Bots. J. Agric. Appl. Sci. Vol. 7 No. 1 2011

Nutritional quality of aspen suckers under simulated browsing on Cedar Mountain of Southern Utah, Western United States of America

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ABSTRACT
The objective of the study was to determine how time and intensity of clipping (simulated browsing) on suckers' of *Populus tremuloides* Michx affected the nutritional quality of the clipped material on Cedar Mountain, Southern Utah, Western United States of America. Three randomly selected stands measuring 70 m x 70 m were clear-felled in mid-July, 2005, and fenced. Simulated browsing treatments of 0%, 20%, 40%, and 60% removal of current year's growth on aspen suckers were randomly applied in early, mid-, and late summers of 2006 and 2007 on permanently demarcated quadrats. The leaf and clipped materials were evaluated for crude protein (CP) content and in vitro true digestibility (IVTD). Data for crude protein and IVTD were analyzed as a three-way factorial in a split-split plot design using the MIXED procedure of Statistical Analysis System. Percentage of both CP and IVTD decreased with intensity of clipping and advancing season, but these differences were small for IVTD. In mid-summer, leaves (18.6±0.98), intensity 20% (19.2±0.98) and 40% (18.1±0.98) were not significantly different ($p>0.05$) but %CP for leaves and intensity 20% had significantly ($p<0.05$) higher CP percentage than intensity 60% (16.2±0.98) in 2006. IVTD percentage for intensity 20% (77.8±0.95) and 40% (76.4±0.95) did not differ significantly in mid-summer but intensity 60% (75.2±0.95) was significantly lower than for intensity 20% in 2007. Relatively high levels of CP and IVTD suggest that carefully managed browsing of aspen suckers can add appreciably to the nutritional budgets of ungulates for at least two years post-treatment.
Key Words: *Populus tremuloides*, browsing season, browsing intensity, crude protein, in vitro true digestibility, herbivory.

INTRODUCTION

Aspen (*Populus tremuloides* Michx.) typically produces vast numbers of root suckers when the mature stand is removed, as in clear-felling or wildland fire. These suckers are highly palatable to wild and domestic ungulates and have the capacity to provide significant quantities of forage for several years post-treatment and still grow to be adult trees if season and intensity of browsing are controlled (Campa *et al.*, 1992).

Studies have shown that excessive browsing by both domestic livestock especially sheep and, elk and deer occur after clear-felling operations especially in the summer growing season (Bailey and Whitham, 2002). Despite the important contribution of aspen to the nutrition of both domestic and wild ungulates, there is little information on the nutritional value of suckers during the summer growing season and as affected by the intensity of browsing. The summer months are nutritionally important for domestic and wild ungulates (Renecker and Hudson, 1988), as this is the time when body condition must be re-gained in a short period of time to ensure successful reproduction, growth and over-winter survival. A study by Tew (1970) reported

crude protein contents of 17.0%, 13.2%, and 11.8% for plugged aspen leaves, for June, July, and September, respectively, in northern Utah. Similar trends in crude protein content were reported by Kubota *et al.* (1970) for aspen leaves for June (16.3%), July (13.1%), and September (6.3%) in Alaska.

In vitro dry matter digestibility values of 18.3% (October) and 33.9% (February) were reported by McCullough (1979) and Campa *et al.* (1992) for aspen leaves plus twigs and aspen twigs, respectively, in Michigan. It should be mentioned that all these studies evaluated the leaves and/or twigs from mature aspen trees and not suckers. However, all these studies indicated that aspen contains significant amounts of crude protein and is considerably digestible.

Considering the literature reports, one can only assume that the excessive browsing on aspen suckers observed on landscapes is due to the high levels of nutrition they provide. The objective of the study was to determine the effects of simulated browsing at four intensities and three seasons on crude protein content and in vitro true digestibility of the clipped materials.

MATERIALS AND METHODS

The study was located on privately owned land on Cedar Mountain, approximately 27 km southeast of Cedar City, Southern Utah, Western United States of America. Mean annual precipitation for the study site averaged 711 mm from 1970 to 2007 and annual precipitation during the study was 1,323 mm, 640 mm, and 810 mm for 2005, 2006, and 2007, respectively. Long-term (1992-2007) average temperature ranged from -3.5 ^{0}C in January to 15.9 ^{0}C in July. Soils are Argic Pachic Cryoborolls, with fine montmorillonitic faim clay loam, with slopes of 0 - 28% (Ohms, 2003). The vegetation consists of interspersed mountain grasslands and woodlands of trembling aspen, with patches of Gambel oak (*Quercus gambelii* Nutt.) (Ohms, 2003). Major browsers of the area include cattle, deer, elk and sheep.

