Paraquat Curing of Seeded Dryland Pasture Species[1]

BURGESS L. KAY

Specialist, Department of Agronomy and Range Science
University of California, Davis.

Highlight

Paraquat applied at early anthesis of soft chess and wimmera ryegrass increased protein retention significantly in the following dry season. The rates of paraquat required varied with growth stage, from ⅛ to ¼ lb./acre to cure grasses and ¼ to ½ lb./acre to cure rose clover and subclover. Curing grasses increased the protein retention of dry grasses only to the maintenance level of livestock. Seeding a legume is necessary to increase the summer protein above maintenance. Spraying with paraquat increased the protein retention of legumes to twice that needed for maintenance.

Resumen[2]

Un estudio anterior demostró que la aplicación de "paraquat" en zacates anuales durante la antesis, aumentó el contenido de proteína de 57 a 77%, el fósforo a 9.125% y se redujo la fibra cruda a un rango de 2 a 4%. El presente estudio se llevo a cabo en los pastizales de California, incluyendo el secado de dos zacates y dos leguminosas, anuales ambas, a los que se les aplicó "paraquat" durante la antesis, dando como resultado un aumento significativo del contenido de proteína para la siguiente época seca. El contenido nutricional de los zacates fue a nivel de mantenimiento mientras que en las leguminosas aumentó al doble, recomendándose la siembra combinada de zacates y leguminosas para obtener más proteína. La cantidad de "paraquat" por acre, varía de acuerdo a la época de crecimiento de ⅛ a ¼ lb. para zacates y de ¼ a ½ lb. para las leguminosas.

The use of paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) to cure standing annual range forage has been described by Kay and Torell (1970). Paraquat applied to grasses at anthesis resulted in forage 57 to 77% higher in protein, higher in phosphorus, and lower in crude fiber than unsprayed forage. The use of paraquat to cure subclover (*Trifolium subterraneum* L.) pastures improved forage quality not only in the year of application but in the year following, as a result of a shift in species composition to more clover and less grass.

Total forage production can be doubled (Kay, 1969) or tripled (Williams et al., 1956) by seeding to better forage species. Paraquat curing may be more economical on these higher-yielding pastures because the cost of application is the same, and the herbicide rate is likely to be similar to that required on unseeded pastures.

The following study compares forage values and paraquat rates required to cure seeded annual grasses vs. seeded annual legumes.

Materials and Methods

The experiments were done at the University of California at Davis (50 ft elevation) over a 3-year period (1965–1967). Two annual grasses, soft chess (*Bromus mollis* L.) and Wimmera ryegrass (*Lolium rigidum* Gaud.), and two annual legumes, Wilton rose clover (*T. hirtum* All.) and Mt. Barker subclover, were planted separately in rows 36 inches apart before the first fall rains. All were grown without supplemental irrigation. Because of differences in height, the grasses and clover were grown in separate randomized blocks to facilitate spraying. The grasses were 3 to 4 ft tall at spraying, and the clovers were 1 to 2 ft.

In the first experiment, paraquat was applied logarithmically to investigate rates from 0.25 to 4.0 lb./acre in a total volume of 84 gpa with X-77[3] added at 0.1%. The material was applied either on May 7 or on May 22. On the first date the grasses were in early anthesis, the rose clover at 50% bloom, and the subclover in full bloom. On May 22 the ryegrass was still green but in the dough stage. Soft chess plants varied from green to 50% dry. Rose clover was in full bloom, and subclover was all green and still blooming. Plants were clipped to ground level on July 26 and analyzed for protein (Kjeldahl nitrogen × 6.25). Selected samples were analyzed also for crude fiber.

In the second and third experiments the paraquat was applied at constant rates to plots 20 ft long. Rates in the second trial were 1/16 to 3 lb./acre and in the third trial ⅛ to 2 lb./acre, all with X-77 at 0.1% v/v in a total volume of 84 gpa.

In the second experiment paraquat was applied on April 28 or May 10. On April 28 ryegrass was in the dough stage and all green, while soft chess was in the dough stage or later, with some basal leaves drying. Rose clover and subclover were both in full bloom. On May 10 ryegrass was browning at the flower tips and basal leaves, and soft chess was either purple or brown. Fifty percent of the rose clover blossoms were shattered, but the leaves were still green. Subclover was green and flowering. Samples were collected for protein analysis on June 1, June 30, September 6, and November 1.

