PARAQUAT-CURED HERBAGE FOR LATE SEASON GRAZING[1]

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Summary

AVERAGE daily gain by yearlings grazing paraquat-cured crested wheatgrass in the fall of 3 years was increased 0.27 kg above that of yearlings grazing naturally cured crested wheatgrass. Calculated total water consumed and daily forage intake was greater on paraquat-cured pastures. Paraquat-cured forage in 5 weeks following treatment retained significantly ($P<0.05$) higher levels of P, K, C.P., lignin and ash. Herbage yield, Ca and ether extract were significantly ($P<0.05$) higher in naturally cured crested wheatgrass while cellulose decreased in time under both curing treatments.

Introduction

Declining nutrient concentration of the primary feed elements and their simultaneous decline in digestibility by the grazing animal is a characteristic of grasses as they mature and cure. In the western United States more than half of the grazing season occurs after the grasses have matured and as such the grasses provide only for maintenance of the grazing animal. Management of the cattle and limited feed supplementation are used to increase livestock returns when using this vast amount of low quality forage.

The two-crop management system as proposed by Hyder and Sneva (1963) attacks the problem directly. However, this is not well adapted to areas with low summer precipitation. Chemically curing the grasses, when at a high nutrient status, and grazing the treated forage later will also provide a high quality forage (Sneva, 1967). This paper presents nutrient composition values of crested wheatgrass following chemical curing with paraquat[3] and livestock response in 3 years when fall-grazing paraquat treated crested wheatgrass (Agropyron *desertorum* [Fisch] Schult) by beef cattle.

Materials and Methods

Grazing trials to determine the effect on animal performance were conducted in 1966, 1967 and 1970. Two pastures of 12.2 ha each were used in 1966. These pastures were subdivided into four, and four additional pastures of 6.1 ha were constructed for the 1967 study. The pastures were again subdivided for the 1970 study to provide 16 pastures of 3.05 ha each.

Paraquat at 0.34, 0.22, and 0.22 kg/ha in 187, 93.5 and 93.5 l of water plus 0.5% X 77 surfactant[4] was foliar applied in 1966, 1967 and 1970, respectively. Pastures were sprayed with a tractor mounted spray boom on June 16 to 18, 1966; June 23 to 26, 1967 and June 16 to 18, 1970. Crested wheatgrass was in early anthesis on those spray dates in each year. Half of the pastures received paraquat in each year.

Yearling heifers with an average weight of 311, 302 and 371 kg in 1966, 1967 and 1970, respectively, were stratified by weight and randomly allocated to treatment. Thirteen yearlings grazed naturally cured (N.C.) and 14 grazed chemically cured (C.C.) pastures for 36 days in 1966 beginning August 16; three yearlings per pasture grazed 75 days in 1967 beginning August 14; and a single yearling per pasture grazed 92 days in 1970 beginning August 17.

The animals were individually weighed following an overnight restriction from feed and water at the beginning of each trial, at approximately 30-day intervals, and at the end of each trial. Water, crushed salt and a 50:50

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[3] Paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) has not been registered by the U. S. Environmental Protection Agency for this use.

[4] Use of a trademark name does not imply its approval to the exclusion of other products that may also be suitable.

salt-bonemeal mix were available in each pasture at all times.

Mineral intake records were maintained by pasture in all years. Water drunk was measured and forage samples for determining forage moisture concentration were obtained during 8/16 to 9/13, 1966; 9/4 to 9/13 and 10/4 to 10/16, 1967 for computing total water and forage intake following the procedure of Hyder *et al.* (1966). Sheltered air temperatures were recorded 2.2 km distant. Forage samples obtained weekly in 1966, 1967 and less frequently in 1970 were analyzed for Kjeldahl-N and reported as crude protein (N x 6.25).

The 1967 and 1970 studies utilized complete block designs with four replications. In 1970, the study incorporated treatments of 22.4 kg/ha nitrogen fertilizer plus paraquat with and without a daily supplement of 0.23 kg rolled barley and 0.34 kg cottonseed meal. Each of the four control pastures were comprised of two adjoining 3.05 ha pastures. Herbage yields were taken prior to paraquat treatment for assessing fertilizer effect.

Data of each year were analyzed statistically using the "T" or Duncan's multiple range test to distinguish significance between means.