During late spring of 2005, three aspen stands were randomly selected on the research area located at latitude 37^{0}29'652''N and longitude 112^{0}56'247''W. These stands were clear-felled in mid-July and logs were immediately hauled off-site using a front loader equipped farm tractor. Slash was left in place. The cleared stands were then fenced with 3-m high game-proof black plastic mesh fences to protect suckers from ungulate browsing.

In June 2006, each stand was divided into three roughly equal portions and each was randomly assigned to one of the three clipping seasons i.e. early summer (ES), mid summer (MS) and late summer (LS), respectively. In each portion, four line transects measuring about 70 m were established, running the entire length of the stand. These transects were placed such that each one had a buffer zone of at least 2 m. The simulated browsing intensities were 0%, 20%, 40%, and 60% removal of current season's growth were then randomly assigned to the line transects. Along each transect, fifteen 1.0 m^{2} square shape permanent quadrats were established, utilizing the nearest plant method (USDI, 1996) for monitoring aspen suckers, with the sucker identified serving to locate the center of the quadrat. Quadrats were permanently marked and labeled.

Simulated browsing treatments were applied to the all suckers in a quadrat in early ES (15 June); MS (30 July); and LS (15 September); using the ocular estimation method (Bonham, 1989), imposed on each current year's branch of each sucker. The

same suckers in the plots were clipped in 2006 and 2007. To minimize the chance occurrence of spreading pathogens between suckers, the hand clippers were dipped into 70% alcohol before the next sucker was clipped.

All of the clipped sucker material was bagged in paper bags in the field. At each sampling time, leaves (0% clipping) were also collected from off-quadrat suckers within the exclosure for comparison of nutritional composition of harvested materials. All samples were then taken to the laboratory and oven-dried at 70^0 C for 72 hours. Samples were then ground through a Wiley mill (Thomas Scientific, Sweedesboro, NJ) equipped using a 1-mm screen. Ground samples were then put in sealed containers until analyzed.

Dry matter (DM) percentage and nitrogen (N) were determined following the AOAC (1996) procedure and for N using a nitrogen analyzer (Leco, St. Joseph, MI). Crude protein (CP) content (%) was calculated as N x 6.25.

In vitro true digestibility (IVTD) was determined following the ANKOM modified procedure (ANKOM Technology Corporation, Fairport, NY). Rumen fluid was obtained and pooled from two ruminally-fistulated Angus cows that were maintained on grass hay-alfalfa diet. Standard samples of a grass hay of known digestibility were included with every run.

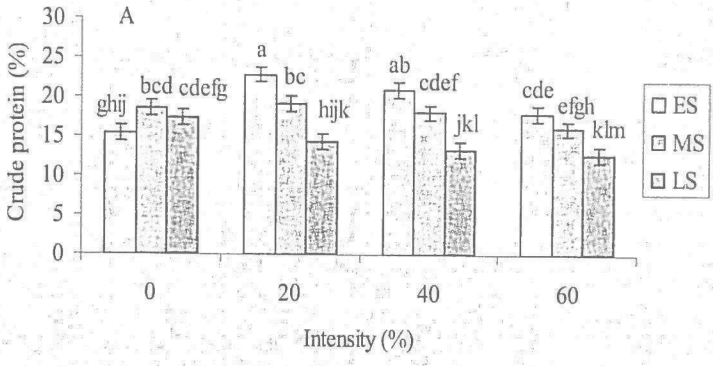
Data for CP and IVTD were analyzed as a 3-way factorial in a split-split plot design with whole plots in blocks by analysis of variance using the MIXED procedure of SAS (2002-2003). Whole plots were seasonally designated portions of the stand nested within sites, and the whole plot factor was season. Subplots were transects within the designated portions of the stand, and subplot factor was intensity. Repeated measures on the transects were the subplots and the sub-subplot factor was year. Fixed effects included season, intensity, year, and their interactions. Sites were considered random effects. In all analyses, zero values were treated as missing data. Multiple comparisons of the least square means for the fixed effects were made using the Least Significance Difference procedure of SAS. Differences were considered significant at $P < 0.05$.