In the third experiment paraquat was applied either on May 5 or on May 18. On May 5 ryegrass was headed but in pre-anthesis, while about 50% of the soft chess had reached anthesis. Rose clover was in the bud stage and subclover was flowering. On May 18 ryegrass was in late anthesis and soft chess in

[1] Thanks are due Mr. Joe Ruckman, Department of Agronomy and Range Science, University of California, for making the many laboratory analyses; and Chevron Chemical Co., for the paraquat and X-77 as well as financial support. Received October 20, 1969; accepted for publication March 21, 1970.

[2] Por Donald L. Huss y E. Hernandez, Dep. de Zootecnia, ITESM, Monterrey, N. L., Mexico.

[3] X-77 is a trademarked nonionic spreader-activator containing alkylarylpolyoxyethylene glycols, free fatty acids, and isopropanol.

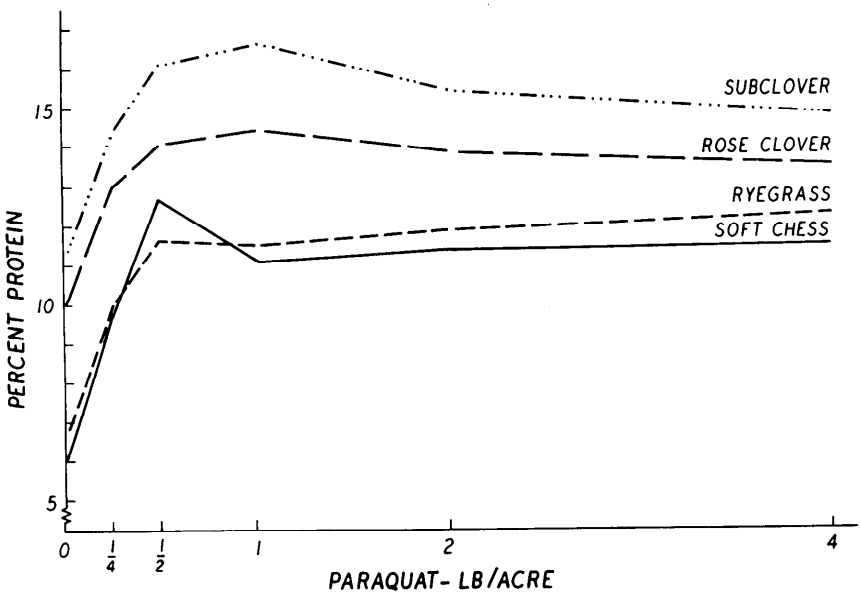

FIG. 1. Effect of paraquat on percent protein retention on August 1; sprayed May 7.

soft dough, while rose clover was in early bloom and subclover in full bloom. Samples were taken on July 3 and September 28.

Guard rows of the same species as the adjacent row were used in all trials to avoid spray drift onto the other treatments. All trials were replicated four times in either a split plot or randomized block design.

Results

Experiment 1

Protein retention was increased by all rates in all species when applied on May 7 (Fig. 1). Spraying on May 22 produced no increase in protein retention in soft chess, and a much lesser increase in the other species compared with the earlier date (Fig. 2). At the later date, ¼ lb./acre was enough to produce an increase in protein retention in ryegrass and subclover, but 1 lb./acre was required to increase the protein in rose clover.

Spraying with paraquat on May 7 reduced the percent crude fiber in the clovers but not in the grasses. Percent crude fiber in rose clover was reduced from 37.8% on the check to 30.7% when sprayed. Subclover was reduced from 33.8% to 27.4%. With the May 22 spraying there was no decrease in percent fiber in any species except subclover, the latest-maturing species, which was reduced from 33.8% to 28.8%.

Experiment 2

Although the calendar date of paraquat application was at least 1 week earlier than in either of the other years, application was later phenologically. Only rose clover had an increase in protein retention from spraying on the second date. While there was an increase in protein retention in both grasses from spraying at the earlier date, the magnitude of the increase was less than in the previous year, because of the late stage at which the plants were sprayed (Table 1). The increase in protein retention in the clovers was similar to that obtained with spraying at the early date the previous year.

