.1	16.6	9.1	7.0	7.9	10.9
75-2-3	1.3	14.9	10.0	7.2	7.8	10.7
73-167-12	1.7	16.5	9.0	6.2	7.8	10.5
Serala	0.8	14.9	9.9	7.8	7.8	10.9
73-162-16	1.0	17.9	7.1	7.2	7.8	10.7
75-2-10	1.1	12.0	12.2	7.6	7.7	10.6
79-290-9	1.3	14.9	8.4	7.4	7.5	10.3
AU L6	1.4	13.2	8.8	8.6	7.5	10.2
73-163-5	1.3	14.1	10.4	6.2	7.5	10.2
AU Lotan	1.2	14.9	9.1	5.6	7.2	9.9
AU L11	1.5	13.1	8.2	7.8	7.2	9.7
R186-79-289-7	1.4	15.0	7.9	6.2	7.1	9.7
73-162-17	1.6	16.7	6.6	4.7	7.0	9.4
AU L2	0.9	13.4	7.6	7.9	7.0	9.6
R189-79-289-15	1.0	13.5	8.8	6.4	6.9	9.6
Serala 76	1.1	12.8	8.5	6.6	6.8	9.3
AU L4	0.8	13.6	7.1	7.6	6.8	9.4
74-100-5	1.0	13.3	7.7	6.3	6.6	9.1
R240-80-37-13	1.2	12.4	8.4	6.0	6.6	8.9
73-162-20	1.0	13.4	7.7	5.9	6.5	9.0
74-31-7	1.1	12.1	8.3	6.3	6.5	8.9
73-90-17	1.3	11.6	9.2	5.7	6.5	8.8
R295-80-88-10	1.0	13.1	6.8	6.4	6.4	8.8
73-167-4	0.5	13.6	7.9	5.5	6.4	9.0
99.5	1.4	12.0	6.9	7.0	6.4	8.6
73-162-19	1.2	12.5	7.8	5.6	6.4	8.6
80-88-10	1.0	11.2	6.8	7.5	6.2	8.5
74-33-16	1.1	12.0	7.8	5.7	6.2	8.5
3170	1.1	11.6	7.4	6.0	6.1	8.3
Interstate	1.3	11.6	6.8	5.6	5.9	8.0
AU L1	0.8	11.5	7.0	6.1	5.9	8.2
R145-79-264-9	1.5	9.5	8.5	5.6	5.9	7.9
R146-79-282-9	1.1	10.1	7.5	6.5	5.9	8.0
R259-80-46-15	1.1	11.1	7.3	5.6	5.9	8.0
R297-80-89-2	1.3	9.8	6.8	6.9	5.8	7.8
R168-79-282-9	1.0	11.8	7.6	4.2	5.7	7.8
73-167-16	1.8	12.0	6.5	3.9	5.7	7.4
R181-79-286-7	1.2	9.9	7.0	6.2	5.7	7.7
1624	0.8	11.0	6.7	5.8	5.7	7.8
R190-79-289-16	0.6	12.1	7.6	4.0	5.6	7.9
R243-80-40-17	1.4	11.8	5.8	4.5	5.5	7.4

Table 1 (continued)

