April 1995

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Abstract: Evaluation of crop loss caused by mule deer (*Odocoileus hemionus*) grazing on alfalfa grown for seed harvest was studied in northern Utah. Results indicated (1) wire baskets used to protect non-grazed plots did not affect alfalfa production, and (2) alfalfa seed crop loss was directly correlated with alfalfa hay crop loss. Consequently, methods used to evaluate crop loss to alfalfa hay may be applied to alfalfa seed.

Pages 56-59 *in* R.E. Masters and J.G. Huggins, eds. Twelfth Great Plains Wildl. Damage Control Workshop Proc., Published by Noble Foundation, Ardmore, Okla.

Key Words: alfalfa, alfalfa seed production, big game, damage evaluation, depredation, mule deer, *Odocoileus hemionus*.

Although big game depredation of commercial crops is at the forefront of wildlife related problems (Reed 1981, Matschke et al. 1984, Toweill 1988, Conover and Decker 1991), no literature is available on the effects of grazing by wild ungulates on production of alfalfa seed. Austin and Urness (1987*a*) suggested estimating big game caused seed loss from depredation by big game by using the same proportion as the estimated alfalfa hay loss.

Forage consumption of fresh alfalfa hay by mule deer (*Odocoileus hemionus)* was reported as 1.1-1.5 kg/100 kg body weight, varying by alternative available feed (Austin and Urness 1987*b*), and about 1.1 kg/100 kg body weight using fecal material to estimate percent alfalfa hay contribution to the diet (Tebaldi and Anderson 1982). Estimates of alfalfa hay consumption/deer-night of grazing in fields were 1.4 kg in Wisconsin (Mullen and Rongstad 1979), 1.6 kg in Wyoming (Demaree and Fagan 1982), and 0.8-1.5 kg in Utah (Austin and Urness 1992). An estimate of total alfalfa hay loss/deer-night was 2.2 kg (Austin and Urness 1993), based on consumption, trampling and bedding, impacts on alfalfa growth potential, and spotlight counts (Bartmann 1974), which inherently fail to count all deer using fields.

Grazing of field-growing alfalfa hay by deer has been shown to significantly reduce yield. Using protected plots, Palmer et al. (1982), Austin and Urness (1993), and Mullen and Rongstad (1979) reported significant losses ($P < 0.05$) when measured crop use exceeded about 15, 18, and 20%, respectively. The objective of this study was to evaluate the effects of grazing by mule deer on alfalfa seed production, thereby providing essential information to wildlife managers and landowners for estimating crop loss. This report is a contribution of the Utah State Division of Wildlife Resources, Federal Aid Project W-105-R.

METHODS

Trials Using Basketed And Non-basketed Plots

In 1989, immediately following cutting and removal of the first alfalfa hay crop, 2 fields (trials 1-2) were selected for study. At each field, 2 adjacent, 0.4-ha square paddocks were marked at the corners with steel posts. Paddocks within fields were visually paired to be equal in production. To exclude all grazing, 1 randomly selected paddock in each field was fenced with 2.4 m high, 15 cm mesh woven-wire. Within each paddock, 1-m^2 circular plots were marked with wooden stakes arranged on an equally spaced 10 X 10 grid. Alternate plots were protected with 1.2 m woven-wire baskets secured with 2 steel posts. Because of the close proximity (about 6 m) between plots and uniformity of the stand following alfalfa hay removal, each set of 2 plots was considered a block.

All plots were clipped at ground level a few days before scheduled commercial alfalfa seed harvest, and plot samples were placed in paper bags. Seeds from all plots were separated from alfalfa hay using a hand-fed thresher. Net weights of alfalfa hay and seed were determined. Following plot clipping, seed was commercially harvested on each paddock by first combining around the outside perimeter, followed by thoroughly cleaning all seed from the combine, and secondly, by separately combining, removing, and weighing the seed harvested from each paddock.

Trials Using Grazed And Basketed Plots

In 1990, 3 0.4-ha square paddocks were enclosed with a 2.4-m high, 15-cm mesh woven-wire fence. These paddocks were on the same fields as those used the previous year, but paired paddocks were not established outside the enclosures. Paddocks were established to obtain exact deer-nights of grazing and to exclude grazing by other ungulates. Paddock fences were built immediately following removal of the first alfalfa hay crop.

In trial 3, 1-m^2 plots were established on a 10 X 10 grid as in trials 1 and 2. However, treatments included protected and those grazed only during vegetative growth. That is, to specifically evaluate the effects of grazing before flowering, grazing was discontinued after flowering began.

