J. Range Manage.
49:151–156

Cutting height effects on wetland meadow forage yield and quality

RANDY L. DOVEL

Author is presently associate professor, Crop and Soil Science Department, Oregon State University, Corvallis, Ore. 97331.

Abstract

Research was conducted to determine the effect of clipping height on forage yield and quality of 3 wetland meadow plant associations. Bluegrass-clover (*Poa* spp. and *Trifolium* spp.), grass-sedge (*Poa* spp., *Deschampsia caespitosa*, and *Carex* spp.), and sedge (*Carex* spp.) associations were cut to stubble heights of 5, 10, or 15 cm in 1988, 1989, and 1990. Forage yield, herbage residue, crude protein (CP), and acid detergent fiber (ADF) were determined for forage harvested in June, July, and August. Forage yields of all associations increased as clipping height decreased. The majority of total forage produced for all associations was harvested in the June clipping. Herbage residue exceeded 1.4 Mg ha^{-1} for all clipping heights, dates, and associations. Average CP concentration of the bluegrass-clover, grass-sedge, and sedge associations was 12.1, 13.3, and 10.8%, respectively. The CP concentration of the 2 grass-dominated associations increased with decreasing clipping height, but clipping height effect on sedge association CP was not consistent across the growing season. Clipping date had a greater effect on forage CP concentration than did clipping height. Crude protein concentration of all associations increased from the June clipping date to the July clipping date and declined in August. Clipping height did not significantly affect ADF of the bluegrass-clover or grass-sedge associations. Sedge ADF decreased with increasing clipping height in the first clipping, but increased with increasing clipping height in the second and third clippings. Bluegrass-clover ADF increased in a linear fashion from 30.9% at the June clipping date to 36.1% at the August clipping date. In contrast, both the grass-sedge and sedge associations showed curvilinear responses to clipping date, increasing from June to July and then declining in August.

Key Words: sedge, *Carex*, bluegrass, *Poa*, tufted hairgrass, *Deschampsia caepitosa.*

Wetland meadows cover over 38,000 ha in the Klamath Basin of southern Oregon and northern California, providing summer grazing for over 100,000 cattle each year. These meadows are extremely variable and productive environments with many different species and plant associations. Little information exists on the productivity, quality, or management of these meadows.

Animal performance on wetland meadows is hampered by variability in forage production with season and declining forage quality with maturity. Dry matter production peaks in early June and declines from July to September. Forage quality of wetland meadows in eastern Oregon and wetland species in North Dakota declined as the season progressed (Rumburg 1972, Kirby et al. 1989).

The amount of forage left after grazing or clipping, i.e. herbage residue, greatly affects regrowth. For example, herbage residue greater than 1 Mg ha^{-1} was required to optimize the regrowth of ryegrass (*Lolium perenne* L.)-white clover (*Trifolium repens* L.) pastures in a short duration grazing system (Milligan 1981). Herbage residue values of 0.6 and 0.8 Mg ha^{-1} produced growth rates that were 70 and 85% of the optimal growth rate, respectively. Currently, there is no information on appropriate herbage residue for optimal regrowth of wetland meadow species, which is needed to develop grazing systems for this unique environment. The objective of this study was to describe the effects of defoliation on herbage residue, forage quality, and forage yield of 3 wetland meadow plant associations.

Study Area and Methods

Research was conducted on an unfertilized meadow in southern Klamath County, Ore., at an altitude of 1,259 m. Nebraska sedge (*Carex nebraskansis* Dew), black sedge (*Carex nigricans* C.A. Mey), baltic rush (*Juncus balticus* Willd.), tufted hairgrass [*Deschampsia caespitosa* (L.) Beauv.], and *Lieburg bluegrass* (*Poa lieburgii* L.), are native species found at the site. Introduced species present include Kentucky bluegrass (*Poa pratensis* L.), white clover, and meadow foxtail (*Alopecurus pratensis* L.). The meadow is naturally flooded for several weeks in the spring by snow melt and runoff and subsequently flood irrigated on a 14-day interval throughout the growing season. Average annual precipitation for the area is 380 to 460 mm. There is little rainfall in the summer months. Total rainfall from June to August was 33, 16, and 50 mm for 1988, 1989, and 1990, respectively. The frost-free season is 50 to 70 days. Frequent spring and fall frosts often reduce forage quality and yield.