Herbage yield, dry matter, mineral and nonmineral concentrations of N.C. and C.C. crested wheatgrass were studied in 1966 only (nongrazing trial). The two curing treatments were randomly assigned to whole plots in five replications with six harvest dates at weekly intervals assigned to subplots. Paraquat at 0.34 kg/ha in 93.5 l of water plus X-77 of 0.5% was applied on June 14. A 4.5 m^2 area within the treatment area was harvested to ground level every seventh day beginning June 13. The samples were immediately weighed, dried in a forced air oven, reweighed, then ground through a Wiley mill and subsampled. The subsample was stored in airtight glass jars. Crude fiber, either extract (E.E.), ash, N, P, K and Ca were analyzed according to A.O.A.C., 1955 edition. Cellulose determination followed that given by Crampton and Maynard (1938) while lignin analyses followed Ellis, Matrone and Maynard (1946). Statistically, analysis was that for a split-plot design with means tested with Duncan's multiple range test.

Results

Nongrazing Trial. The curing treatment by harvest date interaction was highly significant ($P<0.01$) for the following forage characteristics; yield, dry matter, crude protein (C.P.), P, K, Ca, E.E. and lignin. Higher retention of these constituents occurred in C.C. than in N.C. herbage except for herbage yield and Ca, which were lower. Concentrations of crude fiber in N.C. and C.C. herbage remained unchanged but those of cellulose decreased significantly ($P<0.01$). Mean ash concentrations were significantly ($P<0.05$) higher in C.C. herbage. All of the foregoing interactions are presented graphically in figures 1 through 11.

Grazing Trials. Twenty pounds of N failed to increase herbage yield or herbage N concentrations significantly ($P>0.05$); thus, no further separation of this treatment is warranted.

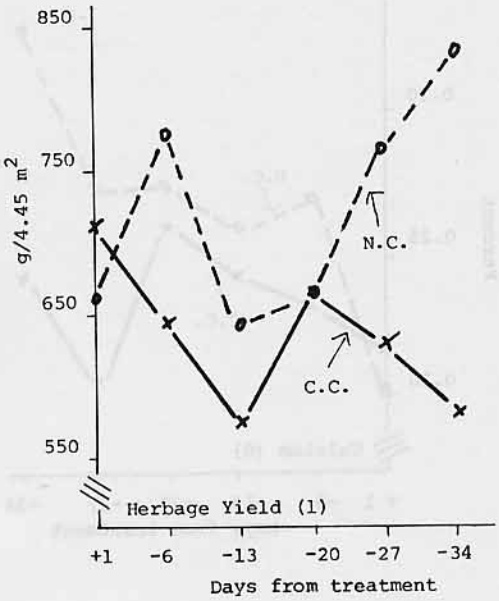
In each year, studies were terminated prior to any animal stress because of forage shortage; thus, the data reflect responses to differences in feed quality and its acceptability. Crude protein concentration was significantly ($P<0.05$) higher in C.C. than in N.C. herbage available to the grazing animals in all 3 years (table 1). In 1966 only was C.P.

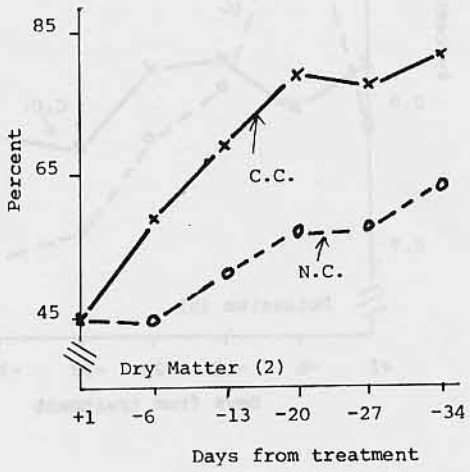
TABLE 1. CRUDE PROTEIN CONCENTRATION OF THE FORAGE AVAILABLE TO THE ANIMALS GRAZING NATURALLY AND CHEMICALLY CURED GRASS IN 1966, 1967 AND 1970

