Reproductive Potential Of Four Annual Range Grasses As Influenced By Season Of Clipping Or Grazing[1]

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Seed production of annual grasses, so necessary for their persistence on the range, is markedly affected by grazing. Timing of herbage removal is a method of encouraging or depressing the annual species. The degree of success achieved by this means rests on understanding the nature of response by individual species. The objective of the present investigation was to determine the effect of clipping or grazing over different portions of the growth cycle on the reproductive potential and vigor of four annual grasses common on California ranges. The grasses studied were soft chess *(Bromus mollis)*, ripgut brome *(B. rigidus)*, Mediterranean barley *(Hordeum hystrix)*, and wild oats, which included common *(Avena fatua)* and slender *(A. barbata)* wildoat. The two oatgrasses were considered together. Their prevalence has been ex-

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pressed by Burcham (1957) in the average percent composition of California's grasslands: soft chess 26.8, wildoats 16.0, ripgut brome and red brome *(Bromus rubens)* 9.5, and barley spp. 6.3 percent.

The vegetative complex of which these grasses are a part is dynamic and fluctuating in nature. Talbot *et al.* (1939) observed that variable weather and grazing treatment produced changes — swift and erratic — in the composition of the annual cover. Such changes are in part a result of the relative ability of parent plants to produce seed under grazing stress. The relative proportion of species for the entire growing season is established before December each year and is due in part to differences in the amount of viable seed produced the previous year (Heady, 1958). Regardless of the severity of weather, or grazing pressure, seldom is an annual seed crop too small to result in an adequate cover the following year. Burcham (1957) has written, "the annuals both introduced and native are favored by their extremely short life cycle and their ability to produce seed under incredibly adverse conditions . . . ."

Sampson (1914) observed that the vigor of vegetation and the time and abundance of flower-stalk production was strongly influenced by the way lands were grazed. Among a number of criteria employed to appraise vigor, indicated by Hanson (1957), was the number and condition of flower stalks. Hurd (1959) found herbage weight, leaf height, and number of flower stalks to be highly correlated in a study of Idaho fescue. Control of grazing to increase or maintain seed production by the desirable species is a vital principle in range management. This has been pointed out by Jones and Love (1945) who state, "clearly any palatable species, whether annual or perennial can be encouraged or discouraged by the time and severity of grazing applied to it . . . if it is an undesirable species it should be discouraged from seeding for reproduction . . . if it is a species to be encouraged, then it should be allowed to nourish itself and to seed."

The period of reproduction is one of the most critical in the life cycle of a grass. Animals may graze the plant so heavily at this time as to consume the seed stalks before seed is dropped, or may so disturb the normal functioning of the plant that no seed is produced (Stoddart and Smith, 1955). Studies on the pasturing of fall-sown small grains have revealed that if grazing is continued so long that the young, developing floral primordia are removed, grain can be produced only from new tillers with a considerable reduction in yield (Sprague, 1954). Work by Laude *et al.* (1957) indicated a similar response by certain annual grasses to clipping. Hulbert (1955) concluded from his studies on annual brome *(Bromus tectorum)* that, in general, the possibility of regeneration following clipping decreased as the plants advanced in development through flowering to fruiting.

Material and Methods

In order to evaluate and compare the four grasses, two study areas were established in 1959, one as a cultivated nursery on fine sandy loam soil at the University of California farm, the other on a range pasture located on a gravelly clay terrace soil six miles northwest of Davis. Although 1.83 inches of rain fell in September 1959, no effective precipitation was received again until late December. Monthly precipitation in inches from December through May 1960, was 1.46, 3.25, 3.43, 1.14, 0.90, and 0.54. Temperatures were unfavorably cool and germination was slow. Emergence was not evident until mid-January.