The meadow formed on a poorly drained flood plain comprised of alluvium and varying amounts of volcanic ash. The soil is a fine, mixed Cumulic Cryaguoll with a surface layer about 28 cm deep composed of silty clay. The subsoil is composed of silty clay loam and extends to a depth of approximately 150 cm. The meadow had not been leveled and water distribution by flood irri-

Manuscript accepted 6 May 1995.

gation was not uniform. This resulted in some areas becoming drought stressed early in the growing season (July), while other areas received more water than was desirable for most grass species.

Grazing management on the meadow was typical of that generally used on wetland meadows in the area. Season long continuous grazing at a set stocking density was employed. Cattle were introduced to the meadow in early May and removed in late September. A stocking density of approximately 0.3 AU ha^{-1} was maintained on the meadow throughout the grazing season.

Three plant associations were identified along a moisture gradient in the meadow. The bluegrass-cover association occupied the driest site and was dominated by both Lieburg and Kentucky bluegrass. White clover was also present and comprised about 20% of the sward biomass when the trial was established. The wettest site, referred to as the sedge association, was dominated by black sedge with minor amounts of tufted hairgrass and Nebraska sedge. An intermediate site, referred to as the grass-sedge association, contained both grasses and sedges. Dominant species included meadow foxtail, various bluegrass species, and black sedge. White clover comprised about 7% of this association.

A 20 × 60-m exclosure was built in April 1988 to protect plots from grazing. Twenty-seven, 1.5 × 6-m plots were permanently marked within the exclosure and arranged in a randomized complete block design with treatments in a split plot. The associations described above were main plots and clipping heights of 5, 10, and 15 cm were the split plots. Treatments were replicated 3 times.

Plots were harvested using a flail harvestor on 15 June, 20 July and 24 August in 1988. Harvests were made within 2 days of the above dates in 1989 and 1990. Forage yield, crude protein (CP), and acid detergent fiber (ADF) were determined in all 3 years. Herbage residue was determined by hand clipping the remaining herbage to ground level in 1 randomly place 0.25-m^2 quadrat in each subplot. Herbage samples were dried in a forced air oven at 50° C for 72 hours.

Crude protein was determined using Kjeldahl digestion and steam distillation as described by Nelson and Sommers (1980) and Bremner and Edwards (1965). Acid detergent fiber was determined using methods described by Van Soest (1963). All percentage data were tested for skewness and kurtosis before analysis (Snedecor and Cochran 1980). Significance of main effects and interactions were determined by analysis of variance with a probability level of 5%. All other data were analyzed as a split-split plot in time and split plot in space, with plant association as the main plot, year as the split plot, clipping date as the split-split plot, and clipping height as the split-split plot (Steel and Torrie, 1980). Because association × treatment interactions were evident, data were further analyzed within plant association. Data within an association were analyzed as a split-split plot in time with clipping height as the main effect, year as the split plot, and clipping date as the split-split plot (Steele and Torrie 1980). Significant treatment effects were partitioned into orthogonal polynomial components, and response surfaces were fitted by least squares regression procedures. Polynomials up to quadratic terms for both clipping date and clipping height, as well as their interaction, were introduced as independent variables in a stepwise regression procedure. Only regression coefficients that differed significantly from zero ($P<0.05$) were retained in the model. Models with the highest R^2 were selected as the best fit models.