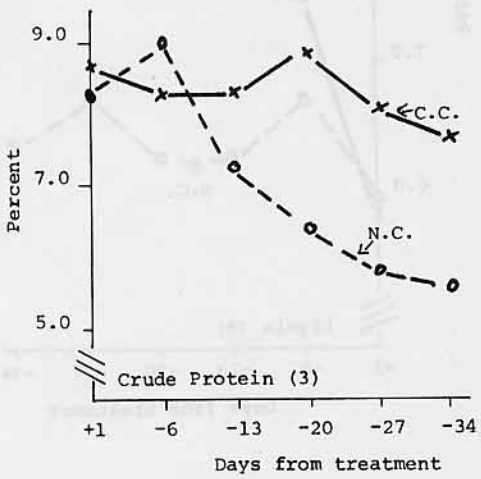
Date	Control	Paraquat[a]
1966		
8/17	5.3	9.1
8/25	4.2	8.2
9/2	4.2	6.8
9/8	3.8	6.2
9/16	4.2	5.3
Mean	4.3[b]	7.1[c]
1967		
8/18	3.2	5.6
8/25	3.1	5.5
9/1	3.1	5.5
9/7	2.9	5.3
9/14	3.0	5.0
9/21	3.0	5.3
9/29	2.7	5.0
10/5	2.6	4.6
10/12	2.7	4.8
10/19	3.0	5.2
10/26	2.7	5.4
Mean	2.9[b]	5.2[c]
1970		
8/8	3.4	5.7
11/20	2.4	4.8
Mean	2.9	5.2

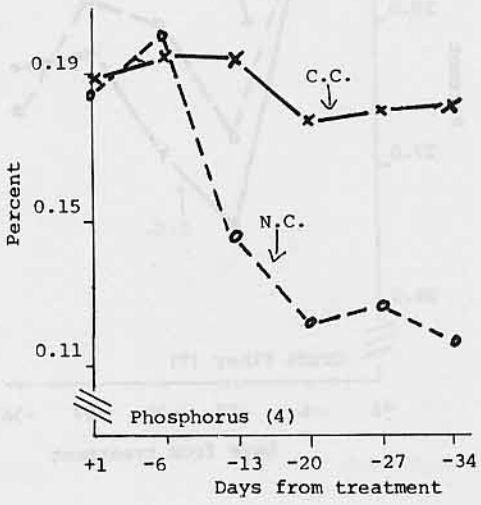
[a] Paraquat applied June 16 to 18, 1966, June 23 to 26, 1967 and June 16 to 18, 1970 when crested wheatgrass was in early anthesis.

[b, c] Means in the same row with unlike superscripts differ significantly ($P<0.05$).

