Hay harvesting by

Self-Propelled Swather

compared with mowing and raking

R. A. Kepner, J. R. Goss, and L. G. Jones

The use of self-propelled windrowers—commonly known as swathers—to cut, condition, and windrow green hay in one operation is a relatively new practice that has gained favor rapidly during the last two or three years. This method appears to have many operational advantages over the conventional method of mowing and raking, particularly for use on large acreages.

A 12′ swather and a 7′ mower were used in tests at Davis to obtain comparative drying rates, yields, and nutrient contents for swathed hay and mowed hay. The support runners on the cutting units of both machines were adjusted to give a knife height of about 1.75″ above a flat surface. Tests included cuttings of Moapa alfalfa made on August 17, 1959, June 1, 1960, and June 27, 1960. Yields for the 1959 cutting were not determined.

The irrigation checks in the test field averaged 25′ in width. For each of the 1960 tests, headlands and every third check in a group of 25 were mowed and raked a day or more ahead of the test cutting. Lengths and widths of the eight standing pairs were then measured, to obtain areas for the yield determinations.

During each test, alternate pairs of checks were mowed but not conditioned. The remaining checks were swathed, using the conditioner for only one of each pair. Mowing and swathing were done simultaneously, both at about 4 mph—miles per hour.

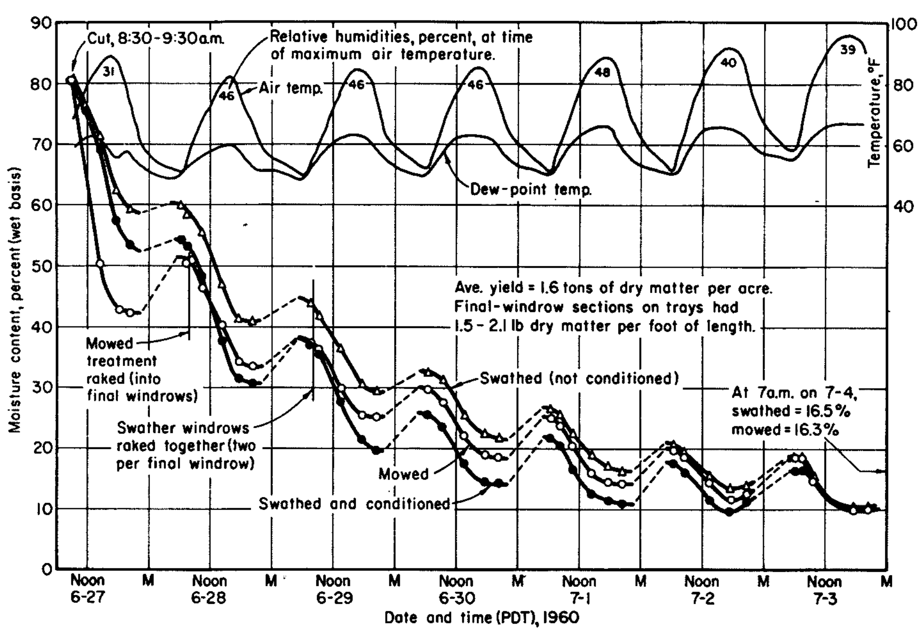
Mowed checks usually were raked into the final windrows—one per check—on the morning after mowing. In each swathed check the two windrows were rolled together with the rake, part of each check two days after cutting and most of the remainder four days after cutting. Raking and baling were always done under favorable moisture conditions. The reel-type rake used in all tests was operated at about 5 mph.

Typical drying rates are shown in the graph on this page. In general, total curing times were about 20% less for swathed-and-conditioned hay than for swathed or mowed hay that had not been conditioned.

There was no difference in curing times when pairs of swather windrows were raked together four days after cutting instead of at two days, provided the last raking was at least one day before baling. Hay remaining in the swather windrow consistently had 2–4 percentage points more early-morning moisture than the raked double windrows, but by evening the hay in swather windrows was a little drier than that in the double windrows. These differences, due primarily to the greater exposed area of the swather windrows, disappeared within one day after the later raking.