Results and Discussion

Forage Yield

The majority of total forage produced for all associations was harvested in the June clipping (Fig. 1). Forage yields of the July and August clippings were less than half that of June. This was due in part to the onset of moisture stress. In addition to moisture stress, higher temperatures in mid-summer also depress forage production of some cool-season species (Cooper 1979, DePeters and Kesler 1985, and Mason and Lachance 1983). Early spring growth of pastures consisting of Kentucky bluegrass, orchard grass (*Dactylis glomerata*, L.), white clover, and smooth brome (*Bromus inermis*, Leyss.) represented almost half the total season yield in Pennsylvania (DePeters and Kesler 1985). A similar pattern of growth was also seen in Canada when initial harvest was delayed until mid-June as in this study (Mason and Lachance 1983). In a 4 cutting study in Montana, the first cutting (1 June) yield of Kentucky bluegrass was almost twice that of subsequent harvests (Cooper 1979). Although the sedge association was not subject to the moisture stress found in the other 2 associations, yields also declined as the season progressed. Decline in mid summer sedge growth could be due to heat stress as has been documented in cool-season grass species (Cooper 1979, DePeters and Kesler 1985, and Mason and Lachance 1983).

Clipping height generally had a smaller influence on forage yield than clipping date; however, lowering clipping height did increase forage yield in all associations and clipping dates. Forage yields of grass-sedge and sedge associations decreased linearly ($P<0.05$) as clipping height increased, while bluegrass clover forage yield decreased curvilinearly ($P<0.05$) (Fig. 1).

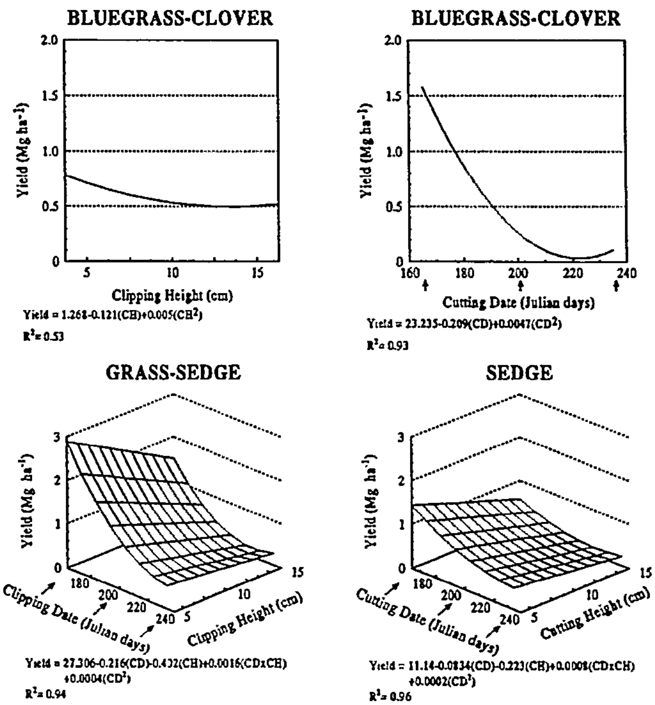


Fig. 1. Forage yield of 3 wetland meadow plant associations in Klamath County, Ore. as affected by clipping date and clipping height. Measurement dates are marked with arrows for June, July, and August, respectively.

Raising the clipping height from 5 to 15 cm reduced total forage yields by 63% and 52% for sedge and grass-sedge associations, respectively. A similar increase in clipping height reduced forage yield of the bluegrass-clover association by an average of 33%. Cooper (1956) found that raising clipping height from 5 to 15 cm decreased yields of native wetland meadow hay in eastern Oregon from 0.15 to 0.70 Mg ha^{-1}. In a study examining clipping height effects on Kentucky bluegrass-white clover pasture, yield also increased as clipping height decreased (Robinson et al. 1952). Clipping heights of 4 and 10 cm did not affect yield of meadow foxtail in an alfalfa-meadow foxtail stand (Smith et al. 1973). Studies examining the effect of clipping height on yield of other species suggest between 2.5 and 5 cm as an optimal clipping height (Reid 1966, Harrington and Binnie 1971).

Regrowth of the grass-sedge and sedge associations following clipping, as reflected in second and third clipping forage yield, increased with decreasing clipping height (Fig. 1). This indicates that a clipping height of 5 cm was not low enough to impede regrowth following clipping in those plant associations. Regrowth is generally reduced when herbage residue is below minimum levels, although this varies among species (Smetham 1990).