Nursery Plots

The nursery, planted on October 17, 1959, was composed of four treatment blocks, each with twelve uniform rows, five feet in length and 24 inches apart. Within each block, three replica-

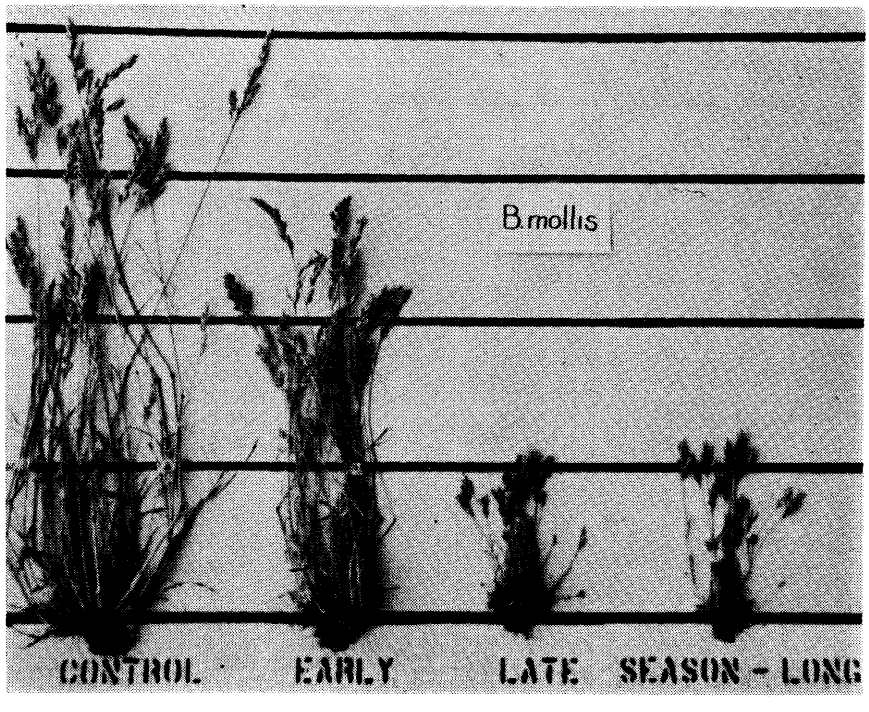

FIGURE 1. Representative plants of soft chess at maturity. Background lines are 6 inches apart.

tions of each of the four species were sown in a randomized pattern. After emergence, each row was thinned to 12 plants, and kept weed-free. Seed for nursery plantings was collected in the Davis area for all but soft chess for which commercial seed was used. Of the two species of *Avena* only common wildoat was studied in the nursery.

Herbage was removed by weekly clipping at one-half to three-fourth inches above soil surface to simulate frequent, close grazing or mowing. Four treatments were applied, one to each block. These were "control", which remained unclipped; "early"-clipped from March 1 to April 5; "late"-clipped from April 12 to May 10; and "season-long"-clipped from March 1 to May 10. Clipping began for early and season-long treatments when seedlings reached a mean height of four inches. The durations of the treatments were based on regrowth height and heading tendency. The cessation of early and commencement of late treatments were placed at about the mid-point in the life cycles of the species. Clipping of the late and season-long blocks was stopped when it was estimated that plants could still bear inflorescences in regrowth.

Following the termination of each treatment, the heads produced in regrowth were allowed to mature. Number of heads, height of the tallest head and, with the exception of Mediterranean barley, number of spikelets per panicle and 100-seed weight were taken for each of the 10 center-most plants in each row. Head height refers to the distance from soil surface to the top of the tallest inflorescence extended vertically. After height measurement, heads were removed and placed in bags for later counts of spikelets and determination of 100-seed weights. Since the seed of the wildoat does not adhere to the panicle after maturity, it was collected at intervals as it matured. Weight of seed was based on 600 filled florets except with the wildoat and ripgut brome from late and season-long treatments where fewer filled florets could be recovered.

Range Plots

The range study was situated on a 24-acre pasture having a cover density estimated at 80 percent. Composition of this cover as determined by step-point transects was 45 percent forbs, 30 percent soft chess, 10.5 percent ripgut brome, 8.5 percent legumes, 3 percent wildoat, 1.5 percent Mediterranean barley, and 1.5 percent other grasses. The pasture in recent years had been heavily grazed from January to June by from 60 to 75 ewes and their lambs, and used for year-round maintenance for a dozen other sheep.