The minimum amount of paraquat necessary to increase the protein retention significantly was ¼ lb./acre for soft chess and rose clover, and ½ lb./acre for subclover and ryegrass. The use of 2 lb./acre resulted in significantly higher protein than the minimal rate in the November 1 samples. The additional increase from the higher rate was not always significant at the earlier dates.

Percent protein declined throughout the 6-month dry period between spraying and the final sample, which was taken just before the first fall rain. The decline was greatest in soft chess, and least in the clovers. The seasonal decline in protein was least with the highest rates of paraquat.

Rainfall was recorded on 7 days during the period April 29 to November 1, for a total of 1.05 inches. The largest amount was 0.40 inch, on September 13. The leaching from this rainfall may explain why many of the larger protein declines occurred between the September 6 and November 1 samplings. A total of 0.60 inch fell in this period.

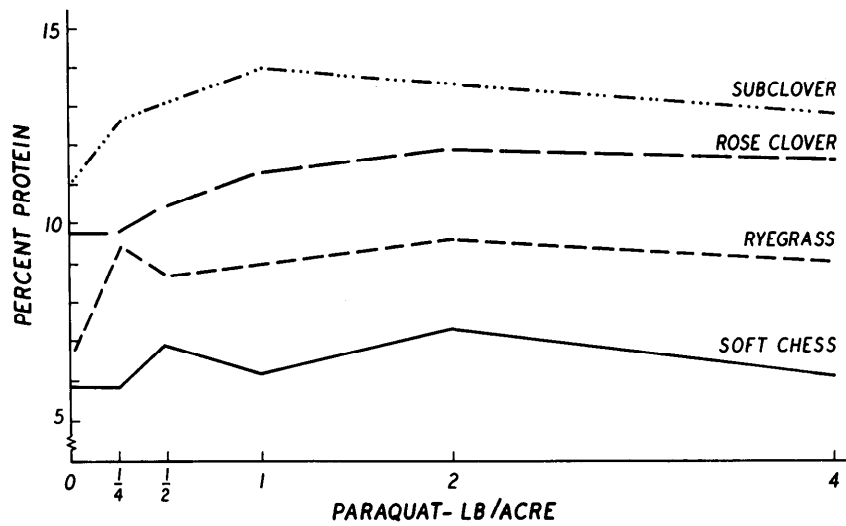

FIG. 2. Effect of paraquat on percent protein retention on August 1; sprayed May 22.

Table 1. Concentration of protein (%) in forage sprayed with paraquat on April 29 and subsequent dates sampled throughout the dry season.

Species and paraquat rate (lb./acre)	Apr. 29	June 1	June 30	Sept. 6	Nov. 1	Decline (%) June 1–Nov. 1	Decline (%) April 29–Nov. 1
Soft chess							
0	7.8	5.2	4.1	3.8	3.2	38	59
1/16		4.8	4.2	3.9	3.0	38	62
1/8		6.3	4.3	4.1	3.6	43	54
1/4		6.8	5.0	4.4	4.3	37	45
1/2		5.8	5.2	4.6	4.7	9	40
1		6.6	5.3	5.5	5.5	17	29
2		7.6	6.7	6.0	5.8	24	26
LSD 0.05		1.4	1.1	0.5	0.9		
0.01		1.9	1.6	0.7	1.2		
Ryegrass							
0	8.5	7.1	6.3	6.0	5.1	28	40
1/16		6.2	5.6	5.1	4.8	23	44
1/8		6.7	5.9	5.5	4.3	36	38
1/4		8.8	6.8	6.0	5.7	26	32
1/2		8.3	8.2	7.5	6.6	20	22
1		8.1	7.4	6.6	6.4	21	25
2		9.4	8.3	7.3	7.9	16	7
LSD 0.05		1.7	1.6	1.2	0.8		
0.01		NS	NS	1.6	1.0		
Rose clover							
0	14.8	10.8	11.6	11.0	10.0	7	32
1/16		14.0	12.9	11.2	11.7	19	21
1/8		12.6	12.1	12.0	11.0	13	26
1/4		14.6	13.4	13.8	11.6	20	22
1/2		14.2	14.4	14.4	12.7	11	14
1		14.0	15.0	12.8	14.2	+1	4
2		15.2	14.7	14.3	13.6	11	8
LSD 0.05		2.9	1.5	1.5	1.5		
0.01		NS	2.1	2.0	2.1		
Subclover							
0	13.4	10.9	11.8	10.1	10.2	6	24
1/16		12.2	11.0	11.2	9.8	20	21
1/8		11.9	12.0	10.0	9.2	23	31
1/4		13.1	12.4	12.0	10.2	22	24
1/2		13.3	13.9	12.7	12.4	8	7
1		14.2	13.8	13.8	13.8	3	+3
2		16.3	15.0	13.8	14.6	10	+9
LSD 0.05		1.8	1.6	1.6	2.2		
0.01		2.5	2.2	2.2	3.0		