Herbage Residue

Clipping date, clipping height, and their interaction significantly affected herbage residue of all 3 associations (Table 1).

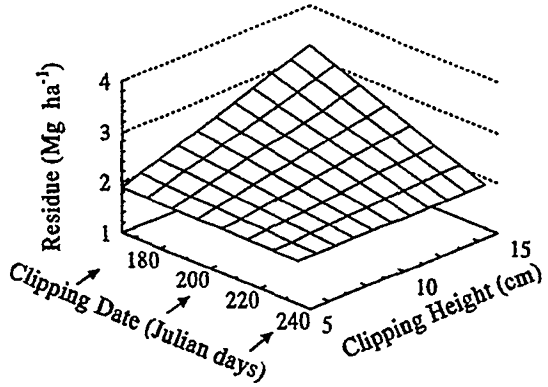
Table 1. Analysis of dry matter yield, herbage residue, crude protein, and acid detergent fiber of wetland meadow forage in 3 plant associations.

	df	Bluegrass/clover	Grass/sedge	Sedge
Yield (Mg ha^{-1})				
Year (Y)	2	NS	NS	NS
Clipping Date (D)	2	**	**	**
Clipping Height (H)	2	**	**	**
YD	4	NS	**	**
YH	4	NS	NS	NS
DH	4	NS	**	**
YDH	8	NS	NS	NS
Herbage Residue (Mg ha^{-1})				
Year (Y)	2	NS	NS	NS
Clipping Date (D)	2	**	**	**
Clipping Height (H)	2	**	**	**
YD	4	NS	NS	NS
YH	4	NS	NS	NS
DH	4	*	*	*
YDG	8	NS	NS	NS
Crude Protein (%)				
Year (Y)	2	**	**	**
Clipping Date (D)	2	**	**	**
Clipping Height (H)	2	*	*	NS
YD	4	NS	NS	NS
YH	4	NS	NS	NS
DH	4	NS	NS	*
YDH	8	NS	NS	NS
Acid Detergent Fiber (%)				
Year (Y)	2	**	**	NS
Clipping Date (D)	2	**	*	**
Clipping Height	2	NS	NS	*
YD	4	NS	NS	NS
YH	4	NS	NS	NS
DH	4	NS	NS	*
YDH	8	NS	NS	NS

*,** Significant at 5 and 1% levels of probability, respectively.

Differences in herbage residue in response to clipping height decreased as the season progressed, possibly as a result of senescence of older lower leaves (Fig. 2).

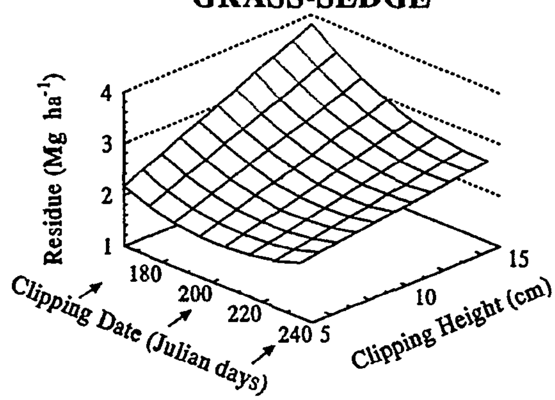
BLUEGRASS-CLOVER



Residue = -0.2269+0.0089(CD)+0.4426(CH)-0.0019(CDxCH)

R^2= 0.63

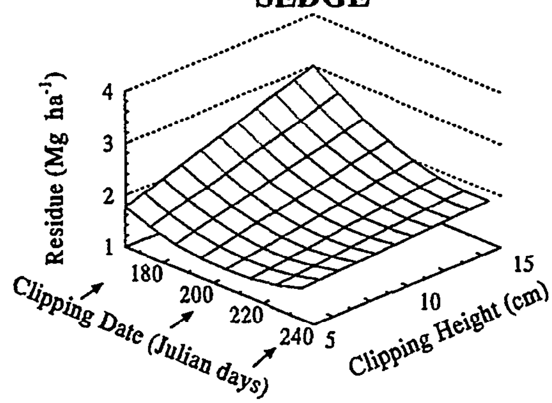
GRASS-SEDGE



Residue = 10.942-0.104(CD)+0.442(CH)-0.0017(CDxCH) +0.0003(CD^2)