In trials 4-5, plots were established on a 15 X 15 equally spaced grid. Treatments included protected, continuously grazed, grazed only during vegetative growth, grazed only during flowering, and grazed only during seed-set. A randomized block design was used for each set of 5 plots within rows, with 3 blocks/row. Plots were cut and samples treated similarly to trials 1 and 2.

Tame mule deer were used to graze paddocks in trials 3-5. Deer were acclimitized to each area in small holding enclosures containing alfalfa and connected to the paddocks. To simulate range conditions and animal behavior, access to paddocks was allowed only between sunset and sunrise. During nighttime grazing periods, deer had free access to paddocks. During the daytime, deer were restricted to holding enclosures, where water and a balanced-ration pelleted feed were available ad libitum.

Plots from trials 3-5 were cut and samples treated similarly to trials 1 and 2. In trials 3-5 fecal pellet groups were removed from paddocks prior to sampling and pellet groups were counted following commercial harvest. In each paddock, counts were made by dividing and marking the area with rope into 16 strips about 4 m wide. All groups within each strip were counted.

Analyses

For trials 1 and 2, data from clipped plots were analyzed using single classification ANOVA to determine the effects of treatments. Similarly for trials 3-5, data were analyzed using single classification ANOVA with unequal sample sizes. Paddocks were considered as experimental units in both ANOVAs.

Because of the low number of replications, we also analyzed data within paddocks using a pseudoreplication design (Hurlbert 1984) with plots as experimental units. For trials 1-3, we used t-tests for paired comparisons between basketed, and non-basketed or grazed plots. For trials 4-5, we again used single classification ANOVAs to determine treatment effects. The relationship between alfalfa hay and seed production was obtained using the coefficient of determination for each treatment within paddocks.

RESULTS AND DISCUSSION

Trials Using Basketed And Non-basketed Plots

Results from 1989, where plots were clipped within fenced paddocks, showed no differences between basketed and non-basketed plots among ($F = 0.0$; 1 df; $P > 0.50$) or within ($t = 0.09, 0.23$; 49 df; $P > 0.50$) paddocks (Table 1). Commercial harvest of seed in trials 1 and 2 yielded alfalfa seed at 20.0 and 7.1 g/m^2, which were within 1 standard error of the means for plot samples. Plot data from unfenced paddocks were invalid because of trespass livestock grazing and are not presented.

Our results indicated the technique of using 1-m^2, circular plots to test for effects of deer use of field-growing alfalfa would not be affected by the plot and wire sizes we selected. In contrast, Owensby (1969) and Heady (1957), using different plot materials and designs, showed increased herbage yields on prairie and annual grass ranges, respectively. However, our high variability between plots, as indicated from the standard errors (Table 1), suggests that a large number of plots would be needed to detect significant differences, especially on areas where big game grazing is light. Austin and Urness (1993) reported similar conclusions.

Trials Using Grazed And Basketed Plots

Deer-nights of grazing were high with use exceeding 120 deer-nights/ha on all grazing treatments (Table 1). The continuously grazed treatments received about 400 deer-nights/ha. Assuming a 50-day growing period, about 2.5 and 8 deer/ha/night would be needed to obtain these intensities of use, which are typically and infrequently, respectively, reached in Utah (Austin and Urness 1993).

Grazing by tame mule deer in trials 3-5 caused differences in alfalfa seed production among treatments ($F = 3.6$; 4,7 df; $P = 0.07$). Continuous grazing and grazing during the flowering and seed-set phenological stages caused decreased seed production compared with the protected treatment ($F = 23.9, 15.6, 15.3$; 1,7 df; $P < 0.01$). No differences in seed production were detected between continuous grazing, flowering, or seed-set grazing treatments, and no differences were detected between vegetative grazing and protected treatments. Unfortunately, because commercial harvest of paddocks was delayed several weeks due to mechanical breakdown and inclement weather, considerable seed shatter occurred, and no comparisons could be made with clipped plots.

Within paddocks, most treatment effects were clearly defined. In trials 4-5, treatment effects differed ($F = 8.6, 15.1$; 4,220 df; $P < 0.01$). Comparisons of seed production between the protected treatment and continuous, flower, or seed-set grazing treatments were all different ($F = 6.6$; 1,220 df; $P < 0.01$). With deer use near the same level for the flowering and seed-set grazing treatments, no differences were found in either trial. However where grazing was heaviest, seed production under the continuous grazing treatment was lowest and different from all other treatments in trial 5 ($F > 4.2$; 1,220 df; $P = < 0.04$), but not trial 4.

