Perennial Irrigated Pastures. I. Plant, Soil Water, and Animal Responses Under Rotational and Continuous Grazing[1]

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ABSTRACT

Continuous grazing favored strawberry clover (*Trifolium fragiferum* L. 'Salina'), and rotational grazing (5-field; 1-week grazing, 4-week recovery) favored Ladino clover (*T. repens* L.) in a sward containing Ladino clover, 'Salina' strawberry clover, orchardgrass (*Dactylis glomerata* L.), and perennial ryegrass (*Lolium perenne* L.). A 2-field rotation (1-week, 1-week) favored strawberry clover but had less influence on botanical composition than either 5-field rotation or continuous grazing. Continuous grazing resulted in a higher percentage of plant cover than did 5-field rotational grazing. Yields of beef per unit area were similar under the three systems. Water infiltration increased progressively during the 4 years of the experiment, and final infiltration rates were 2 to 3 cm/hr in both continuous and rotationally grazed pastures.

Additional index words: **Beef from pasture, Plant competition, Infiltration, *Trifolium, Dactylis, Lolium.***

DESPITE years of research, there does not appear to be a clear consensus regarding the relative merits of continuous and rotational systems of grazing. Limitations imposed by experimental procedures, or simply the sheer magnitude of studying adequately all the important variables in a single experiment (9), often deny well-intentioned objectives. Spedding (7) contends that the grazing system is less important than the combined influences of plant and animal physiology. Models have been formulated which indicate that, with a number of assumptions and simplifications, gains per unit animal and per unit area can be related to stocking rate by a combination of linear and nonlinear formulas which reveal discontinuities at the "optimum" or "critical" stocking rate (5, 6). The fact that much available experimental data do not readily fit these models indicates that response at the animal level can "plateau" over a fairly wide range of stocking rates. It is still tenable, however, to investigate the influence of systems of grazing management on aspects of the pasture ecosystem, which, while not influencing animal gains at first, may influence the level of primary productivity significantly (and therefore animal yields) at a later date.

The purpose of the experiment reported here was to determine whether, under a common stocking rate in both systems, the management alternatives of continuous grazing (CG) and rotational grazing (RG: 5-field; 1-week grazing, 4-week recovery, or 2-field; 1-week, 1-week) of irrigated pastures differed appreciably in their influence on sward composition and condition, and on irrigation requirements.

MATERIALS AND METHODS

The experimental pasture was located at Davis, California, on Yolo clay loam, a deep alluvial soil of generally favorable physical characteristics. The area had previously been planted to row crops, barley, and alfalfa.

A uniform new seeding of Ladino clover (*Trifolium repens* L.), strawberry clover (*T. fragiferum* L. 'Salina'), orchardgrass (*Dactylis glomerata* L.), and perennial ryegrass (*Lolium perenne* L.) was made in October 1965, at rates of approximately 4, 3, 6, and 3 kg/ha, respectively. Legume seeds were pellet-inoculated (2) with appropriate rhizobial cultures. The mixture was sown broadcast on dry soil. Germination and emergence were accomplished through sprinkler irrigation; subsequent irrigations during the growing seasons were by flooding in checks approximately 90 × 810 m.

Winter annual weeds were cut in March 1966, with a field chopper, and removed from the fields. Beginning 28 days prior to the start of the experiment, excess forage was also cut and removed. This was done to establish the desired recovery interval for the RG system. In subsequent years, this interval was established by grazing with beef steers or heifers. Beef steers were used during the first 3 years of the study and heifers the final year. The lengths of the experimental grazing seasons during the 4 years of the study were 110, 203, 200, and 215 days. The experiments were initiated each spring after the rate of forage growth was deemed sufficient so as not to limit gain per animal. The stocking rate was considered to be of medium intensity, and was based on previous work at this station using similar pastures and animals.

The RG pastures were clipped at the end of each week's grazing, using a tractor-mounted sicklebar mower. Occasionally the clippings were removed if their bulk was considered sufficient to hamper regrowth, but the dry matter removed was not credited to the experiment.