R^2= 0.60

SEDGE



Residue = 10.676-0.102(CD)+0.3659(CH)-0.0015(CDxCH) +0.0003(CD^2)

R^2= 0.62

Fig. 2. Herbage residue of three wetland meadow plant associations in Klamath County, Ore. as affected by clipping date and clipping height. Measurement dates are marked with arrows for June, July, and August, respectively.

The 5 cm clipping height resulted in season-long herbage residue averages of 1.8, 2.0, and 1.5 Mg ha^{-1} for the bluegrass-clover, grass-sedge, and sedge associations, respectively. This exceeded recommended levels of 1,000 kg ha^{-1} for optimizing forage production in ryegrass-clover pastures (Smetham 1990). Thus, clipping heights lower than 5 cm may be needed to optimize forage production in these associations. However, factors other than forage yield, such as stand vigor and animal performance, must be considered in determining defoliation height. Kentucky bluegrass stands lost vigor and stand thinning resulted when cut below 2.5 cm (Robinson et al. 1952). Other species require a much higher clipping height than Kentucky bluegrass to maintain adequate stand vigor. Total annual forage yield of plots clipped to a 5 cm clipping height did not decline over the 3 years of the study, indicating that stand vigor was not adversely affected. Optimal animal performance is obtained at grazing heights or herbage residue higher than that required for maximizing forage yield, due to herbage residue impacts on forage quality and intake (Smetham 1990). Forage intake may be limited by both forage availability and forage quality (Thompson and Poppi 1990). The relationship of forage intake to herbage residue varies with livestock class and plant species. Forage intake in a short duration grazing system, was not limited when herbage residue was above 1.2 to 1.6 Mg ha^{-1} (Nichol 1987). All associations in this study had herbage residue above this level when cut to a 5 cm clipping height. Consideration of clipping height and herbage residue effects on forage quality are needed to determine if defolitation to a 5 cm stubble would adversely affect forage quality enough to decrease forage intake and animal performance.

Forage Quality

Both clipping date and clipping height were significant components of crude protein (CP) response surfaces for all 3 associations (Table 1). The CP concentration of the bluegrass clover and grass-sedge associations increased with decreasing clipping height (Fig. 3). Lowering the clipping height increased the proportion of clover harvested in the 2 grass dominated associations (data not presented) and could explain this trend. Lowering clipping height produced a similar trend in a Kentucky bluegrass/white clover pasture (Robinson et al. 1952). In contrast, clipping height did not affect CP concentration in the sedge association in the same manner throughout the growing season (Table 1). Forage CP concentration of the sedge association decreased with decreasing clipping height at the first clipping date, was not affected by clipping height at the second clipping date, and increased with decreasing clipping height at the third clipping date (Fig. 3). Decline in forage CP of the sedge association at the first harvest date with decreasing clipping height was probably due to the presence of older plant material in the lower sections of the sward. Higher forage CP concentration at lower clipping heights in late summer may be due to increased regrowth of the sedge association with lower clipping height.

Clipping date had a greater effect on forage crude protein (CP) concentration than did clipping height (Fig. 3). Crude protein concentration of all associations increased from the first clipping date to the second and declined at the third. This does not agree with Kirby et al. (1989) who found CP of various wetland species to decline linearly with season. Similarly, Mason and Lachance (1983) found that CP content of Kentucky bluegrass declined curvilinearly as season progressed. Lower CP values in the first harvest may be due to the presence of regrowth following the last

