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Sericea Lespedeza Biomass Composition for Bioenergy in the Southeastern USA

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Summary: Sericea lespedeza (*Lespedeza cuneata* (Dumont) G. Don) is used for forage or as a soil conservation plant that has shown potential for the production of ligno-cellulosic biomass in the Southeastern USA. Four genotypes of sericea lespedeza were grown at Tallassee, Alabama. Plant canopy of those genotypes was divided into three 10-cm strata. Year of harvest affected NDF, protein and hemicellulose content of leaves and stems. Cut affected NDF, cellulose and hemicellulose content and protein of leaves. No differences were measured among the four genotypes except for protein content in the stems. Leaves had a much higher protein content than stems which makes them undesirable for biofuel use. Large strata effects on stem composition were measured on all traits except lignin which had the same value across the strata. Values of NDF, ADF, cellulose, and hemicellulose increased from the top of the stem to the base whereas protein content was reduced.
Key words: biofuel, biomass, *Lespedeza cuneata* (Dumont) G. Don, sericea lespedeza

Introduction

Sericea lespedeza is a forage crop used for grazing, hay, or as a soil conservation plant that has shown potential for the production of ligno-cellulosic biomass in the Southeastern USA (Bransby et al. 1989, Mosjidis 1996).

Once established, sericea lespedeza costs are relatively small compared to other plants (Ball & Crew 1995). 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 this species (Mosjidis 1997). It is one of the most commonly used species for cultivation on strip mine spoils, road banks, and other disturbed or eroding areas because it can improve important physical characteristics of eroded soils (Campbell et al. 1995). Furthermore, sericea lespedeza is tolerant of aluminum-toxic conditions; therefore, it is especially valuable in soils below pH 5.0 where aluminum toxicity is a problem (Fletcher & Livingston, 1949). This species tolerates drought and low soil fertility (Mosjidis 1997).

Agblevor et al. (1994) investigated the conversion of sericea lespedeza biomass into energy using pyrolysis. They reported that biomass from plants harvested in December after defoliation produced lower char than switchgrass (*Panicum virgatum* L.), whereas plants harvested in October had higher char production. Plant biomass is a mixture of structures of differing maturity and composition. Plant cells are composed of two major constituents, cell walls and cell contents. Cell walls make up the ligno-cellulosic material of major importance for biofuel production by pyrolysis whereas cell contents such as protein and carbohydrates contribute to the formation of undesirable residues (Theander & Nelson 1989) A high protein content in the plant tissue increases char formation because of the interaction between amino acids and carbohydrates (Theander & Nelson 1989).

The objective of this work was to determine the composition of stems at three canopy levels of four genotypes of sericea lespedeza at different times during the growing season in two years.

Materials and Methods

Four genotypes of sericea lespedeza (L18, AU Donnelly, 74-24-7, and 79-290-9) were planted in a randomized complete block design with three replications at Tallassee, Alabama, in May 1986. This experiment was located on a Wickham sandy loam (fine-loamy, mixed, semiactive, thermic,

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Typic Hapludults) soil. Plots were single rows 7.6 m long, planted 0.91 m apart. In 1990 and 1991, herbage from each genotype was harvested twice. The canopy of each genotype was divided into three 10-cm strata starting from the tip of the stems. Herbage subsamples were divided into leaves (leaves and petioles) and stems. Herbage samples were taken from each plant structure of each segment, dried at 60 C for 48 h, ground to pass a 1 mm screen, and analyzed for concentration of nitrogen 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. Data were analyzed using SAS. Significant differences between treatment were estimated using Waller-Duncan's MSD (minimum significant difference, $P<0.05$).

Results and Discussion

Year of harvest affected NDF, protein and hemicellulose content in leaves and stems (Tab. 1). Cut affected NDF, cellulose and hemicellulose content of stems and protein content of leaves.

No differences were measured in stem composition among the four genotypes except for protein content (Tab. 1). Protein content in leaves of the four genotypes ranged from 197 to 231 g kg^{-1} whereas in stems it ranged from 140 to 156 g kg^{-1} (Tab. 1). The much higher protein content of leaves makes them undesirable for biomass use because they would increase char production when using pyrolysis. Genotype L18 had lower protein content than the other genotypes which would make it more desirable but it was reported by Mosjidis (1993) to have lower biomass yield than AU Donnelly and 79-290-9.