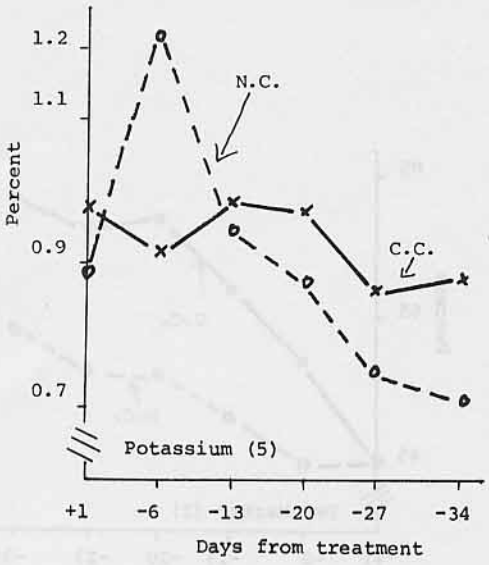


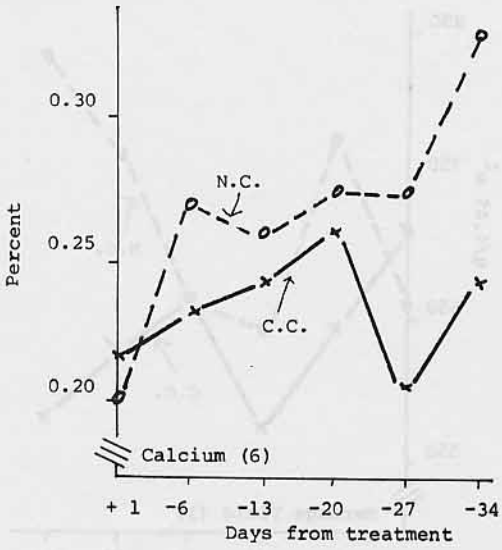


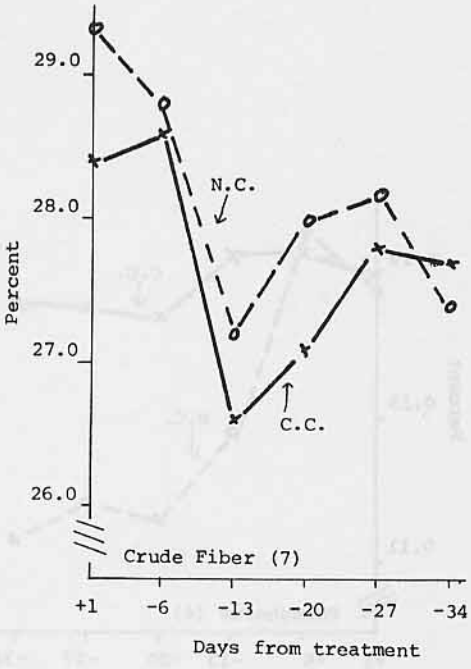


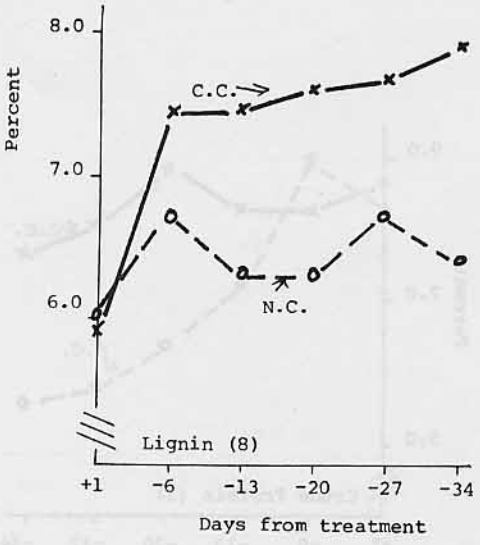


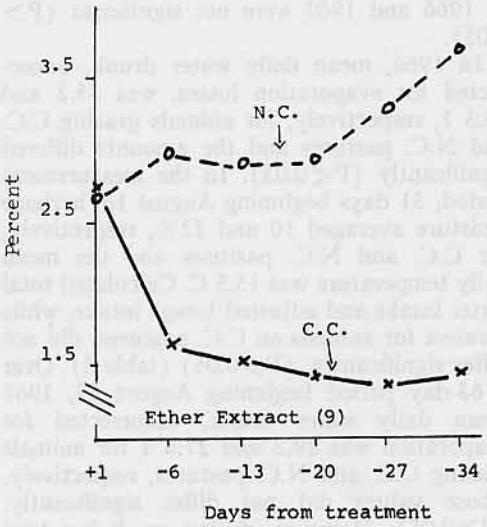
Figures 1 to 11. Mineral and nonmineral changes in naturally cured (N.C.) and chemically cured (C.C.) crested wheatgrass treated on June 14, 1966.

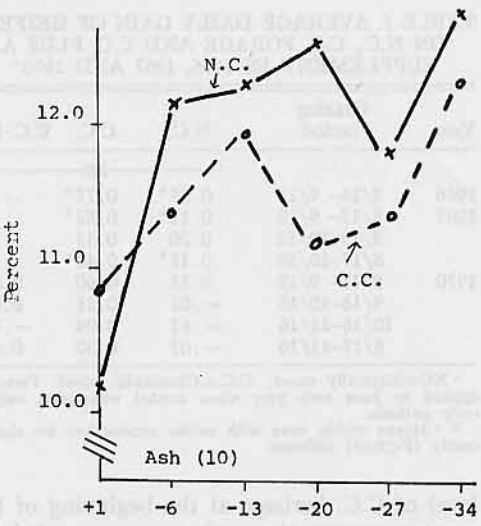

1.2
1.1
0.9
0.7
Percent
N.C.
C.C.
Potassium (5)
+1 -6 -13 -20 -27 -34
Days from treatment


0.30
0.25
0.20
Percent
N.C.
C.C.
Calcium (6)
+1 -6 -13 -20 -27 -34
Days from treatment


29.0
28.0
27.0
26.0
Percent
N.C.
C.C.
Crude Fiber (7)
+1 -6 -13 -20 -27 -34
Days from treatment


8.0
7.0
6.0
Percent
C.C.
N.C.
Lignin (8)
+1 -6 -13 -20 -27 -34
Days from treatment


