Alfalfa Hay Conditioning Tests

relative drying rates, field losses, chemical composition of the hay, and feeding response of sheep studied in '58 season

R. A. Kepner, J. R. Goss, J. H. Meyer, J. B. Dobie, and L. G. Jones

Four hay conditioning machines—two models of smooth-roll crushers and two models of crimpers—were used in tests in 1958 on all six cuttings of a four-year-old alfalfa field at Davis.

Evaluation of the use of hay conditioners must include many factors, especially in California where fast curing—to reduce the chances of damage due to bad weather—is of far less importance than in some of the midwestern and eastern states. The farmer who uses a hay conditioning machine has the added costs and problems of an extra operation with a special piece of equipment, and tests indicate that there is some additional field loss of hay. Also, consideration must be given to such factors as the possibility of improved feeding response, or a higher selling price per ton; the possibilities and importance of improved scheduling of other operations in the hay-making sequence; and, possible reductions in time or labor required for the other operations.

Field experience with the conditioners in the Davis trials was too limited to yield much information about operational problems but none of the machines gave any appreciable trouble with clogging of rolls. In general, smooth-roll machines crush the stems throughout their entire length, whereas crimpers have intermeshing, fluted rolls that merely bend and crack the stems at intervals of 1″–2″.

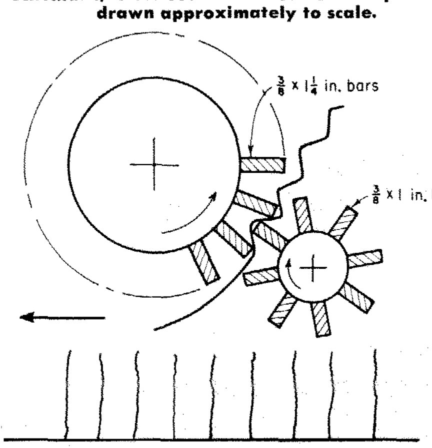
Roll Diameters and Operating Conditions

[1]Machine	Roll O.D. inches Lower	Roll O.D. inches Upper	[2]Ratio roll periph. speed ÷ fwd. speed	Usual roll pressure lbs./in. length
C-1	4	7½	4.4	19–21
C-2	4	9	2.5	11–15
R-1	6⅝	6½	2.2	9–10[3]
R-2	12	12	2.8	16–22[3]

[1] C-1, C-2, Crimper. R-1, R-2, Smooth-roll.
[2] Always operated in second gear, at a forward speed of about 4 mph.
[3] A few tests were made with roll pressures of 13½ lbs. per in. on R-1 and 32 lbs. per in. on R-2.

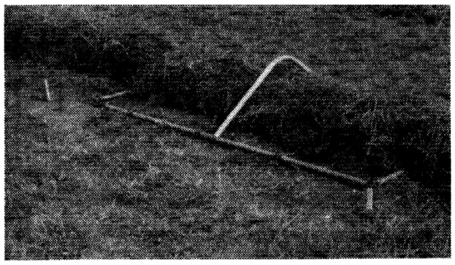
One crimper-type machine—C-1—had rectangular steel bars on each roll. The second crimper-type machine—C-2—had malleable-cast-iron rolls with tapered flutes. Springs normally held the movable roll of each crimper against stops that limited the amount of radial overlap to about ⅜″ for the bars of machine C-1 and ⅝″—adjustable—for the flutes of machine C-2. The springs permit spreading of the rolls if a heavy slug of hay or some foreign object is encountered. The rolls of the two smooth-roll crushers—R-1 and R-2—were held together by adjustable springs that controlled the crushing force.

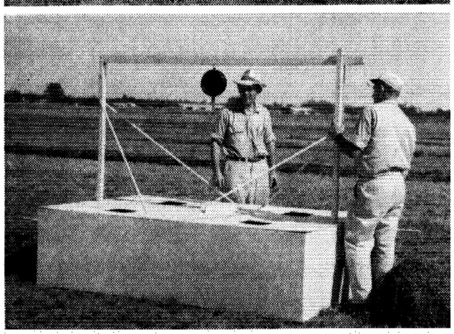
Schematic, cross-sectional view of crimper C-1, drawn approximately to scale.



Machine R-1 was equipped with a floating, spring-finger pickup cylinder whereas machine R-2 had a small-diameter, paddle-type pickup cylinder. The lower crimping roll on machines C-1 and C-2 served as the pickup. The pickup cylinder on machine R-1 was considerably more effective than the pickups on the other three conditioners, particularly when operating over rough ground or with one wheel on an irrigation levee.

Top—Section of windrow on a flexible-netting tray for determination of drying rates. Bottom—Weighing a tray. The portable box shields the tray from wind during weighing.