Sixteen plots 7 feet square were located so as to include the four grasses studied (two species of *Avena* treated as one). Four-plot replicates were designed for each of four treatments: grazed "early" in the season, "late" in the season, "season-long", and ungrazed "control". Wire exclosures provided protection from grazing when desired. These were placed on the control and late treatment plots in December, prior to emergence of growth. Sheep were on the pas-

Table 1. Mean values for selected characteristics in the regrowth following four clipping treatments.

Species	Treatment	Height of tallest head/plant (inches)	Heads/plant (number)	Spikelets/head (number)	100-seed weight (grams)
Wildoat	C[1]	42.6[2] a[3]	24.8 a	32.6 a	3.36 a
	E	29.2 b	24.0 a	15.4 b	2.08 b
	L	11.2 c	3.3 c	5.1 c	1.13 c
	SL	15.4 c	8.7 b c	5.9 c	1.32 c
Soft chess	C	26.2 a	39.3 a	50.9 a	0.21 a
	E	17.8 b	30.3 b	25.8 b	0.17 b
	L	7.4 c	22.6 c	10.2 c	0.15 b
	SL	8.1 c	18.7 c	10.9 c	0.16 b
Ripgut brome	C	33.6 a	36.6 a	33.4 a	1.23 a
	E	22.5 b	40.8 a	16.1 b	1.25 a
	L	5.2 c	11.5 b	4.4 c	0.64 c
	SL	5.7 c	8.3 b	4.9 c	0.95 b
Mediterranean barley	C	17.5 a	125.5 a	.....	.....
	E	13.6 b	88.6 b	.....	.....
	L	3.5 c	12.1 c	.....	.....
	SL	4.6 c	21.9 c	.....	.....

[1]C = unclipped control; E = early; L = late; SL = season-long clipping.

[2]Mean of 30 measurements.

[3]1% level by Duncan's Multiple Range Test. Means in each test group are significantly different unless followed by the same letter.

ture at this time and by February 1, 50 ewes and their lambs were grazing the area. Twenty six additional head were added before March 1 and on March 26 the entire band was removed. To this date, the vegetation was kept cropped to a mean height of about 1 inch, but by April 9 when the sheep returned plant height had reached 3 inches and grasses were heading-out. At this time exclosures were placed around early plots and removed from those to be subjected to late grazing until sampling in late May, after which it was believed little regrowth on these and season-long plots would take place.

Sampling consisted of the collection of 25 plants of each species from every plot by inserting a point-step pin into the plot five times in a random fashion and removing the five plants of each species nearest the pin. Plants were saved and height of the tallest head, number of heads per plant and, except for Mediterranean barley, number of spikelets per plant recorded later. Due to low production per head, spikelets were counted on a per plant basis.

Data for both the nursery and range plot studies were tested by analysis of variance applied to the treatment means for each of the measurements on each of the four grasses studied. Duncan's multiple range test was used to separate means when significance resulted.

Results and Discussion

Nursery Plots

The effects of season of clipping on the characteristics of subsequent regrowth are presented in Table 1. In general, similar patterns in results for all species were noted for the four measurements considered. In all comparisons but that for 100-seed weight of soft chess, means for late and season-long treatments were clearly separated from values for control and early clipping. In all but two comparisons the late and season-long treatments did not differ significantly; in the two exceptions the late treatment was more depressing than the season-long. Values for controls were significantly different from those for early treatments in all but three of the fourteen comparisons. Representative plants of soft chess photographed at maturity are shown in Figure 1 to exemplify the response by the grasses to clipping treatments.