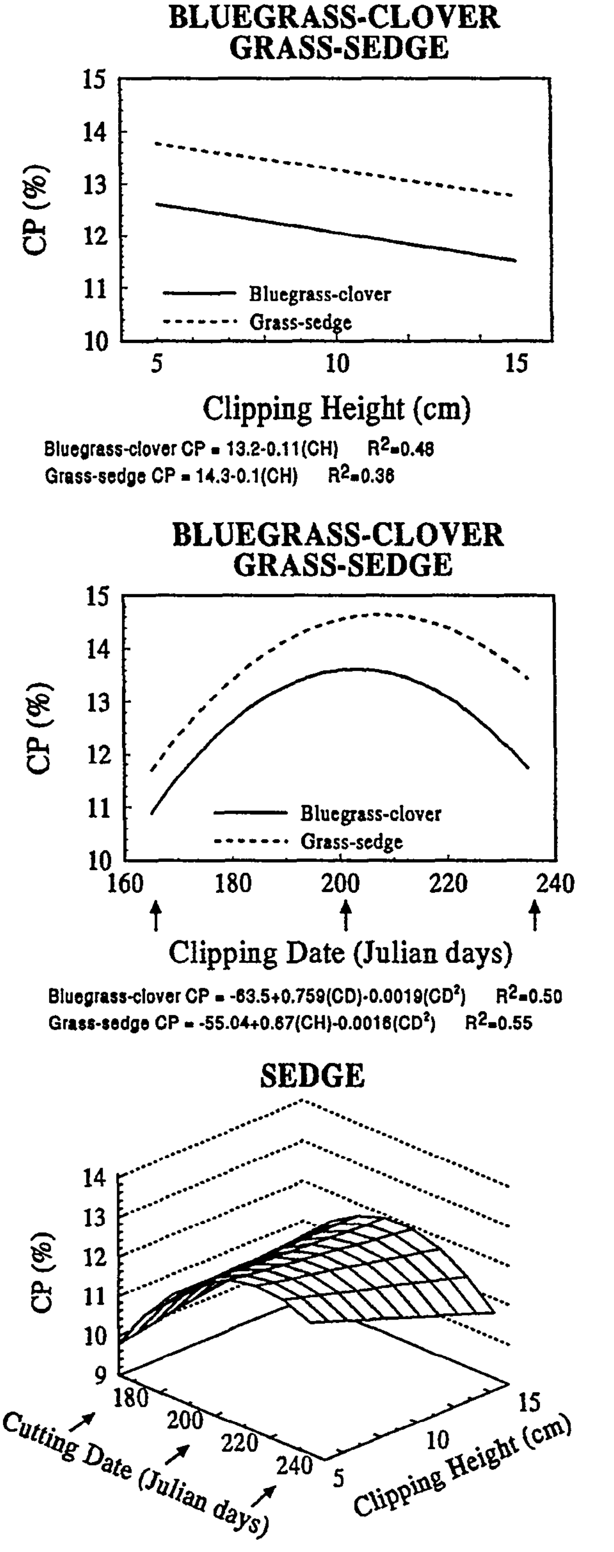


Fig. 3. Crude protein concentration of three wetland meadow plant associations in Klamath County, Ore. as affected by clipping date and clipping height. Measurement dates are marked with arrows for June, July, and August, respectively.