Genotype	1986	1988	1989	1990	Mean Yield	
					Four † Year	Three ‡ Year
	----- Mg ha ⁻¹ -----					
R298-80-90-13	1.4	10.4	7.5	4.1	5.5	7.3
R184-79-286-13	1.2	11.9	6.9	3.4	5.5	7.4
R226-80-27-13	0.8	10.5	6.8	5.3	5.5	7.6
2017	0.8	9.9	7.2	5.3	5.4	7.4
80-89-2	1.3	9.4	7.0	5.3	5.4	7.2
Interstate 76	0.9	8.8	7.4	6.0	5.4	7.4
R227-80-29-14	0.8	8.7	8.7	4.8	5.4	7.4
80-91-15	1.1	9.4	6.7	5.7	5.4	7.3
79-282-9	0.8	11.3	7.5	3.4	5.4	7.4
R296-80-88-14	1.1	8.8	6.0	6.7	5.3	7.2
74-24-20	1.1	10.3	6.1	4.7	5.2	7.0
AU L5	1.5	10.2	6.6	3.7	5.2	6.8
AU L15	1.3	9.8	6.0	4.9	5.2	6.9
R5-79-3-17	0.8	10.3	5.8	5.2	5.2	7.1
R301-80-91-15	1.6	7.6	6.2	6.1	5.1	6.6
80-90-13	0.9	10.1	5.9	4.8	5.1	6.9
73-91-4	0.8	10.3	6.0	4.5	5.0	6.9
AU L16	0.8	8.4	5.8	6.5	5.0	6.9
73-62-18	0.9	9.7	5.9	4.9	5.0	6.8
AU L18	0.8	9.5	7.5	3.3	4.9	6.8
74-24-7	0.8	10.4	6.0	5.9	4.9	7.2
79-19-11	1.4	8.7	5.8	4.5	4.8	6.3
73-167-6	1.1	10.0	4.6	3.3	4.8	6.0
R27P2	1.6	7.2	5.8	5.5	4.7	6.1
80-88-14	1.4	8.8	4.7	4.9	4.7	6.1
AU L12	1.0	9.2	3.5	6.1	4.6	6.3
R163-79-277-5	1.1	9.1	5.4	4.1	4.6	6.2
AU L14	0.5	8.3	6.3	4.5	4.6	6.4
R38-79-72-10	1.1	9.0	6.0	3.1	4.5	6.1
R47-79-81-4	0.9	9.3	5.8	3.9	4.5	6.3
R39-79-72-16	1.1	7.8	6.1	4.2	4.5	6.0
R19-79-19-11	1.4	8.1	4.4	4.8	4.4	5.7
AU L17	0.9	8.2	5.0	4.2	4.3	5.8
AU L9	0.5	6.5	5.5	4.7	4.0	5.5
AU L10	0.9	5.9	5.4	4.5	3.9	5.3
AU L8	0.5	8.0	5.3	3.1	3.9	5.4

Table 1 (continued)

Genotype	1986	1988	1989	1990	Mean Yield	
					Four † Year	Three ‡ Year
	----- Mg ha ⁻¹ -----					
R14-79-15-12	0.6	8.0	4.5	2.8	3.7	5.1
AU L13	0.5	5.4	2.6	4.8	3.1	4.3
MSD §	ns	3.0	4.3	4.8	1.2	1.7

† 1986 (establishment), and 1988 to 1990

‡ 1988 to 1990

§ Minimum significant difference at a probability of 0.05 according to Waller-Duncan k-ratio test.

Table 2. Mean, standard deviation, minimum, and maximum biomass yield (Mg ha^{-1}) obtained from 81 sericea lespedeza genotypes.

	Mean	Std dev	Minimum	Maximum
Yield 86	1.140	0.31	0.519	1.896
Yield 88	11.183	2.63	5.437	17.949
Yield 89	7.137	1.66	2.629	12.262
Yield 90	5.602	1.34	2.891	8.664

Fig. 1. Mean biomass yield of 81 genotypes and yield of three selected genotypes.

Table 3. Biomass yield and crude protein, NDF (neutral detergent fiber), ADF (acid detergent fiber), lignin, hemicellulose, cellulose, and holocellulose content of the 16 highest yielding sericea lespedeza genotypes.

Genotype	Mean Yield			Crude Protein	NDF	ADF	Lignin	Hemi-cellulose	Cellulose	Holo-cellulose
	Four Year	Three Year	†							
	Year	Year	Year							
	--- Mg ha ⁻¹ ---									
	----- % -----									
R194-79-290-9	9.05	12.26		11.25	50.7	40.7	9.7	10.0	30.7	40.7
73-34-7	7.95	10.06		11.08	50.7	42.3	12.7	8.3	29.0	37.3
Low-tan Synth.	7.94	10.94		11.13	50.7	42.7	16.0	8.0	28.3	36.3
75-2-3	7.88	10.77		10.05	53.7	43.3	12.0	10.3	32.7	43.0
73-167-12	7.87	10.59		12.24	48.3	39.7	12.0	8.7	28.3	37.0
Serala	7.85	10.94		11.38	44.3	39.3	9.7	5.0	29.7	34.7
73-162-16	7.80	10.78		11.31	51.7	41.0	9.3	10.7	33.0	43.7
75-2-10	7.73	10.65		11.48	45.3	39.3	10.7	6.0	29.3	43.7
79-290-9	7.54	10.32		12.69	49.3	43.3	10.0	6.0	32.0	35.3
AU L6	7.53	10.25		11.06	49.3	42.7	12.3	6.7	30.7	38.0
73-163-5	7.52	10.27		11.59	48.0	38.7	8.3	9.3	31.0	37.3
AU Lotan	7.24	9.92		11.27	50.3	43.3	12.3	7.0	32.7	40.3
AU L11	7.20	9.72		11.08	50.0	46.3	8.3	3.7	34.3	39.7
R186-79-289-7	7.19	9.75		10.05	54.0	41.3	10.0	12.7	32.3	38.0
73-162-17	7.01	9.42		12.08	47.0	39.7	10.3	7.3	29.0	45.0
AU L2	7.00	9.68		10.79	48.0	43.0	10.0	5.0	29.7	34.6
R189-79-289-15	6.99	9.63		11.59	55.0	47.0	10.0	8.0	32.3	40.3
Serala 76	6.83	9.34		10.75	51.0	44.3	10.3	6.7	35.7	42.3
AU L4	6.80	9.47		11.00	53.0	45.0	12.0	8.3	32.7	41.0
74-100-5	6.68	9.17		11.38	52.0	44.7	14.3	7.3	31.3	38.7
R240-80-37-13	6.61	8.98		11.40	50.0	41.0	11.7	9.0	32.3	41.3
73-162-20	6.56	9.03		11.80	48.7	42.0	10.0	6.7	31.7	38.3
74-31-7	6.55	8.95		10.87	53.3	44.0	12.3	9.3	32.3	41.7
73-90-17	6.54	8.86		10.07	62.0	48.3	8.7	13.7	34.3	48.0