About 30 kg N (as NH_4NO_3)/ha were applied in May 1966, to stimulate growth of the two grass species so as to avoid clover dominance. No additional fertilizer was applied during the remainder of the experiment. Soil analyses had previously established that none of the major nutrient elements, except N, would be limiting.

During the 3rd and 4th years of the trial, part of another pasture which had previously been used under a 5-field RG system in a separate experiment (4) was converted to a 2-field rotation treatment. Stocking rate was as similar to that of the two main treatments as restrictions on field size permitted. The grazing animals (also steers) were alternated between the two fields on a weekly basis.

Botanical composition, using a modified point quadrat procedure (1), plant cover, and plant canopy height were determined at weekly intervals throughout most of the season during all four experimental periods.

Animals were weighed at 28-day intervals. Determinations were made of carcass specific gravity on a representative group of animals slaughtered before the experiment began, and on all the animals at the end of each grazing season. Empty body weight and body composition were estimated by standard procedures.

Adequate soil water for rapid growth was maintained in all treatments. Soil moisture conditions in all treatments were monitored at 20- and 45-cm depths, using 10 to 12 electrical resistance blocks at each depth. Since no difference developed among treatments, all plots were irrigated weekly during midsummer except in the 5-field rotation, where one field each week was irrigated on a 10-day interval to allow a 3-day drying period prior to the 7-day grazing period. Usually, after the 10-day interval, the field was irrigated again 4 days later.

The water applied was measured for each irrigation. During the first three seasons, only the water applied to the entire pasture was metered. In the 4th year the water applied to CG and RG treatments was recorded separately.

Ring infiltrometer tests were made in the spring and fall of the 4th season, utilizing 45-cm diameter unbuffered rings driven 10 cm into the soil. Tests were made on 24 replicates the day after flood irrigation.

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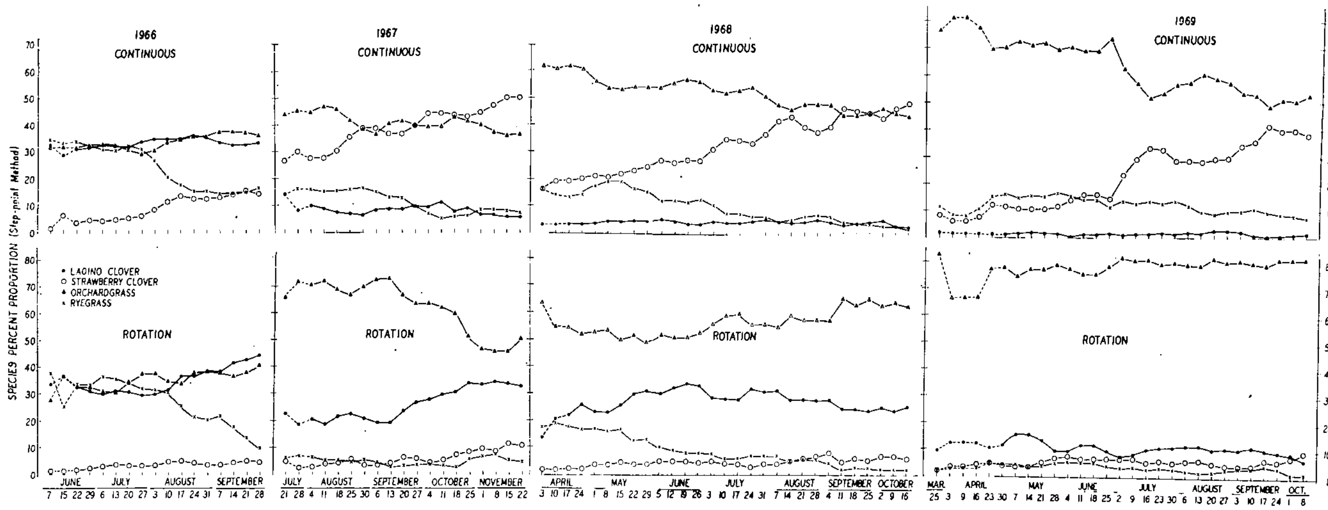

Fig. 1. Trends in botanical composition as measured by step-point quadrat analysis during 4 years of continuous and rotational grazing. All points not joined by dotted lines are 3-week running means.