Large strata effects on stem composition were measured on all traits except lignin which had the same value across the strata (Tab. 1). Values of NDF, ADF, cellulose, and hemicellulose increased from the top of the stem to the base whereas protein content was reduced. Results indicate that mature stems harvested late in the season would be more advantageous for biofuel use. Therefore, the ideal time to harvest sericea lespedeza plants for biofuel production would be during winter time when the plants are dormant and have lost most leaves.

Table 1. Neutral detergent fiber (NDF), acid detergent fiber (ADF), protein, lignin, cellulose and hemicellulose content (g kg^{-1}) of sericea lespedeza stems as affected by year, cut, genotype, and strata
Tabela 1. Sadržaj (g kg^{-1}) neutralnih (NDF) i kiselih rastvorljivih vlakana (ADF), proteina, lignin, celuloze i hemiceluloze stabla lespedeze u zavisnosti od godine, otkosa, genotipa i sloja

	NDF	ADF	Protein Proteini	Lignin Lignin	Cellulose Celuloza	Hemicellulose Hemiceluloza
Year / Godina						
1990	533*	431	163***	62	324	100*
1991	553	418	138	82	320	139
Cut / Otkos						
1	532**	424	153	69	308**	107*
2	554	424	148	74	336	132
Genotype / Genotip						
L18	534	406	140	65	306	126
AU Donnelly	536	431	152	76	325	115
74-24-7	559	424	156	75	324	127
79-290-9	544	437	155	72	334	109
MSD 0.05	ns	ns	5	ns	ns	ns
Strata / Sloj						
Top 10 cm / Vrh	456	352	181	68	274	103
Central 10 cm /Sred.	550	436	146	74	325	117
Lower 10 cm / Dno	618	483	125	74	366	138
MSD 0.05	11	16	4	ns	14	15

*, **, ***, Significant at probabilities 0.05, 0.01, 0.001, respectively.
*, **, ***, Značajno uz verovatnoću od 0,05; 0,01; 0,001; *ns* – nije značajno.

Conclusions

Sericea lespedeza represents a crop with a relatively non-expensive cultivation for diverse purposes such as forage. Its additional value lays in the possibility of its use as biofuel, as supported by the results of this research, with numerous advantages in comparison to other crops.

Composition of sericea lespedeza stems indicated that this plant has the potential to be utilized for biofuel production. Genotypes of sericea lespedeza had the same composition when grown for biofuel use. Thus, genotypes need to be chosen based on biomass yield. Mature stems harvested late in the season would be more advantageous for biofuel use. Harvest of sericea lespedeza plants for biofuel production should be during winter time when the plants are dormant and have lost most leaves.

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Sastav biomase lespedeze i njeno korišćenje za bioenergiju u jugoistočnom delu SAD

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Izvod: Lespedeza (*Lespedeza cuneata* (Dumont) G. Don) se koristi na više načina, prvenstveno kao krmna biljka, ali i za očuvanje zemljišta, uz dokazani potencijal za proizvodnju ligninsko-celulozne biomase u jugoistočnom delu SAD. Četiri genotipa lespedeza gajena su u Talasiju, Alabama. Usev ovih genotipova bio je podeljen u tri sloja po vertikali od po 10 cm. Godina kosidbe uticala je na sadržaj kiselih rastvorljivih vlakana (NDF), proteina i hemiceluloze u listu i stablu. Otkos je uticao na sadržaj NDF, celuloze, hemiceluloze i proteina lista. Nije bilo razlika između genotipova izuzev sadržaja proteina u stablu. List je imao značajno veći sadržaj proteina u odnosu na stablo, što ga čini nepogodnim za korišćenje u vidu biogoriva. Značajan uticaj sloja utvrđen je kod svih osobina osim lignina, koji je imao istu vrednost u svim slojevima. Vrednosti NDF, kiselih rastvorljivih vlakana (ADF), celuloze i hemiceluloze rasle su od vrha ka osnovi stabla, dok se sadržaj proteina smanjivao.

Ključne reči: biogorivo, biomasa, *Lespedeza cuneata*, lespedeza