The patterns followed by head height and number of spikelets were remarkably parallel and appeared highly correlated, reflecting the severity of treatment. The values for number of spikelets per panicle are portrayed for example in Figure 2. Means for head height and spikelet production on late and season-long treatments were less than 53 percent of the values for the grasses clipped early which were, in turn, less than 78 percent and 51 percent respectively, of those for the controls. The taller, more robust culms bore more spikelets per inflorescence. This agrees with the evidence reported by Laude *et al.* (1957) on decreased spikelet weight per panicle in annual bromes subjected to late clipping. The similarity in behavior among the species studied suggested that these characteristics have indica-

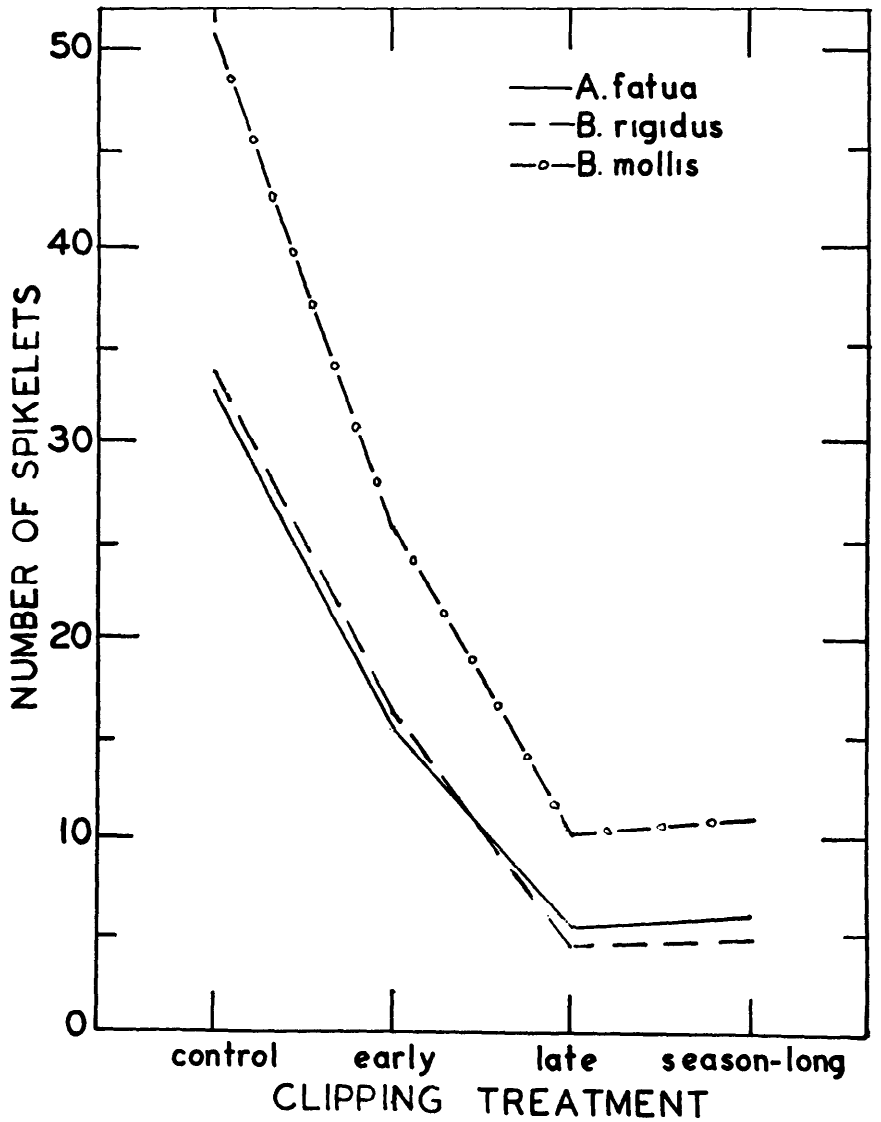

FIGURE 2. Spikelet production per panicle following clipping treatments.

Table 2. Mean values for selected characteristics in the regrowth following grazing treatments.