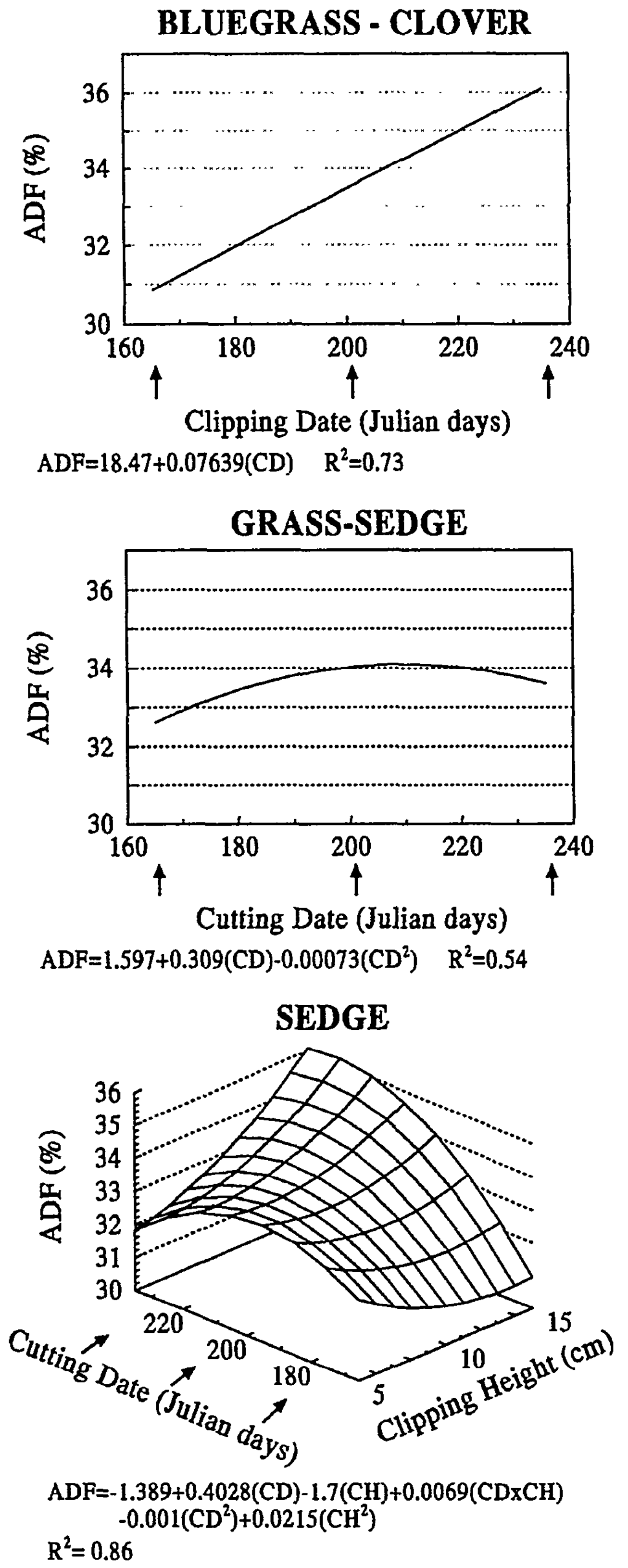


Fig. 4. Acid detergent fiber concentration of three wetland meadow plant associations in Klamath County, Ore. as affected by clipping date and clipping height. Measurement dates are marked with arrows for June, July, and August, respectively.

harvest the preceding fall as well as older plant tissue from growth in the early spring. Plant growth initiated in April so that some plant material from the June harvest was older than in subsequent harvests.

The acid detergent fiber (ADF) in harvested herbage of the 3 associations responded quite differently to clipping date and clipping height (Table 1). Clipping height did not significantly affect ADF of the bluegrass-clover or grass-sedge associations, but was a significant component of the sedge association ADF response surface (Fig. 4). The sedge ADF response to clipping height was not consistent across clipping dates (Table 1). Sedge ADF decreased with increasing clipping height in the first clipping, but increased with increasing clipping height in the second and third clippings. This trend is similar to the response of sedge crude protein concentration to clipping date and clipping height. Bluegrass-clover ADF increased in a linear fashion across clipping dates, while both the grass-sedge and sedge associations showed curvilinear reponses to clipping date. ADF of the grass-sedge association increased from the first clipping date by the third clipping date. The sedge association reacted similarly at the 5 and 10 cm clipping heights. The 15 cm clipping height in the sedge association decreased in ADF from the first to the third clipping dates (Fig. 4).

Summary and Conclusions

Highest forage yield, regrowth following clipping, and overall forage quality were obtained at the 5 cm clipping height in all associations. The 5 cm clipping height did not appear to reduce stand vigor or persistence as indicated by high forage yields in the third year of the study. Animal performance in a short duration grazing system would also be expected to be highest at the 5 cm clipping height since forage production was greatest at this defoliation intensity without decreasing forage quality or availability. Acid detergent fiber of the sedge association was lower than the 2 grass dominated associations, and sedge crude protein content was slightly lower than the other 2 associations.