Each cutting of alfalfa included an unconditioned treatment—the control—and from two to four conditioned treatments. Machines R-1 and C-1 were used for all six cuttings, machine R-2 for four cuttings, and machine C-2 for two cuttings. In each treatment there were four randomized replications, consisting of the center two-thirds of an irrigation check 38′ wide and 240′ long.

The checks were mowed by successive pairs as soon as the dew was off in the morning. Conditioning was usually done within 15 minutes after mowing. For most cuttings the hay was raked on the morning following mowing, putting the 25′–28′ wide test strip of each check into a single windrow.

Baling was always done in the morning, starting after the free moisture had disappeared from the windrows and finishing before the hay became dry enough to cause appreciable leaf shatter.

Protein and carotene contents were determined just before mowing and just after baling. Protein determinations were made also at the beginning of the feeding trials, and carotene content for the sixth-cutting hay was checked after several months of storage. Crude fiber was checked at the time of baling and at the time of feeding.

In general, there was no great difference in drying rates obtained with the four conditioners. Machine R-1 tended to be slightly slower than C-1 when the roll pressure was 9–10 pounds per inch of roll length, but slightly faster when the roll pressure was 13½ pounds per inch. Drying-rate curves for C-1 and C-2 checked rather closely, and there was not much difference between R-1 at a roll pressure of 9–10 pounds per inch and R-2 at 16–22 pounds per inch. Machine R-2 required a higher roll pressure than R-1 primarily because of the larger diameter of the rolls and the resulting greater contact area on the hay.

Moisture levels at the time of baling ranged from 26% for an early baling of part of the first-cutting control, to 12%

Continued on next page

HAY

Continued from preceding page

for conditioned hay in the third cutting. Most of the other balings were at moisture contents of 15% to 23%. In general, it was found that anything baled at an average moisture content above 16–17% developed some mold in storage and anything baled above 20% heated sufficiently to impart a brown color to the hay.

If an early morning moisture content of 20% is considered to be the upper safe limit for baling, field curing times in the first five cuttings would have ranged from 4–8 days for the unconditioned hay and from 3–5 days for the conditioned hay. Conditioning usually reduced the field curing time by about two days. Baling at night, after the hay has picked up enough moisture to become tough but not enough to exceed the upper safe limit, might reduce these curing times.

Field Losses

The field losses evaluated in these tests consisted of freshly cut plant material—primarily shattered leaves, tips of plants, short sections of stalk, and short pieces of leaf branches—that ordinarily would not be recovered in the raking operation. The samples were picked up by hand from 2′ × 6′ areas soon after mowing and conditioning and again after raking.

Average losses for three cuttings in which the roll pressures were 9–10 pounds per inch for machine R-1 and 16–22 pounds per inch for R-2 are shown in the table in column two. All differences between treatments were highly significant. The 1% increase in loss as a result of rolling is not economically important but the 3.6% increase due to crimping does represent an appreciable loss of income. Both crimping and rolling losses were considerably less in the first cutting than in later cuttings. Because of the predominance of leaves and stalk tips, the protein content of the material lost in the conditioned treatments was several percentage points higher than the protein content of the baled hay.

Field Losses from Mowing and Conditioning (Average for second, third, and fourth cuttings)

Treatment	Total loss: Lbs. dry matter/acre	Total loss: Percent of yield	Loss due to conditioning percent of yield
Control	27	1.0	0.0
Crimped	120	4.6	3.6
Rolled	55	2.1	1.1

Average yield was 2,600 lbs. of dry matter per acre.
Maturity ranged from 9% to 56% bloom.

Total losses determined after raking averaged practically the same as those obtained after conditioning. Losses were about the same for both crimpers, and there was no significant difference between the results for the two smooth-roll crushers. However, increasing the roll pressure of machine R-1 from nine pounds per inch to 13½ pounds per inch increased the total loss by 50% to 60%. The loss from R-2 also was greater at higher roll pressures.

Feeding Trials

Feeding trials with 36 sheep—18 pens with two sheep in each pen—were started in mid-October and continued for a period of eight weeks. Rolled, crimped, and unconditioned hay from the first, fourth, and fifth cuttings was used. Part of each treatment for each cutting was pelleted and part was fed directly from the bale.

The average gain per 100 pounds of feed consumed was 15% to 20% greater with rolled hay than with either crimped or unconditioned hay. The difference was significant and was found with both pellets and bales. There was no appreciable effect of hay conditioning in regard to average daily feed consumption, percentage of the baled hay refused by the sheep, or chemical composition of the refused hay.