Species	Treatment	Height of tallest head/plant				Heads/plant				Spikelets/plant			
		(inches)				(number)				(number)			
Wildoat	C[1]	16.7[2]	a[3]			1.23	a			5.93	a		
	E	12.9		b		1.33	a			3.81	a		
	L	11.2		b		1.40	a			3.63	a		
	SL	7.1			c	1.39	a			2.79	a		
Soft Chess	C	7.9	a			1.00		b		2.53		b	
	E	8.2	a			1.04	a	b		4.68	a		
	L	5.3		b		1.03	a	b		1.63		b	
	SL	4.6		b		1.06	a			2.98		b	
Ripgut brome	C	10.3	a			1.00	a			2.41	a		
	E	9.6	a	b		1.05	a			2.97	a		
	L	7.6		b	c	.99	a			2.06	a		
	SL	5.8			c	1.01	a			2.11	a		
Mediterranean barley	C	6.3	a			1.01		b		.....			
	E	6.5	a			1.24		b		.....			
	L	6.8	a			1.11		b		.....			
	SL	4.4		b		1.67	a			.....			

[1]C = ungrazed control; E = early; L = late; SL = season-long grazing.
[2]Mean of 100 measurements.
[3]5% level by Duncan's Multiple Range Test. Means in each test group are significantly different unless followed by the same letter.

tor value in estimating vigor of annual grasses.

Number of heads per plant and 100-seed weight followed essentially the same pattern as head height and number of spikelets. While all species showed a large depression in head number due to late clipping, no clear explanation was apparent for other differences. Grasses clipped late in growth produced seed of significantly lighter weight with more unfilled florets than those not clipped. Reduction in seed quality due to foliage removal has been recognized in previous studies. Sampson (1914) found that grazed plants of low vitality were likely to produce flower stalks so late in the season that the seed could not fill and mature properly. Sprague (1954) hypothesized that the stored carbohydrates utilized during tiller formation following late grazing of cereals could not, therefore, be directed toward filling-out the grain.

Range Plots

The extent to which variability could be reduced on the range was limited since the use of natural stands for study of individual plants presented problems in experimental procedure and sampling techniques, and the sheep did not impose a uniform degree of grazing on the plots, particularly as the season advanced. Measurements and analyses were made in a similar manner to those in the nursery study. Table 2 presents the results.

Maximum head height appeared to have been most influenced by the grazing treatments. For all species the ungrazed plants produced significantly taller heads than those under season-long treatment, and the association of reduced height with later grazing was indicated. Less difference among treatments and indication of higher values for head height on late-grazed plots may be a reflection of selective grazing. Earlier commencement of the late season treatment might have reduced this factor. There is a suggestion in Table 2 that grazing resulted in increased heading per plant, with some significance for this being revealed by soft chess and Mediterranean barley. Although means for number of heads and spikelets per plant differed noticeably for the wildoat, extreme variability in replicate data resulted in lack of significance. Plant competition and micro-habitat variation most certainly contributed to this result. Soft chess, however, responded with a significant increase in spikelet number with early grazing while ripgut brome showed no significant change in head or spikelet production under the treatments.

Although it is recognized that annual grasses exhibit less regrowth potential following clipping or grazing at progressively advanced stages from flowering to fruiting, the reasons are not clearly understood. Among possible considerations on this point, however, must be the repeated removal of photosynthetic tissue and floral buds, depletion of stored food reserves, effect of a changing environment through the growing season, and the general maturity and senescence of the organism. More investigation along these lines would undoubtedly be rewarding, particularly in reference to the relative reproductive potentials of the species making up the complex on our annual ranges.

Summary

Nursery and range studies were conducted on four annual range grasses to measure plant responses indicative of reproductive potential and vigor. The nursery plots were clipped, the range plots were grazed by sheep. Treatments in both areas consisted of foliage removal in the early or late portions of the growing season, or season-long.

In the nursery and on the range late and season-long use reduced head height and number of spikelets produced. In the nursery where by virtue of re-

duced variability, treatment means were more distinct, these periods of use also reduced head number per plant and 100-seed weight. These results contribute to an understanding of the way season of grazing may encourage or discourage an annual species.

The four species studied responded in like manner with regard to head height and spikelet numbers. This similar behavior supports the view that these are characteristics of value in estimating vigor in annual grasses.

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