3.5
2.5
1.5
Percent
N.C.
C.C.
Ether Extract (9)
+1 -6 -13 -20 -27 -34
Days from treatment


12.0
11.0
10.0
Percent
N.C.
C.C.
Ash (10)
+1 -6 -13 -20 -27 -34
Days from treatment

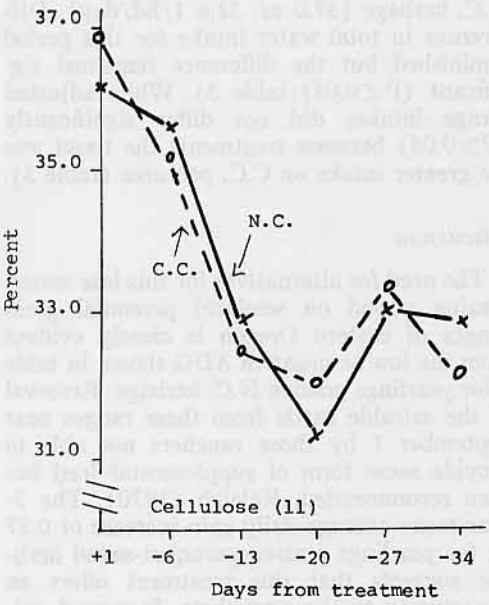

37.0
35.0
33.0
31.0
Percent
N.C.
C.C.
Cellulose (11)
+1 -6 -13 -20 -27 -34
Days from treatment

TABLE 2. AVERAGE DAILY GAIN OF HEIFERS ON N.C., C.C. FORAGE AND C.C. PLUS A SUPPLEMENT IN 1966, 1967 AND 1970[a]

Year	Grazing period	N.C.	C.C.	C.C.+S.
		kg		
1966	8/16– 9/13	0.55[b]	0.77[c]	....
1967	8/17– 9/19	0.11[b]	0.52[c]	....
	9/19–10/30	0.20	0.33	....
	8/17–10/30	0.15[b]	0.42[c]	....
1970	8/17– 9/19	0.55	0.60	0.84
	9/18–10/16	—.02	0.25	0.49
	10/16–11/16	—.62	0.04	—.16
	8/17–11/16	—.03	0.30	0.38

[a] NC=Naturally cured; C.C.=Chemically cured: Paraquat applied in June each year when crested wheatgrass was in early anthesis.
[b, c] Means within rows with unlike superscripts are significantly ($P<0.05$) different.

level of C.C. herbage at the beginning of the grazing season above that recommended by N.R.C. (1963) for yearlings of this size and gaining 0.54 kg/day.

Average daily gain was 0.22, 0.27 and 0.33 kg higher for yearlings grazing C.C. than N.C. herbage in 1966, 1967 and 1970, respectively (table 2). Differences in 1966 and 1967 were significant ($P<0.05$) while significance ($P<0.05$) was approached in 1970.

The addition of the feed supplement of 0.23 kg rolled barley and 0.34 kg cottonseed meal increased ADG by 0.24 kg in the first and second period above that gained by animals grazing C.C. herbage alone. Weight loss occurred in the last two periods by yearlings grazing N.C. herbage and in the last period by yearlings grazing C.C. herbage and receiving the supplement.

Salt and bonemeal intake varied by years with the highest daily intake occurring in 1970 (table 3). Yearlings, in 1970, grazing N.C. consumed 43% more salt and 50% more bonemeal than yearlings grazing C.C. herbage.

TABLE 3. DAILY INTAKE OF VARIABLES MEASURED OR COMPUTED OF HEIFERS GRAZING N.C. AND C.C. FORAGE IN 1966, 1967 AND 1970[a]

Year	Treatment	Salt	Bonemeal	Water	Forage[b]
		gr	gr	l	kg
1966[c]	N.C.	35	14	32.2	6.2
	C.C.	38	14	36.0	6.9
1967[c]	N.C.	22	22	35.0[d]	7.1
	C.C.	21	27	38.1[e]	7.5
1970	N.C.	79	27[d]	...	...
	C.C.	55	18[e]	...	...

[a] N.C.=Naturally cured; C.C.=Chemically cured.
[b] Adjusted for constant metabolic size ($W^{.75}$) of 100.
[c] Water and forage intakes for the period 8/16 to 9/20, 1966 and 9/6 to 9/13, 1967.
[d, e] Means within years in the same column with unlike superscripts differ significantly ($P<0.05$).