Table 3 (continued)

Genotype	Mean Yield		Crude Protein	NDF	ADF	Lignin	Hemi-cellulose	Cellulose	Holo-cellulose
	Four Year	Three Year							
	--- Mg ha ⁻¹ ---								
	----- % -----								
R295-80-88-10	6.44	8.83	8.55	61.0	49.3	12.0	11.7	38.7	50.3
73-167-4	6.43	9.06	11.65	48.3	40.0	9.3	8.3	26.0	34.3
99.5	6.42	8.65	10.28	62.3	50.0	9.0	12.3	38.0	50.3
73-162-19	6.40	8.67	11.97	48.0	39.3	10.7	8.7	31.0	39.7
80-88-10	6.25	8.57	9.52	54.0	47.3	11.0	6.7	35.7	42.3
74-33-16	6.24	8.52	11.13	51.7	44.3	8.3	7.3	30.7	38.0
3170	6.14	8.37	11.10	49.3	41.0	6.7	8.3	31.3	39.7
Interstate	5.97	8.04	11.57	44.3	42.0	11.0	2.7	31.3	34.0
AU LI	5.96	8.24	10.49	50.0	44.0	10.0	6.0	32.7	38.7
R145-79-264-9	5.94	7.90	9.67	56.7	45.3	13.3	11.3	32.7	46.7
R146-79-282-9	5.93	8.07	12.06	50.0	41.0	11.8	9.0	35.3	38.5
R259-80-46-15	5.92	8.03	10.79	52.7	43.3	6.3	9.3	29.5	43.0
R297-80-89-2	5.86	7.87	10.13	59.3	47.7	12.7	11.7	33.7	43.0
R168-79-282-9	5.79	7.89	12.31	44.7	40.7	9.7	4.3	35.3	32.3
73-167-16	5.77	7.49	10.94	52.3	43.0	8.0	9.3	28.0	44.3
R181-79-286-7	5.77	7.77	11.82	52.7	44.0	13.0	8.7	35.0	41.7
1624	5.70	7.86	9.86	56.0	47.0	9.7	9.0	33.0	45.7
R190-79-289-16	5.66	7.91	10.64	54.7	46.7	11.3	8.0	36.7	43.7
R243-80-40-17	5.59	7.43	11.84	57.0	41.3	8.0	15.7	35.7	51.7
R298-80-90-13	5.56	7.37	10.68	53.0	45.0	12.7	8.0	36.0	42.3
R184-79-286-13	5.53	7.46	12.14	47.7	42.3	9.7	5.3	34.3	37.7
R226-80-27-13	5.53	7.61	12.06	58.5	46.0	11.5	12.5	32.3	48.5
2017	5.46	7.49	11.72	61.7	47.7	13.7	14.0	36.0	51.3
80-89-2	5.46	7.27	10.93	58.0	47.7	7.0	10.3	40.7	51.0
Interstate 76	5.45	7.46	11.50	45.3	41.0	14.0	4.3	28.3	32.7
R227-80-29-14	5.41	7.46	9.56	59.7	44.7	10.3	15.0	37.7	52.7

