THE RESPONSE OF BEEF CATTLE TO PHOSPHORUS FERTILIZED AND UNFERTILIZED FLOOD MEADOW HAY WITH IN VITRO OBSERVATIONS ON FACTORS INFLUENCING RUMEN MICROORGANISM ACTIVITY

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Work at the Squaw Butte Station has shown that the use of phosphorus fertilization on proper sites in flood meadow hay production results in increased yield, crude protein, and phosphorus content of the forage (Cooper, 1957). The response is primarily due to an increase in vegetative composition of annual white-tip clover (Trifolium variegatum).

A biological evaluation of the increase in forage quality associated with the phosphorus fertilization practice in terms of beef cattle gains is important in the final evaluation of the fertilization practice. One of the most urgent needs of ranchers relying on flood meadows for their winter hay supply is that of increased forage quality or proper supplementation methods to improve the nutrient content of the ration consumed.

It was the purpose of the work reported in this paper to study the value of unfertilized and phosphorus fertilized flood meadow hays when fed as the main source of nutrients in the wintering ration of beef calves with and without cottonseed meal supplementation.

A second objective was to conduct in vitro studies on the influence of the hays on the ability of rumen microorganisms to digest the forage cellulose as a further indication of forage quality.

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EXPERIMENTAL PROCEDURE

Winter Feeding Study. Forty Hereford weaner steer calves were used in a 2 x 2 factorial experiment to study the influence of phosphorus fertilization on the nutritive value of flood meadow hay and the affect of cottonseed meal when fed in the wintering ration of weaner calves. Four lots of 10 steers each were fed for a 132-day period, extending from December 6, 1957 to April 18, 1958. Rations were fed as follows:

Lot 1 - Unfertilized flood meadow hay ad libitum
Lot 2 - Unfertilized hay plus one pound of cottonseed meal
Lot 3 - Phosphorus fertilized flood meadow hay ad libitum
Lot 4 - Phosphorus fertilized hay plus one pound of cottonseed meal

All animals received 2 pounds of barley per day and had access to a 50:50 salt:bonemeal mixture. One gram of $CuSO_4 \cdot 5H_2O$ per steer per day was provided for all animals from January 7, 1958 as an aid in controlling severe scouring which was assumed to be due to imbalance of trace minerals. Chopped hay was weighed into covered feeders daily. Orts were weighed back at weekly intervals.

The hays used in the study were grown on a meadow typical of the rush-sedge-grass type. These meadows are flooded from early April until late June or early July from a depth of 1 to 6 inches. The unfertilized vegetation consists principally of rush (Juncus spp.) and sedge (Carex spp.)with minor amounts of grass and native clover. The fertilized hay received a surface application of 40 pounds P_2O_5 during the fall of 1955 and 1956. The chemical composition of the unfertilized and fertilized hays is shown in table 1. The response due to fertilization was primarily a result of increased content of annual white-tip clover. Fertilized hay harvested in 1957 was fed for the first 94 days of the study and hay harvested in 1956 was fed for the last 38 days.

Table 1. Summary of crude protein, calcium, and phosphorus content of feeds

Feed	Crude protein	Calcium	Phosphorus
	(%)	(%)	(%)
1957 Unfertilized hay	7.61	0.40	0.11
1957 P fertilized hay	9.34	0.63	0.20
1956 P fertilized hay	8.54	0.57	0.17
1957 Barley	12.45	0.07	0.39
1957 Cottonseed meal	40.42	0.10	1.34

IN VITRO SUTDY OF RUMEN MICROORGANISM ACTIVITY. Rumen contents were collected from 2 yearling steers fitted with permanent rumen fistulas. Each animal was maintained on rations of unfertilized meadow hay, one pound of cottonseed meal, and 2 pounds of barley per day. The artificial rumen procedures used were a modification of the method outlined by Barnett (1957). Samples of the hays fed to the steers were ground in a Wiley mill and 0.250 gm. of the forage to be studied was used as the substrate in 50 ml. pyrex centrifuge tubes. Twenty-five ml. of a mixed suspension of microorganisms and mineral solution (Burroughs et al. 1950) were added to each tube. Residual cellulose was determined at the end of a 24-hour fermentation period by the method of Crampton and Maynard (1938). All determinations were run in duplicate as were the control tubes on each type of hay.

RESULTS AND DISCUSSION

Winter Feeding Study. The results of the 132-day feeding trial are summarized in table 2. The analysis of variance of average daily gains indicated that both phosphorus fertilized hay and cottonseed meal supplementation resulted in significant increases. An increase in average daily gain of approximately 0.25 lb. resulted from both treatments. There was no interaction between the fertilization and supplementation treatments. It is interesting to note that there was no difference in the amount of hay consumed due to any of the experimental treatments (table 2). This fact resulted in 11.6 lb. of total feed being required for 1 pound of body weight gain in the case of the fertilized hay treatment as compared to 15.4 lb. for the unfertilized hay ration. The most efficient conversion of feed to gain of 9.4 lb. was made by supplementing the fertilized hay with 1 pound of cottonseed meal.