Summary of Feeding Response with Sheep (Average for first, fourth, and fifth cuttings)

Hay treatment	Feed[1]: Protein content %	Feed[1]: Crude fiber %	Aver. daily gain lbs.	Lbs. gain /100 lbs. feed consumed
Pelleted				
Unconditioned	21.4	27.8	0.31	9.9
Crimped	21.4	28.2	0.28	9.5
Rolled	21.9	27.8	0.37[2]	11.9[2]
Baled				
Unconditioned	22.3	27.8	0.26	9.3
Crimped	21.7	28.5	0.25	9.1
Rolled	21.7	27.3	0.30[2]	10.5[2]

Hay in each cutting was about 10% bloom.
[1] Dry basis.
[2] Difference between rolled and other two treatments statistically significant at the 5% level.

Protein and crude fiber contents for the hay at the time of feeding are shown in the table in this column. Crude fiber content is a readily determinable and reliable index of total-digestible-nutrient content, with high crude fiber content being undesirable. Crude fiber contents for the last five cuttings, at the time of baling, averaged 27.4%, 28.8%, and 28.2% for the control, crimped, and rolled treatments. Corresponding protein contents were 22.5%, 21.6%, and 22.0% as compared with 22.3% for the standing crop at the time of mowing. Conditioned hay showed a slight advantage over unconditioned hay in regard to carotene content at the time of baling, but no advantage after several months in storage.

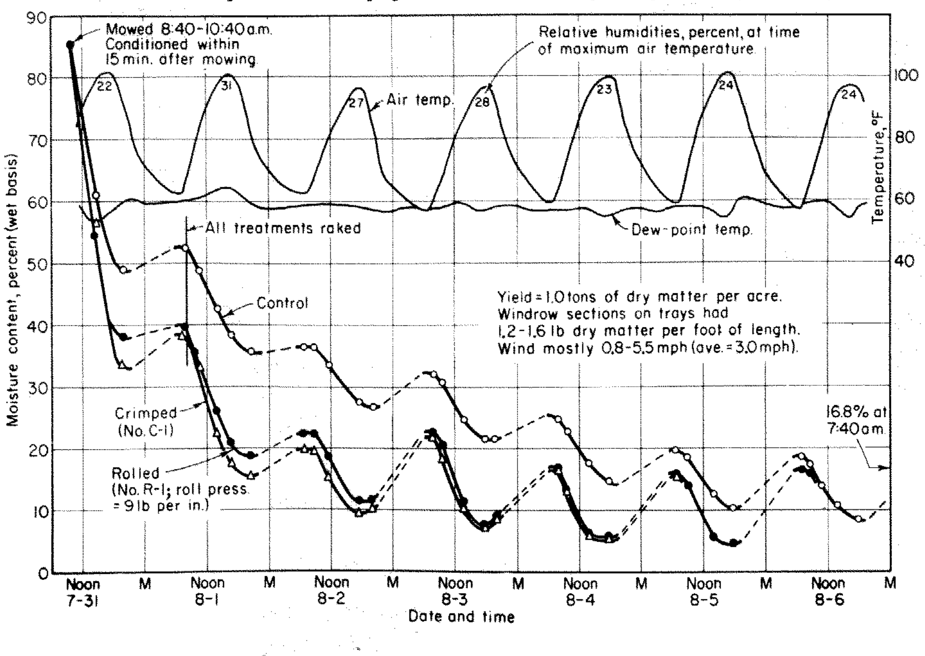
More Trials Planned

The chemical-analysis results do not afford an explanation for the greater feeding response with rolled hay as compared with the control treatment. The crimped hay, however, as indicated above, had a higher crude fiber content than the other two treatments and the average protein content at the time of baling was lower.

Although the results of the feeding trials indicate a statistically significant

Concluded on page 14

Field drying rates for the fourth cutting, under summer weather conditions typical for the Sacramento Valley. Part of the advantage of faster daytime drying of conditioned hay was lost by greater moisture pickup during the night.



STRAWBERRIES

Continued from page 2

length. Season lengths were estimated at 150 hours for Regions *3–7* and 200 hours for Regions *1*, *2*, *8*, and *9* as compared with 1,000 hours in California. In regions in which strawberry freezing equipment is also used for processing other products, an allocation of equipment fixed costs was made to the different products processed.

Processing costs are lower in large plants, as measured by hourly capacity rate, than in small plants. In this study, it was assumed that all processing would occur in uniformly large plants unless expected regional output would not require large plants. In those cases processing was assumed to occur in smaller plants and unit costs were increased accordingly.

Because of a longer season and in spite of higher labor wage rates, California is able to process strawberries for freezing at a lower cost than any other region. Regions *1* and *2* follow California in processing cost advantage. The processing costs of these regions are slightly lower than the next group—Regions *3–7*—because of the slightly longer processing season. Regions *8* and *9* have highest processing costs because of higher wage rates than other regions of similar processing season length.

The cost of frozen strawberries at a freezing plant in each region is composed of the costs of farm production and delivery to the processing plant, processing the berries for freezing, sugar, containers, and freezing. California, followed closely by Washington and Oregon, holds an advantage in total at-plant frozen product cost. Among eastern regions, Regions *2* and *4* have lowest frozen product cost.