Table 3 (continued)

Genotype	Mean Yield		Crude Protein	NDF	ADF	Lignin	Hemi-cellulose	Cellulose	Holo-cellulose
	Four † Year	Three ‡ Year							
	---- Mg ha ⁻¹ ----								
	----- % -----								
80-91-15	5.41	7.32	10.83	51.7	43.0	13.7	8.7	30.3	39.0
79-282-9	5.41	7.43	10.45	53.0	44.3	8.7	8.7	35.7	44.3
R296-80-88-14	5.33	7.20	10.77	54.3	43.7	13.7	10.7	30.7	41.3
74-24-20	5.25	7.07	10.58	53.7	43.0	11.0	10.7	31.7	42.3
AU L5	5.24	6.88	9.82	52.0	44.7	13.3	7.3	33.7	41.0
AU L15	5.22	6.96	9.29	58.7	50.0	11.3	8.7	36.3	45.0
R5-79-3-17	5.20	7.14	10.18	55.7	48.0	9.3	7.7	37.3	45.0
R301-80-91-15	5.12	6.68	11.69	52.0	41.7	12.7	10.3	33.3	43.7
80-90-13	5.10	6.96	10.55	53.3	46.7	9.0	6.7	38.0	44.7
73-91-4	5.09	6.98	13.19	50.0	44.0	9.3	6.0	34.7	40.7
AU L16	5.07	6.93	10.98	50.0	46.0	14.0	4.7	32.3	37.0
73-62-18	5.05	6.88	11.65	50.0	40.3	10.0	9.7	28.7	38.3
AU L18	4.99	6.82	11.00	50.3	41.7	8.3	8.7	32.7	41.3
74-24-7	4.95	7.26	11.13	50.0	41.3	9.3	8.7	32.0	40.7
79-19-11	4.83	6.36	11.76	52.0	42.0	11.7	10.0	30.3	40.3
73-167-6	4.82	6.04	10.79	50.7	42.7	10.3	8.0	31.3	39.3
R27P2	4.79	6.19	11.36	47.7	40.3	14.0	7.3	28.3	35.7
80-88-14	4.72	6.16	10.26	55.0	44.0	14.0	11.0	31.3	42.3
AU L12	4.69	6.30	10.62	53.0	45.7	15.0	7.3	32.0	39.3
R163-79-277-5	4.66	6.24	10.28	58.3	44.0	13.3	14.3	32.3	46.7
AU L14	4.62	6.44	10.26	54.7	46.3	9.0	8.3	35.3	43.7
R38-79-72-10	4.57	6.11	13.36	48.0	39.7	9.0	8.3	30.7	39.0
R47-79-81-4	4.57	6.37	10.86	52.5	45.0	9.5	7.5	36.5	44.0
R39-79-72-16	4.53	6.05	12.20	55.0	44.0	10.3	11.0	34.7	45.7
R19-79-19-11	4.44	5.79	10.20	58.3	48.0	11.0	10.3	34.0	44.3
AU L17	4.34	5.86	10.47	55.3	46.0	10.7	9.3	34.7	44.0

Table 3 (continued)

Genotype	Mean Yield		Crude Protein	NDF	ADF	Lignin	Hemi-cellulose	Cellulose	Holo-cellulose
	Four Year	Three Year							
	Mg ha ⁻¹								
AU L9	4.05	5.59	10.70	50.7	44.0	9.7	6.7	34.7	41.3
AU L10	3.97	5.32	9.61	61.7	51.7	9.3	10.0	38.7	48.7
AU L8	3.96	5.49	10.45	52.7	44.7	12.3	8.0	34.0	42.0
R14-79-15-12	3.75	5.15	11.97	49.0	40.0	8.3	9.0	28.7	37.7
AU L13	3.15	4.31	10.17	52.7	47.0	11.0	6.3	32.0	38.3
MSD §	1.22	1.79	ns	12.1	ns	ns	9.5	ns	16.8

† 1986 (establishment), and 1988 to 1990

‡ 1888 to 1990

§ Minimum significant difference at a probability of 0.05 according to Waller-Duncan k-ratio test.

however, these differences were consistent in 1986 and 1990 (Appendix), i.e., genotype-environment interactions were not significant.