RESULTS

Generally, mean crude protein content decreased with advancing season and intensity of clipping in 2006 (Fig. 1A). However, crude protein content of aspen leaves from un-clipped suckers as opposed to leaves and stems for clipped plots did not exhibit the declining seasonal pattern. Moreover, in early season, levels in leaves were considerably lower than in any of the clipped plot samples. Also in early summer only the 60% intensity caused a decline in crude protein with late summer clipping having no effect among the intensities. Contrary to suckers, crude protein for leaves increased from early to mid- summer. For 2007, there was a seasonal decline for both leaves and all clipping intensities, but not as much as in 2006 (Fig. 1 B). Within a season, there was no difference between the leaves and all clipping intensities. Overall crude protein levels were higher in 2006 than in 2007 for both suckers and leaves.

Sucker material clipped at 20%, and 40% intensities had higher IVTD in early summer than did the leaves of unclipped suckers (Fig. 2A). Compared to the leaves, the difference in digestibility increased as the intensity of clipping increased in late summer. Suckers clipped at 20%, 40%, and 60% intensities had a low IVTD in 2007 compared to the leaves, within a season (Fig. 2B). Comparisons between years indicated no difference in IVTD for the

leaves in early summer, but suckers clipped at 20%, 40%, and 60% intensities, were 10.0%, 11.6%, and 10.7% lower, respectively, in 2007 than in 2006 (Figs. 2A and 2B). In mid-summer, IVTD for the leaves was 6.8% lower in 2007 compared to 2006. Also, sucker material clipped at 20%, 40%, and 60% were 6.7%, 3.6%, and 3.6% lower, respectively, in 2007 compared to 2006, for this season. In late summer, even though IVTD of harvested sucker material was numerically lower in 2007 for all intensities, it did not differ ($P < 0.05$) from that in 2006 (Figs. 2A and 2B).



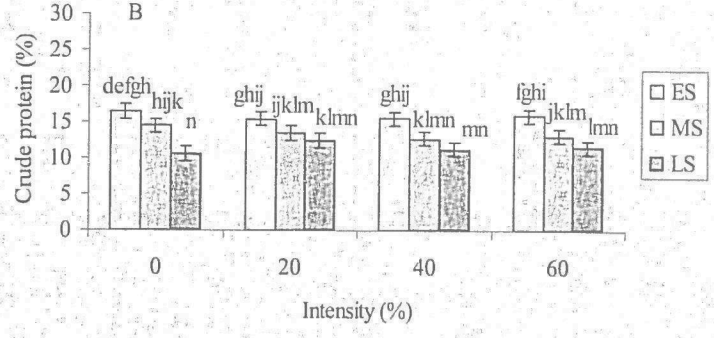


Figure 1. Mean crude protein (%) content of aspen suckers clipped at different intensities and seasons in 2006 (A) and 2007 (B). ES = early summer; MS = mid- summer; LS = late summer. Bars indicate standard errors. Means with different letters are significantly different at $P < 0.05$.