Differences in mineral intake due to treatment in 1966 and 1967 were not significant ($P>0.05$).

In 1966, mean daily water drunk, uncorrected for evaporation losses, was 35.2 and 30.3 l, respectively, for animals grazing C.C. and N.C. pastures and the amounts differed significantly ($P<0.05$). In the measurement period, 31 days beginning August 16, herbage moisture averaged 10 and 22%, respectively, for C.C. and N.C. pastures and the mean daily temperature was 15.5 C. Calculated total water intake and adjusted forage intake, while greatest for animals on C.C. pastures, did not differ significantly, ($P>0.05$) (table 3). Over a 63-day period beginning August 29, 1967 mean daily water drunk, uncorrected for evaporation was 29.5 and 27.6 l for animals grazing C.C. and N.C. pastures, respectively. Those values did not differ significantly, ($P>0.05$). However, during an 8-day trial period commencing September 6, 1967, yearlings grazing C.C. herbage drank significantly, ($P<0.05$), more water than those grazing N.C. herbage (37.0 *vs.* 32.6 l/hd/day). Differences in total water intake for this period diminished but the difference remained significant ($P<0.05$) (table 3). While adjusted forage intakes did not differ significantly ($P>0.05$) between treatments the trend was for greater intake on C.C. pastures (table 3).

Discussion

The need for alternatives for this late season grazing period on semiarid perennial grass ranges of eastern Oregon is clearly evident from the low or negative ADG shown in table 3 for yearlings grazing N.C. herbage. Removal of the saleable cattle from these ranges near September 1 by those ranchers not able to provide some form of supplemental feed has been recommended, Raleigh (1970). The 3-year mean average daily gain increase of 0.27 kg for yearlings grazing paraquat-saved herbage suggests that this treatment offers an opportunity to those ranchers. Increased animal gain from pastures treated thusly and when forage supply was adequate have also been reported, Kay and Torell (1970); Arnold *et al.* (1970). Romberg *et al.* (1969) found no difference in sheep gains due to treatment, however, they indicated that the results obtained in that study were influenced by heavy rains.

Calculated daily forage intakes in 1966 and 1967 of yearlings on treated pastures was

greater than that of yearlings grazing naturally cured pastures, Romberg *et al.* (1969) reported slightly greater intake by sheep on untreated pastures but their results are conditioned as previously mentioned. The higher intakes in this study are compatible with the higher *in vitro* digestibilities found for N and cellulose in C.C. herbage and its better acceptance by sheep (Wallace *et al.*, 1966; Kay and Torrell, 1970).

Negative or near zero gains were recorded for all treatments in the third grazing period in 1970 (table 2). At the end of this period the C.P. concentration of N.C. herbage was only 2.4% as compared with 4.8% in grasses on C.C. pastures. These low concentrations of C.P. are, perhaps, sufficient in themselves to explain the poor response. Just as important is the knowledge that mean air temperature during the month of October was 7 C and decreased in November 2 C. These cool temperatures increased maintenance requirements and concomitantly reduced gain.

Supplementation of yearlings in the late grazing season should bring a favorable return so long as the forage available provides maintenance and some gain. The constant-rate fed supplement in this study produced an additional 0.24 kg/day gain during the first two periods of grazing above that from C.C. herbage alone. It is inferred that paraquat-saved herbage can be used to provide a forage base of sufficient quality to permit the extension of the supplemental feed program.

Precipitation in the amount of 0.69 cm was recorded during the 5 weeks following treatment application of the nongrazed trial in 1966, the greatest 24-hr. amount was 0.20 centimeters. This was insufficient for causing regrowth on treated areas and the results obtained are similar to that obtained in other dry summers (Sneva, 1967). Sneva also measured a rapid decline in carotene concentrations in treated plants and this is probably the major cause for the rapid decline measured in this study for ether extract. Arresting plant growth at anthesis, as in this study, should be expected to cause a significant reduction in yield. Arnold *et al.* (1970) suggests that use of paraquat in the role of a curing agent will depend, a great deal, upon the willingness to sacrifice yield for quality.

Paraquat-saved forage appears to have, as evidenced by the results of these trials, a favorable potential use on perennial grass stands in semiarid ranges. Clearance of paraquat for this use is currently being sought. As of January 1971, clearance of paraquat for chemically curing of grasses to be grazed has not been authorized.

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