Analysis of variance of crude protein content indicated that there were no significant differences among genotypes. Percentage of crude protein content ranged between 8.55 and 13.36% with an average of 11.01%. Distribution of sericea lespedeza genotypes for crude protein content is presented in Fig. 2. The genotypes with the highest biomass yield had a crude protein content that ranged between 10.05 (75-2-3 and R186-79-289-7) and 12.69% (79-290-9) (Table 3). These crude protein contents are substantially lower (about 25%) than those previously reported by Bransby et al (1989). In their research sericea lespedeza was harvested twice instead of once. In this study, samples were taken when plants were fully mature but still had a variable amount of leaves. It is certain that lower nitrogen contents can be obtained if the plants are harvested in late November, early December, when all leaves have shed. However, biomass yields will be lower than those in previous years (Table 1).

Analysis of variance of NDF content indicated that there were significant differences among genotypes. Percentage of NDF content ranged between 44.3 and 62.3% with an average of 52.4%. Distribution of sericea lespedeza genotypes for NDF content is presented in Fig. 2. The genotypes with the highest biomass yield had a NDF content that ranged between 47.0% (73-162-17) and 53.7% (75-2-3) (Table 3).

Analysis of variance of ADF content indicated that there were no significant ($P = 0.07$) differences among genotypes. Percentage of ADF content ranged between 38.7 and 51.7% with an average of 43.8%. Distribution of sericea lespedeza genotypes for ADF content is presented

in Fig. 2. The genotypes with the highest biomass yield had an ADF content that ranged between 38.7 (73-163-5) and 46.3% (AU L11) (Table 3).

Analysis of variance of percentage of lignin indicated that there were no significant differences among genotypes. Percentage of lignin ranged between 6.3 and 16% with a mean of 10.8%. Distribution of sericea lespedeza genotypes for lignin content is presented in Fig. 3.

Analysis of variance of percentage of hemicellulose indicated that there were significant differences among genotypes. Percentage of hemicellulose content ranged between 2.7 and 15.7% with an average of 8.7%. Distribution of sericea lespedeza genotypes for hemicellulose content is presented in Fig. 3. The genotypes with the highest biomass yield had a hemicellulose content that ranged between 3.7 (AU L11) and 12.7% (R186-79-289-7) (Table 3).

Analysis of variance of percentage of cellulose indicated that there were no significant ($P = 0.08$) differences among genotypes. Percentage of cellulose content ranged between 26.0 and 40.7% with an average of 32.8%. Distribution of sericea lespedeza genotypes for cellulose content is presented in Fig. 3. The genotypes with the highest biomass yield had a cellulose content that ranged between 28.3 (Low-tan Synth. and 73-167-12) and 34.3% (AU L11).

Analysis of variance of percentage of holocellulose indicated that there were significant differences among genotypes. Percentage of

Fig. 2. Distribution of sericea lespedeza genotypes for ADF, NDF and crude protein.

Fig. 3. Distribution of sericea lespedeza genotypes for lignin, cellulose, hemicellulose, and holocellulose.

holocellulose content ranged between 32.3 and 52.7% with an average of 41.5%. Distribution of sericea lespedeza genotypes for holocellulose content is presented in Fig. 2. The genotypes with the highest biomass yield had a holocellulose content that ranged between 34.6 (AU L2) and 45.0% (73-162-17).

Pearson's correlation coefficient indicated that lignin was not correlated to most quality traits with exception of cellulose. Significant correlation coefficients were found between pairs of all the other quality traits measured, but ADF-hemicellulose (Table 4). The negative correlation between crude protein content and NDF, ADF, and hemicellulose indicate that crude protein tended to be lower in genotypes that had a high content of NDF, ADF, and hemicellulose. The positive and highly significant correlation between NDF and ADF indicate that when any of these traits increases, the other will also increase. The lack of correlation between ADF and hemicellulose and the positive correlation between NDF-hemicellulose indicate that hemicellulose content is independent of ADF but closely related to NDF. The high value of the correlation coefficient between NDF and holocellulose indicates that holocellulose changes parallel those of NDF (Table 4).