A summary of the content of crude protein, phosphorus, and of the rations consumed is shown in table 3. The most obvious differences between the various experimental rations are those of crude protein and phosphorus content.

It appears safe to assume that the animals being considered in this study were all on an adequate protein level. The data do not justify a final conclusion as to the influence of increasing increments of crude protein intake on animal performance because of interrelationships of other nutrients.

Heinemann et al. (1957) have recently summarized the literature on the effects of phosphorus fertilization on the feeding value of forage. These authors report improved performance of rabbits fed phosphorus fertilized hay compared to unfertilized hay of lower phosphorus content.

The phosphorus intake, shown in table 3, of the animals in lot 1 and lot 2 was lower than the level recommended by the National Research Council (1950). This was true in spite of the fact that a

Table 2. Summary of body weights, average daily gains, feed intakes, and feed cost data for the 132-day feeding period

	Treatment			
	Unfertilized hay		Phosphorus fertilized hay	
	No Cottonseed meal	Cottonseed meal	No Cottonseed meal	Cottonseed meal
Lot number	1	2	3	4
No. steers	10	10	10	9[a]
Initial weight (lb.)	409	403	399	404
Final weight (lb.)	520	551	543	595
Avg. daily gain (lb.)	0.84	1.12	1.09	1.45
Avg. daily hay consumed (lb.)	10.9	10.7	10.6	10.7
Avg. daily barley consumed (lb.)	2.0	2.0	2.0	2.0
Avg. daily cottonseed meal (lb.)	----	1.0	----	1.0
Avg. daily bonemeal (lb.)	0.021	0.012	0.012	0.010
Avg. total feed consumed (lb.)	12.9	13.7	12.6	13.7
Feed per lb. gain (lb.)	15.4	12.2	11.6	9.4
Feed cost per lb. gain[b]	$ .202	$ .180	$ .152	$ .139

[a] One calf was removed in early December because of pneumonia.

[b] Unfertilized and fertilized hays valued at $20 per ton.
Barley " " $60 per ton.
Cottonseed meal " " $70 per ton.

mixture of equal parts of salt and bonemeal was available in all lots. The increased bonemeal consumption of the animals in lot 1 (table 2) reflects the phosphorus deficiency. Although the phosphorus intake of the animals in lot 2 was lower than recommended by the National Research Council the average intake of 13.3 gm. per day (table 3) meet the requirements for growing beef calves as estimated by Mitchell and McClure (1937).

Table 3. Summary of content and intakes of crude protein and phosphorus of the experimental rations

	Unfertilized Hay		Fertilized Hay	
	No supplement	Cottonseed meal	No supplement	Cottonseed meal
Lot Number	1	2	3	4
Crude protein (%)	8.4	11.0	9.4	11.7
Protein/calf/day (lb.)	1.08	1.51	1.18	1.60
Phosphorus (%)	.15	.24	.23	.31
Phosphorus/calf/day (gm.)	9.1	15.0	13.3	19.4

As is generally true in studies of changes in forage quality, both phosphorus and crude protein increased in the fertilized forage making it difficult to clearly define the factors that may be responsible for increased animal performance. The possibility that the response to the experimental rations in this study might have been mediated, at least in part, through increased activity of the rumen microorganisms should not be overlooked.

IN VITRO STUDY OF RUMEN MICROORGANISM ACTIVITY. Samples of the hays fed in the winter feeding trial and a sample of pure white-tip clover were used as the substrates in a 24-hour fermentation period. The results of the average % cellulose digested are summarized in table 4.

Table 4. Summary of in vitro cellulose digestion

Treatment	Cellulose digestion (%)
Unfertilized hay	33.6
Phosphorus fertilized hay	38.0[a]
White-tip clover	46.7[a]
Unfertilized hay + .0250 gm. clover ash	37.2[b]
Unfertilized hay + .0125 gm. clover ash	36.3[b]
Unfertilized hay + .0062 gm. urea	42.8[a]
Unfertilized hay + .0125 gm. urea	35.0

[a]Significant at the 1% level of probability.

[b]Significant at the 5% level of probability.

The fact that the addition of white-tip clover ash significantly increased the in vitro cellulose digestion of the unfertilized hay emphasizes the importance of the inorganic fraction of the phosphorus fertilized hay since the main vegetative response was due to the increase in composition of white-tip clover. Also, the beneficial influence of the addition of the lower level of urea suggests that the possible contribution of the added nitrogen in the fertilized hay cannot be eliminated.

SUMMARY

Both phosphorus fertilized hay and cottonseed meal supplementation were found to significantly increase average daily gains during a 132-day feeding period. No interaction was found between the fertilization and supplementation treatments.

It was found that the rumen microorganisms digested significantly more cellulose in the fertilized hay and a sample of pure white-tip clover than in the unfertilized hay, during a 24-hour in vitro fermentation period.

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