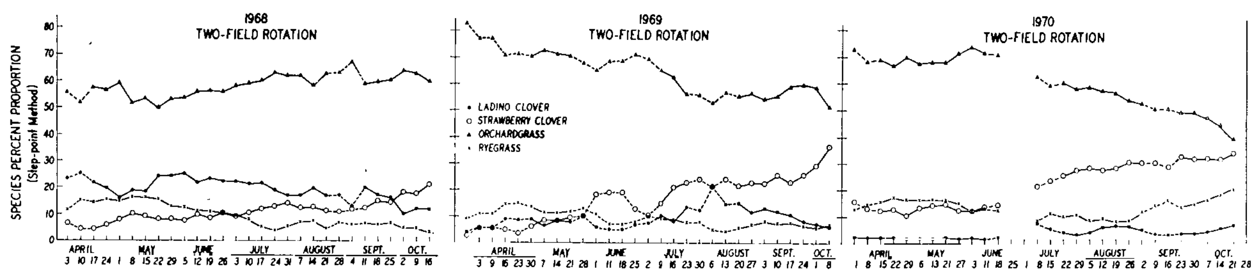

Fig. 2. Trends in botanical composition as measured by step-point quadrat analysis during 3 years of 2-field rotational grazing following 2 years of 5-field rotational grazing. All points not joined by dotted lines are 3-week running means.

RESULTS AND DISCUSSION

Plant Responses

Botanical composition trends for the two grazing systems over the 4 years are shown in Fig. 1. In both RG and CG, the first grazing year appeared to be a year of adjustment from initial seedling ratios. This was especially so for the perennial ryegrass component, which dropped from a proportion of about 30% to generally between 10 and 20% in the remaining 3 years, except for periods early in the spring. 'Salina' strawberry clover was the only species which responded positively to a particular grazing system during the first year, increasing in proportion under CG to the end of the season. The initially low levels of this species, in comparison to Ladino clover, were due to a lower proportion of seed sown, a higher percentage of hard seed, and a general slowness of this species to establish itself.

During the 2nd and 3rd years, Ladino clover and orchardgrass became dominant under RG, and 'Salina' strawberry clover and orchardgrass became dominant under CG. Although morphologically similar (both are stoloniferous), the somewhat taller-growing Ladino clover was favored under rotational grazing, while the CG system allowed a more constant defoliation pressure on the Ladino clover. At the same time, the competitive advantage of strawberry clover could have been enhanced by improved light penetration into the canopy under CG (8). Based on these assumptions, a greenhouse experiment was set up to test for shifts in botanical composition under simulated conditions of CG and RG. Changes in botanical composition very similar to those observed in the field occurred in this experiment.

Trends in botanical composition over a 3-year period for the two-field RG system are shown in Fig. 2. Percentages of both clovers were low at the beginning of the first season (1968); and, because the 2-field system was intermediate between CG and RG, a rapid shift in botanical composition was not expected. In the 2nd year, Salina strawberry clover ranked above or equal to Ladino clover after the end of May, in a replacement similar to that which occurred under CG. In the 3rd year, Ladino clover declined still further while the proportion of ryegrass increased, again, in a manner similar to CG. The seasonal production of Salina strawberry clover appeared to have stabilized in a pattern intermediate between CG and 5-field RG. This is evidence that species balance can be quite delicately poised, with the outcome of competition between species of similar morphology and periodicity of growth dependent on grazing management, even where stocking pressures favorable to both plant and animal are involved.

It was not the intent of this study to critically compare RG and CG with respect to animal product yield; therefore, multiple stocking rates were not used. Other studies with similar pastures (3) have indicated that an interaction exists between stocking pressure

Table 1. Summary of stocking conditions and animal responses under three systems of grazing management.