Grazing by deer during the vegetative growth stages before flowering produced inconclusive results from trials 3-5 (Table 1). That is, grazing caused no change, a significant decrease, and a significant increase in production of seed, respectively. The data suggest that grazing during the vegetative stage has less effect on seed production compared with grazing during later phenological stages. One explanation is that grazing early may reduce plant biomass, which reduces transpiration losses during the warmer mid-summer period, and soil moisture may be used more efficiently for growth and seed production during the cooler, late-summer period.

In 1990, the number of pellet groups/deer-night were 4.9, 8.2, and 6.8 ($\bar{x} = 6.6$; SE = 1.7, $n = 3$) for trials 3-5, respectively. This value was lower than the commonly used average of 13.0 pellet groups/deer-day (Smith 1964, Neff 1968, Collins and Urness 1981), because it represents only nighttime defecations, and was also decreased by machine disturbance of the ground through harvest of alfalfa. Nonetheless, assuming constant defecation rates and similar harvest disturbance, pellet-group counts may serve as a very rough approximation of deer use after harvest of alfalfa seed.

The coefficients of determination between the production of alfalfa hay and seed ($r^2 = 0.67$; SE = 0.12; $n = 16$) suggest reasonable determinations of alfalfa seed loss could be obtained by using the same proportion as estimated for alfalfa hay loss. Either the nighttime count or basket methods could be used. When the nighttime count method is used, because of the destruction of alfalfa hay during seed harvest, an estimate of hay production must be obtained from a minimum of 10 plots, clipped at cutter blade height just prior to harvest, or an estimated production must be assumed (Austin and Urness 1992).

RECOMMENDATIONS

Based on data from this study, our previously suggested method (Austin and Urness 1987*a*) for estimating crop loss from big game depredation of alfalfa hay harvested for seed, remains the best approach. Based upon the moderately high correlation between alfalfa hay and seed production, hay and seed losses are approximately proportional. Consequently, only the percentage of production loss to alfalfa hay from depredation and total commercial production of seed on grazed fields needs to be determined. We suggest using the nighttime count method to determine alfalfa hay loss, rather than basketed

Table 1. Alfalfa seed production by treatment (g/m²), indexes of mule deer use, deer-nights/ha (dn/ha) and pellet-groups/ha (pg/ha), and coefficients of determination (r^2) between alfalfa hay and seed production.

		Trials[a]				
Treatments	Parameters	1	2	3	4	5
	Year	1989	1989	1990	1990	1990
	n	100	100	100	225	225
	pg/ha	—	—	803	3,220	3,079
Protected	$\bar{x}$	17.2A	11.3A	—	—	—
(basket exclosure)	SE	8.1	4.5	—	—	—
	r^2	0.5	0.5	—	—	—
Protected	$\bar{x}$	17.1A	11.1A	—	—	—
(exclosure only)	SE	6.6	4.2	—	—	—
	r^2	0.6	0.7	—	—	—
Protected	$\bar{x}$	—	—	7.2A	8.4A	12.2A
(basket only)	SE	—	—	4.3	5.7	6.7
	r^2	—	—	0.6	0.8	0.8
Grazed	$\bar{x}$	—	—	—	4.6B	4.6D
(continuously)	SE	—	—	—	3.1	3.5
	r^2	—	—	—	0.7	0.7
	dn/ha	—	—	—	390.0	450.0
Grazed	$\bar{x}$	—	—	10.5B	8.4A	8.8B
(vegetative only)	SE	—	—	4.7	4.6	5.0
	r^2	—	—	0.6	0.8	0.7
	dn/ha	—	—	166.0	133.0	143.0
Grazed	$\bar{x}$	—	—	—	5.0B	7.7BC
(flowering only)	SE	—	—	—	3.1	4.3
	r^2	—	—	—	0.6	0.6
	dn/ha	—	—	—	133.0	133.0
Grazed	$\bar{x}$	—	—	—	6.2B	6.7C
(seed set only)	SE	—	—	—	3.5	4.1
	r^2	—	—	—	0.9	0.7
	dn/ha	—	—	—	124.0	173.0

[a] Within column means with the same letter were not different at $P > 0.05$.

plots methods (Austin and Urness 1992). However, because the impacts of grazing may not be detrimental to seed production during vegetative growth, counts of big game may not need to begin until the onset of the flowering phenological stage.

A final alternative to determine alfalfa hay and seed loss via estimating deer-nights of grazing, when nighttime count or basket data is unavailable, is to use fecal pellet-group counts. Our data suggest that fecal pellet-group counts taken after harvest of seed and converted at 6.6 pellet-groups/deer-night, may be used as a rough approximation.

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