Both rail and truck transport are used to move frozen strawberries, and the lowest cost method was assumed to be utilized in each interregional movement. Truck transport was estimated to be most economical at distances of less than 1,200 miles, and rail transport most economical at greater distances. Regions *8*, *9*, and *10*—at a comparatively great distance from eastern consuming areas—have a transportation cost disadvantage of 1.5¢ to more than 2¢ per pound in most of the eastern United States markets.

Possible Production Pattern

A production pattern—toward which the industry could be expected to move—was estimated with a projected 1970 consumption and 1957–58 costs. Assuming the possibility of greatly increased output without increased cost, California—on the basis of least-total-cost—has a cost advantage for nearly all the frozen strawberries in the United States. The total cost of Region *10* strawberries delivered to Regions *1*, *3*, *5*, *6*, and *7* was less than the at-plant cost of frozen strawberries produced in those regions. The delivered cost of Region *10* frozen strawberries in Regions *2*, *4*, *8*, and *9* was only slightly greater than their regional at-plant costs. Small transportation charges raise these costs above those of Region *10* so the areas of advantage of these eastern producing regions are limited.

Cost and Return Variations

A precise solution based on current data is possible, but different data may apply to future periods and projections would be changed. If transportation costs, for instance, increased as little as 10%, Region *2* would have a comparative advantage in production for institutional and manufacturing uses in Michigan and Illinois, which represent about 6% of total United States consumption. At a 50% rate increase, Region *2* would have a comparative advantage in production for all uses in the states of Michigan, Ohio, Indiana, Illinois, and Wisconsin, representing approximately 24% of the total United States frozen strawberry consumption.

A technological change specifically adapted to one or a few regions could result in large production shifts. The introduction of new, long-bearing, heavy-yielding strawberry varieties especially adapted to local growing conditions has been a contributing factor, for example, in the recent rapid increase in California strawberry production. However, such an advantage is precarious. If a similar cost-reducing technology were developed in Region *2*, for example, and it became possible to produce 50% more strawberries per year on a given bearing acreage, Region *2* could—assuming a 50% increase in processing season length; constant total nonharvesting costs; and an increase in harvesting costs in proportion to yield—become the most important frozen strawberry producing area of the United States.

Most of the increased production advantage to be gained by other regions would be at the expense of California producers. However, future technological advance is as likely in California as elsewhere—as indicated by the promising trials with the new Solana variety.

Interregional price differentials based on quality characteristics are not in extensive use, but there is considerable interest in the effect they could have on the industry. If, for instance, the strawberries of Regions *8* and *9* were priced just one-fourth cent per pound higher than berries from any other region, Region *8* would obtain a production advantage for about 25% of total United States consumption, all of which would be at the expense of California.

Although California holds a total unit cost—production, processing, and shipping—advantage, based an present cost structures in nearly all of the United States markets, the advantage is slight and small changes in certain cost components or product pricing could eliminate a large part of that advantage. The differences in total unit costs of production and processing among Regions *8*, *9*, and *10* are so small that the costs might well be considered equal.

Regions *8*, *9*, and *10* probably will remain dominant in the frozen strawberry industry, but—contrary to the indications of a least-cost analysis based on present regional costs and returns—it is unlikely that Region *10* will expand to produce nearly all of the United States frozen strawberries.

Relatively minor shifts in regional costs and returns growing out of unpredictable future changes could greatly modify any industry adjustment based on least cost for the United States output of frozen strawberries.

Carleton C. Dennis was Co-operative Agent of the Agricultural Marketing Service, United States Department of Agriculture and the California Agricultural Experiment Station, University of California, Berkeley, at the time this study was made.

This brief report is based on a manuscript for a detailed report, "Interregional Frozen Strawberry Competition." This report will be available without charge from the Giannini Foundation of Agricultural Economics, 207 Giannini Hall, University of California, Berkeley 4.

HAY

Continued from page 6

difference in favor of rolled hay, the absence of a satisfactory explanation in terms of chemical content raises some doubt as to the validity of any generalization based on this one set of tests. Experience has indicated that feeding results may vary somewhat in different groups of tests, probably because of biological variations.

Additional sheep-feeding trials at Davis with conditioned and unconditioned hay are planned for the fall of 1959.

R. A. Kepner is Professor of Agricultural Engineering, University of California, Davis.

J. R. Goss is Assistant Agricultural Engineer, University of California, Davis.

J. H. Meyer is Associate Professor of Animal Husbandry, University of California, Davis.

J. B. Dobie is Specialist in Agricultural Engineering, University of California, Davis.

L. G. Jones is Specialist in Agronomy, University of California, Davis.

The above progress report is based on Research Project No. 1793.