Item	Grazing system		
	Continuous	*5-field rotation*	*2-field rotation*
Animals carried/hectare (initial only)	7.6	7.6	7.8
Animal days/hectare	1,501	1,501	1,501
Initial wt, kg	202.1	202.8	203.9
Avg daily gain, kg	0.73 a	0.65 b	0.68 b
Final wt, kg	352.2 c	336.8 d	345.2 c
Final USDA grade	Low good+	Low good+	Low good
Live wt gain/ha, kg	1,080	960	1,050
Energy gain/ha, megcal	4,285	4,025	3,970

Means on the same line followed by the same letter do not differ significantly ($P < 0.01$).

and system of grazing management with respect to animal yield, but that there is often a fairly broad plateau of stocking rates at which little or no difference in yield occurs. A small, but statistically significant difference between CG and the two rotational grazing treatments was noted in this experiment (Table 1). The difference may have been due to a consistently more uniform utilization of available forage by the livestock under CG. The data in Table 2 indicate that percent cover tended to be higher under CG than under 5-field RG, with values from the 2-field RG being intermediate. Canopy heights (Table 2) indicate that availability of forage under CG changed little from year to year, and was quite uniform during the grazing season. Also, forage quality in all treatments was excellent throughout the season, as judged by visual observations and by occasional measurements of percent protein (usually 20% or higher).

Animal Responses

Animal productivity, as measured in terms of energy produced per unit area, was essentially the same for all three grazing systems (Table 1). However, a significantly higher average daily gain was obtained under CG than under either of the two RG treatments. Detailed results concerning animal productivity, including comparative performance data for steers and heifers, are to be reported elsewhere. (J. Anim. Sci., in press)

Soil Water Responses

Soil water tensions at the 20-cm depth just prior to irrigation averaged 0.7 to 1 bar during July and August in all treatments, with no trend during the 4 test years. Tensions at the 45-cm depth were generally below levels detectable with electrical resistance blocks, but occasionally increased to 0.5 bar, especially during the first year. Readings after irrigations, when tensions had reached 0.5 bar, indicated that water penetrated readily to the 45-cm depth except at a few locations during the first year.

Water application data for the CG and 5-field RG treatments are given in Table 3. The depth of water per irrigation increased materially in the third and fourth seasons. Since irrigation procedure was not changed, these data indicate that the infiltration rate increased during the experimental period. In the fourth season, the depth of water per irrigation was the same for both grazing treatments.

Infiltration rates were relatively high, and the values (average of 24 measurements) were 3.33 (CG) and 2.90 (RG) cm/hr in April 1969 and 2.29 (CG) and 2.26 (RG) cm/hr in October 1969.

Table 2. Average canopy heights and percent cover estimates of swards under three systems of grazing management.

	Month	5-field rotation			Continuous			2-field rotation	
		1967	1968	1969	1967	1968	1969	1968	1969
Average	Jun	--	25	21	--	12	9	22	10
monthly	Jul	27	22	19	14	13	9	20	11
canopy	Aug	21	21	21	13	13	9	20	10
heights, cm*	Sep	18	22	17	12	13	9	17	11
Estimated	Jun	--	82	75	--	92	95	82	86
percent	Jul	63	87	79	84	79	95	90	90
plant	Aug	76	81	79	91	73	96	88	92
cover	Sep	69	83	76	93	77	97	91	94

* Values for canopy heights under 5-field rotation taken from measurements made 1 week prior to entry of the grazing animals; for the 2-field treatment, from measurements made the day before grazing and for the continuous treatment, from weekly measurements made concurrently with those for the 5-field rotation. All values are given to the nearest cm.

Table 3. Irrigation data for CG and 5-field RG treatments.

Season	Treatment	Number irrigations	Seasonal depth, cm	Depth per irrigation, cm
1	Both	26	156	6.0
2	Both	24	156	6.5
3	Both	29	226	7.8
4	CG	23	213	9.2
4	5-field RG	23	218	9.5

CONCLUDING REMARKS

The grazing management systems compared had pronounced effects on pasture botanical composition, suggesting that this is a factor to be considered when species are selected for a pasture mixture.

Year-by-year management decisions can also markedly influence competition among pasture species, and their subsequent productivity, as evidenced by the reversal of botanical composition trends illustrated in Fig. 2. In our experiments, a favorable grass-legume balance was maintained longer under CG than under RG.

The data indicate that for Yolo clay loam, animal traffic produced no more deleterious effect on soil under continuous grazing than under rotational grazing. In fact, soil physical condition markedly improved with both types of grazing.

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