Calculation of genetic variances from the analysis of variance showed that there is no genetic variance among the genotypes tested for crude protein and lignin (Table 5). Broad sense heritability estimates give an idea of the relative importance of the genetic and environmental variation. The medium value of broad sense heritability for NDF indicates that there is genetic variation in the group of genotypes tested that

Table 4. Pearson correlation coefficient among quality traits

	NDF	ADF	Lignin	Hemi-cellulose	Cellulose	Holo-cellulose
Crude Protein	-0.592**	-0.635**	-0.114	-0.263*	-0.503**	-0.474**
NDF	---	0.800**	0.038	0.748**	0.750**	0.905**
ADF		---	0.061	0.201	0.773**	0.616**
Lignin			---	0.003	-0.236*	-0.152
Hemicellulose				---	0.366**	0.795**
Cellulose					---	0.855**

*, ** indicate significant differences at $P = 0.05$ and $P = 0.01$, respectively

Table 5. Genetic variance and broad sense heritability of crude protein, NDF, ADF, hemicellulose, lignin, cellulose, and holocellulose (sum of hemicellulose and cellulose) content in the biomass of 81 sericea lespedeza genotypes.

Trait	Genetic Variance	Heritability %
Crude protein	0	0
NDF	7.22	41
ADF	2.04	25
Lignin	0	0
Hemicellulose	2.02	32
Cellulose	2.00	23
Holocellulose	6.60	32

could be used in a selection program to increase (in the case of biomass production) or decrease (if the objective is forage production) NDF. The smaller broad-sense heritability values obtained for the other traits indicate that the variability available is limited. However, the large correlation coefficients between NDF and ADF, hemicellulose, cellulose, and holocellulose indicate that changes in NDF content will bring about correlated changes in the other quality traits.

In summary, there is variability for biomass yield and for some quality traits that are considered important for biofuel production. Thus, it is possible to select sericea lespedeza genotypes within the breeding lines tested that would be particularly adapted for some methods of biofuel production. Screening of accessions from the Plant Introduction System should be conducted to determine their variability for lignin and crude protein content. If accessions with lower levels are found, recombination, using genetic procedures, could be carried out to obtain plants with reduced content of lignin and crude protein.

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APPENDIX

Canopy height of 81 sericea lespedeza genotypes

	1986	1990	Mean
	----- cm -----		
73-34-7	58	129	93
R19-79-19-11	79	117	93
R295-80-88-10	66	122	90
73-162-19	69	117	89
74-31-7	58	126	87
99.5	70	109	87
R181-79-286-7	60	119	85
R189-79-239-15	68	106	84
73-167-12	63	111	83
AU L6	67	104	83
Low-tan Synth. (C-Blck.)	58	116	83
73-162-16	53	123	83
1624	56	117	82
73-167-16	64	107	82
AU Lotan	63	108	82
79-290-9	60	112	82
R297-80-89-2	64	105	81
Serala	63	106	81
73-163-5	50	123	81
R301-80-91-15	61	107	81
Serala 76	59	110	81
AU L11	55	115	81
R39-79-72-16	62	103	80
73-90-17	54	114	80
AU L5	68	95	80
R186-79-289-7	58	108	80
80-88-10	55	113	80
R194-79-290-9	59	107	80
80-89-2	57	110	80
R145-79-264-9	51	117	79
R243-80-40-17	59	106	79
R227-80-29-14	52	113	78
AU L1	48	117	78
79-19-11	60	101	78
R163-79-277-5	64	93	77
74-33-16	55	106	77
AU L15	56	103	76
73-167-6	58	95	76
80-88-14	53	105	75
R5-79-3-17	51	108	75
73-91-4	53	104	75
75-2-3	50	107	74
80-91-15	46	113	74

(continued)

	1986	1990	Mean
	----- cm -----		
R240-80-37-13	48	109	74
74-100-5	48	106	73
73-62-18	51	102	73
R296-80-88-14	52	101	73
R226-80-27-13	43	112	73
79-282-9	44	109	72
2017	47	105	72
AU L17	56	93	72
74-24-20	49	102	71
R184-79-286-13	53	97	71
Interstate	59	87	71
AU L12	39	114	71
AU L10	50	99	71
80-90-13	52	95	71
R47-79-81-4	48	104	70
75-2-10	46	102	70
73-162-20	50	96	70
AU L9	45	104	70
R259-80-46-15	45	103	70
R168-79-282-9	45	102	69
AU L4	47	98	69
74-24-7	46	97	68
R146-79-282-9	42	102	68
AU L2	43	100	68
R298-80-90-13	47	93	67
R190-79-289-16	37	103	65
Interstate 76	39	97	64
R38-79-72-10	41	94	64
3170	39	97	63
73-167-4	34	102	63
73-162-17	50	81	63
AU L14	41	90	62
R27P2	45	84	62
R14-79-15-12	40	88	61
AU L13	38	87	59
AU L8	39	85	59
AU L16	35	90	58
AU L18	28	64	44

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