Experiment 3

The first date of application was earlier phenologically than in the other experiments and resulted in much better protein retention by the sprayed grasses (Fig. 3). Although the retention was still significantly increased by spraying on the second date, the increase was only about one-half that obtained from spraying earlier (Fig. 4).

Percent protein declined again in all treatments as the season progressed. The decline between July 3 and September 28 was similar to that noted in the previous year.

The amount of paraquat necessary at the early date to cause a significant increase in percent protein retention was ¼ lb./acre for ryegrass and subclover, ½ lb. for rose clover, and ⅛ lb. for soft chess. The values per acre for the later date were: soft chess, 1 lb.; rose clover, ½ lb.; and subclover, ¼ lb. The increases in ryegrass were not significant at the second date.

Discussion and Conclusions

Spraying green forage with paraquat resulted in cured standing forage higher in percent protein in all experiments. The amount of paraquat required depended on the species and on the stage of plant

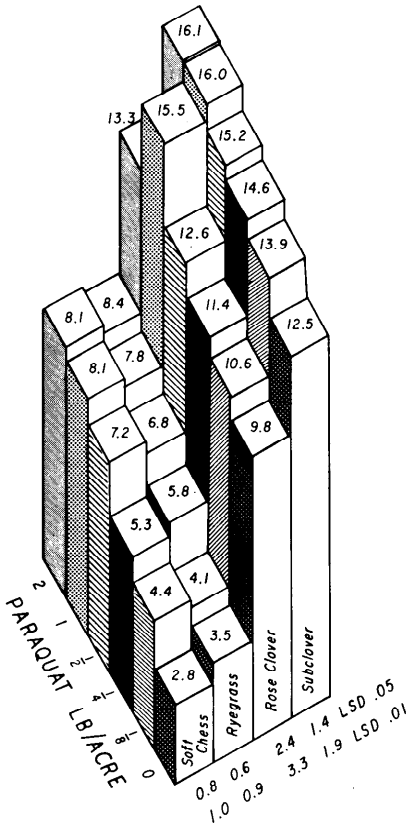

FIG. 3. Effect of paraquat on percent protein retention on September 29; sprayed May 5.

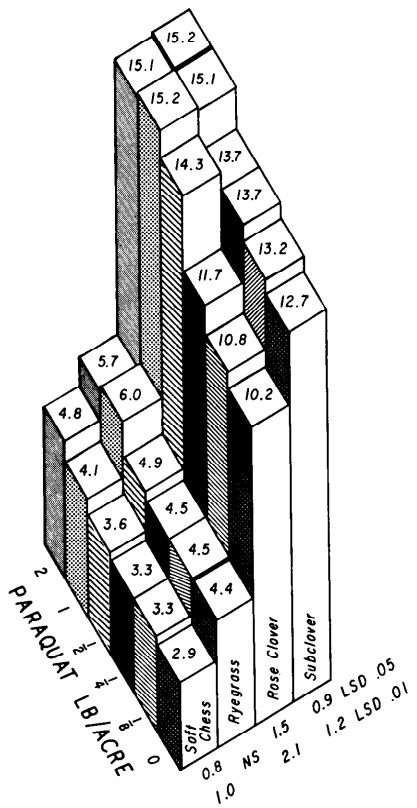

FIG. 4. Effect of paraquat on percent protein retention on September 29; sprayed May 18.

growth at spraying. As little as ⅛ lb./acre was sufficient if applied to soft chess at pre- or early anthesis, while ¼ lb./acre was the lowest successful rate on ryegrass, rose clover, and subclover. As the plants matured, higher rates of paraquat were required to retain protein.