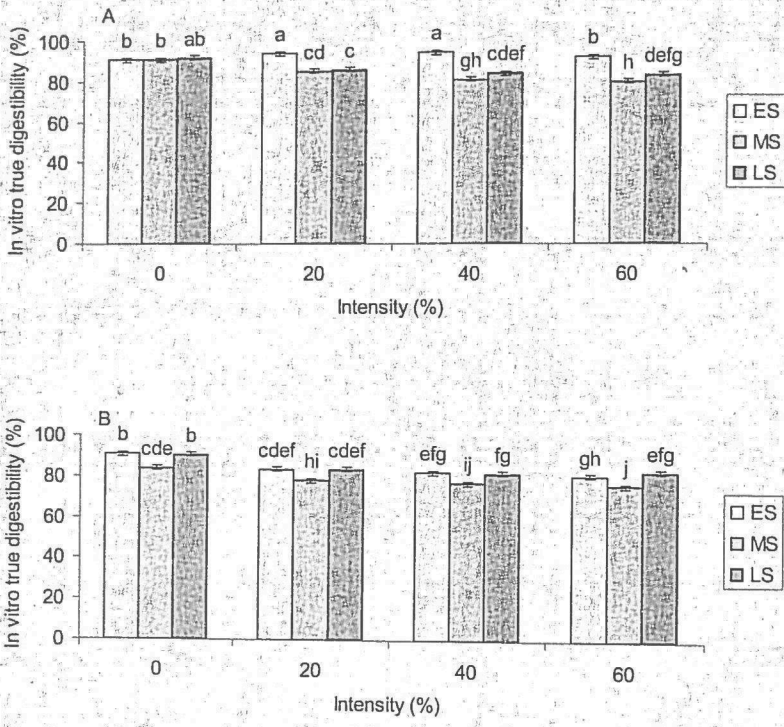


Figure 2. Mean in vitro true digestibility (%) of aspen suckers clipped at different intensities and seasons in 2006 (A) and 2007 (B). ES = early summer; MS = mid-summer; LS = late summer. Bars indicate standard errors. Means with different letters are significantly different at $P < 0.05$.

DISCUSSION

In general, forage plants are high in CP early in the growing season, and then decline as the growing season progresses (Palo *et al.*, 1985). The present study indicated that, true to this generalization, CP generally decreased as the growing season progressed. Kubota *et al.* (1970) and Tew (1970) reported such trends in CP content through the summer months for quaking aspen in Alaska and Utah, respectively. Substantial movement of nutrients between

the growing points and the perennial tissues of deciduous trees have been reported (Chapin and Kedrowski, 1983). Therefore, lower CP content in leaves in early summer for this study may have reflected a time effect, suggesting that nitrogen was not yet fully mobilized from the perennial tissues to leaves.

In this study, mean CP appeared to decrease as the intensity of clipping increased for all seasons in 2006. However, no comparable differences were noted for all clipping intensities within a season in 2007. The results for year two were in agreement with those of Campa *et al.* (1992) who observed no difference in CP content between clipped plots and the control for quaking aspen twigs after two years of simulated browsing.

In this study, mean CP content of suckers (17.3%) would largely meet the nutritional requirements of adult deer (6-9%), growing deer (12-16%) (Mould and Robbins, 1981), maintenance (9.4%) and flushing (13.4%) of 70 kg sheep (Jurgens, 2002) in the first year after clear-felling. However, in 2007 mean CP of suckers failed (< 11.8%) to meet the requirements for growing deer (12-16%). The summer months are nutritionally important for wild ungulates because body condition must be re-gained in time for successful reproduction, growth and over-winter survival (Renecker and Hudson, 1988). The results suggested that growing deer would not meet their late-summer protein requirements in the second year post-clear-felling if aspen suckers are the most protein-rich forage available. Usually forage nutrients are diluted by structural carbohydrates as the plant matures (Short *et al.*, 1974), and as intensity of utilization increases. In this study, digestibility of harvested materials were high (≥ 80%) for all seasons and intensities in both years, suggesting that herbivore production would not be limited by aspen sucker digestion on these landscapes. It should be noted that the values observed in the present study are substantially higher than the literature values partly because research has also shown that IVDMD obtained by the Daisy^{II} Incubator (ANKOM Technology) can vary for some feedstuffs because of the porosity of the F57 sample bags and the sample size per unit of bag surface area (Mabjeesh *et al.*, 2000).

Furthermore, the findings provide some insight into why both deer and elk consume more suckers but less notably so for leaves of mature aspen trees. At CP content > 17% and digestibility ≥ 70%, aspen suckers provide higher levels of CP and digestibility than any of the associated species in the plant community, especially considering the fact that these landscapes no longer support the protein-rich forb component that they once did. In fact, Ruyle (1983) analyzed the diets of sheep grazing Cedar Mountain ranges and reported dietary CP levels not exceeding 12% at any time during the summer.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Generally, CP content decreased with advancing season for both years but CP was lower in 2007 than in 2006 for all intensities within a season. Digestibility of harvested materials were high (≥ 80%) for all intensities with slight differences. From a management standpoint, because early and late summer browsing constrain suckers and exposes suckers to winter kill, respectively, browsing at < 40% intensity in mid-summer after clear-felling operations can appreciably contribute to the nutritional budgets of ungulates for at least two years post-treatment.

ACKNOWLEDGEMENTS

Thanks to Utah Agriculture Experiment Station and Botswana College of Agriculture for funding the research and Dr. John C. Malechek for comments on paper.

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