Season-long average herbage residue at the 5 cm clipping height was 1.8, 2.0, and 1.5 Mg ha^{-1} for the bluegrass-clover, grass-sedge, and sedge associations, respectively. It may be possible through short duration grazing to control defoliation intensity of the diverse plant associations in a wetland meadow. In such a system, grazing to a 5 cm stubble height would produce the highest forage yield with no decrease in forage quality, forage availability, or stand vigor. This would probably result in highest animal performance as well; however, validation of this assumption will require grazing trials in this environment.

Literature Cited

Bremmer, J.M. and A.P. Edwards. 1965. Determination and isotoperation analysis of different forms of nitrogen in soils: I. Apparatus and procedures for distillation and determination of ammonium. Soil Sci. Soc. Amer. Proc. 29:504–507.

Cooper, C.S. 1956. The effect of time and height of cutting on the yield, crude protein content, and vegetative composition of native flood meadow in Eastern Oregon. Agron. J. 48:257–258.

Cooper, C.S. 1979. Yields of irrigated grass and legume pasture mixtures in the Northern Rocky Mountain area. Agron. J. 71:885–888.

DePeters, E.D. and E.M. Kesler. 1985. Yields and nutritive value of cuttings of permanent pasture harvested as dry forage. J. Dairy Sci. 68:996–999.

Harrington, F.J. and R.C. Binnie. 1971. The effect of height and frequency of cutting on grass production, p. 17–24. *In:* 44th Ann. Rep. Agr. Res. Inst., Northern Ireland.

Kirby, D.R., D.M. Green, and T.S. Mings. 1989. Nutrient composition of selected emergent macrophytes in northern prairie wetlands. J. Range Manage. 42:323–326.

Mason, W. and L. Lachance. 1983. Effects of initial harvest date on dry matter yield, in vitro dry matter digestibility, and protein in timothy, tall fescue, reed canary grass, and Kentucky bluegrass. Can. J. Sci. 63:675–685.

Milligan, K. 1981. Herbage residue: A guide to improvement. New Zealand J. Agr. 142:39–42.

Nelson, D.A. and L.E. Sommers. 1980. Total nitrogen analysis of soil and plant tissues. J. Assoc. Off. Anal. Chem. 4:700–778.

Nicol, A.M. 1987. Livestock feeding in pasture. Occasional Publication No. 10, New Zealand Soc. of Anim. Prod.

Reid, D. 1966. Studies on cutting management of grass clover swards. 4. The effect of close and lax cutting on the yield of herbage from swards cut at different frequencies. J. Agr. Sci. 66:101–106.

Robinson, R.R., V.G. Sprague, and A.G. Lueck. 1952. The effect of irrigation, nitrogen fertilization, and clipping treatments on persistance of clover and on total and seasonal distribution of yields in a Kentucky bluegrass sod. Agron. J. 44:239–244.

Rumberg, C.B. 1972. Yield and N accumulation of meadow forage fertilized at advancing maturity with N. Agron. J. 64:187–189.

Smethen, M.L. 1990. Pasture management, p. 197-240. *In*: R.H.M. Langer (ed), Pastures, their ecology and management. Oxford University Press, Oxford.

Smith, D., A.V.A. Jacques, and J.A. Balasko. 1973. Persistence of several temperate grasses grown with alfalfa and harvested two, three, and four times annually at two stubble heights. Crop Sci. 13:553–556.

Snedecor, G.W. and W.G. Cochran. 1980. Statistical methods, seventh edition. Iowa State Univ. Press. Ames, Iowa.

Steel, R.G.O and J.H. Torrie. 1980. Principles and procedures of statistics, second edition. McGraw-Hill Book Company, N.Y.

Thompson, K.F. and D.P. Poppi. 1990. Livestock production from pasture, p. 263–283. *In:* R.H.M. Langer (ed), Pastures, their ecology and management. Oxford Unviersity Press, Oxford.

Van Soest, P.J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. Assoc. Off. Agr. Chem. 46:829–835.