The minimum rates of paraquat required to retain protein in these experiments, as well as the decline in protein throughout the dry period, are similar to those reported for crested wheatgrass (*Agropyron desertorum* Fish. ex Link Schult.) in southeastern Oregon (Sneva, 1967). Crude protein in untreated crested wheatgrass declined 50% in a 40-day period, compared with an increase of 10% in sprayed plants. The increase was due to regrowth in this perennial species. Protein in untreated grasses in the present experiments declined 40 to 50%, compared with 7 to 45% when plants were sprayed. Protein in the untreated clovers declined 24 to 32%, compared with an increase of 9% to a decrease of 22% in treated plants.

A question remains: is it better to plant grass species which can be sprayed to retain protein up to 8.5%, or is it better to plant a clover which can be cured at 15 to 16%? Cattle gains cease and losses begin when protein concentration falls below 7 or 8 percent (Wagnon et al., 1942). Therefore, spraying grass increased protein only to a maintenance level. To raise the protein above such a level, legumes must be present, either sprayed or unsprayed. It seems obvious that a clover would be the better choice. The difference in amount of paraquat necessary to increase the protein level in clover, as compared with grass, is not great. Also, the total yield of a legume is usually greater than that of a grass.

A problem encountered both in this study and in the series of range-curing experiments (Kay and Torell, 1970) was determining the correct time to spray. Both Sneva (1967) and Kay and Torell (1970) noted a relative decrease in forage yield in paraquat-sprayed pastures due to the growth which continued on the unsprayed pastures after the spraying date. Because of this growth it is important to wait as long as possible before spraying. However, forage should be sprayed just prior to the protein decline associated with early maturity. The onset of maturity can come very rapidly, and may not be detected. With annual grasses it seems best to plan to spray at the first sign of anthesis. Then if weather or other activities delay spraying a few days, it would still not be too late. Clovers bloom over a long period, and a spraying date might best be determined on the basis of soil moisture.

Another reason to delay spraying as long as possible is to avoid rainfall and the molding of hay which results. Although Kay and Torell (1970) found that the mold resulting from rain after spraying subclover pasture with paraquat did not seem to affect animal acceptance, it is undesirable in that it represents a loss of carbohydrate. In experiment 3 a total of 1.0 inches of unseasonal rain fell between spraying and July 7. The clovers were blackened by a mold, with the degree of blackening increasing

Table 2. Moldiness of paraquat-cured forage on July 7 presented on a scale of 1 through 10; 10 = completely black.

Species	Paraquat (lb./acre)	Spraying dates	
		May 5	May 18
Subclover	0	3	3
	⅛	8	4
	¼	9	4
	½	10	6
	1	10	5
	2	10	7
Rose clover	0	1	1
	⅛	2	2
	¼	2	5
	½	3	8
	1	10	9
	2	10	9

Table 3. Desiccation (%) of forage 6 days after spraying at the early application date.

Paraquat rate (lb./acre)	Second experiment				Third experiment			
	Rose clover	Sub-clover	Soft chess	Rye-grass	Rose clover	Sub-clover	Soft chess	Rye-grass
0	0	0	50	0	0	0	0	0
1/16	0	0	50	0	–	–	–	–
1/8	10	10	50	10	5	2	10	5
1/4	25	25	75	30	10	5	10	10
1/2	50	25	75	50	20	10	30	30
1	75	25	95	90	30	20	60	50
2	95	50	100	99	80	40	90	90

with the amount of paraquat applied (Table 2). Grasses were not seriously affected by the fungus. These unseasonably late rains also resulted in prolonged growth of the unsprayed clover and an increase in total production up to three times that of the sprayed clover.

The amount of paraquat necessary to desiccate the different species within 6 days of the early spraying varied with species and year (Table 3). The grasses were desiccated by lower rates than were the clovers. Subclover was the most resistant, never drying greater than 50% even with 2 lb./acre. Earlier studies also showed subclover very resistant to damage from paraquat (Kay, 1964 and 1968).

This report indicates that complete desiccation of the plants studied is not necessary for protein retention. While more than 1 lb./acre was required for complete desiccation of any of the species tested, protein was retained with much lower rates. This was also noted in the work on curing range forage (Kay and Torell, 1970).

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