If there is insufficient dew during the curing period to permit raking without excessive leaf loss, swathed hay can be baled without raking and the greater night-time moisture pickup of the swather windrows would be advantageous. But with normal or heavy dews, leaving the hay in the swather windrows probably would delay baling.

In these tests only two swather passes were required for each irrigation check, and one end of the header was always on top of a levee. Because the swather was wider than the mower, the stubble next to the levee was longer, as illustrated by the diagram at the left on page 3. For the test conditions, with an average levee height of 4.3″, the theoretical dif-



Field drying rates for mowed and swathed hay.

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ference in average height of stubble, over a 12′ width, is 0.9″. The actual measured differences in average stubble length were 1.85″, 2.2″, and 1.45″, for the three cuttings. Actual length differences were greater than the theoretical height difference because stalks were not upright when cut, either bending naturally or being pushed forward by the cutting unit.

In the cutting of June 1, the 2.2″ difference represented 8.9% of the mowed stalk length and the swathed-hay yield of 1.72 tons per acre was 8.0% less than the mowed-hay yield of 1.87 tons per acre, at 15% moisture. Prior to the June 1 cutting, the entire field had been mowed.

At the time of the June 1 cutting, made at 62% bloom, the new crown growth was 4″–5″ high. Because the mower clipped considerably more of this new growth than did the swather, the swathed checks recovered more rapidly. In the June 27 cutting, with each pair of checks harvested by the same method as on June 1, there was no appreciable difference between swathed and mowed yields, even though the swather stubble averaged 1.45″ longer. More tests are needed to show how the yields would compare if the preceding cutting were early enough to eliminate or minimize clipping of regrowth.

Wider checks, that would require some of the swather passes to be made on the flat, would proportionately reduce the over-all loss due to the longer swather stubble adjacent to the levees. Higher levees or a wider swather would increase the loss. On the other hand, poor mowing conditions, such as a crop that is leaning badly or is partly lodged, and raking when the hay is too dry, would increase mowed-hay losses in relation to swather losses.

Bale samples for moisture content and chemical analyses were taken with a push-type probe immediately after baling. Crude protein averages for the swathed treatments and mowed hay, respectively, were: August 17 cutting—21.5% and 20.8%; June 1—20.0% and 19.5%; June 27—22.8% and 22.4%. The difference between treatments in the August cutting was statistically significant at the 1% level, but the other two differences were not significant. There were no significant differences in crude fiber contents of swathed and mowed hay. One might expect that the longer low-quality stubble left by the swather adjacent to the levees would tend to result in slightly higher protein and lower crude fiber for the swathed hay from this area.

In a survey involving 14 swathers, all with 12′ or 14′ headers, the alfalfa harvested per machine ranged from 300 to 1,000 acres per cutting. Only one machine was without a conditioner attachment. All but two of the growers raked two swather windrows together, usually two or three days after cutting. Double windrows permit baling at high tonnage rates without excessive forward speeds, but they may be damaged if a moderate or strong cross wind occurs within a day or so after raking.

Observed swather operating speeds averaged about 4 mph and were usually between 3½ and 4½ mph. With the usual knife crank speeds of 550–650 rpm—revolutions per minute—on swathers, contrasted with 900 to 1,100 rpm on mowers, operation at forward speeds much above 4–4½ mph results in a poor cutting job and uneven stubble heights. In more than half of the fields, the levee spacing was such that the effective width of cut was 1½′–2′ less than the swather width, reducing the field capacity of the machine.

In laying out a new field, the check width should represent an even number of swather passes, allowing about 1′ of overlap per pass. The check width for a 14′ swather would then be 26′, 52′, or 78′. Levees should be as low as feasible—not more than 4″ or 5″ high after settling. They should have a base width of 8′–10′, a narrow crest, and uniformly sloping sides.

Owners and operators pointed out that a swather seldom plugs, even in down hay, and that it works satisfactorily in a strong wind. Hay that is leaning or down can be cut in any direction of travel. Timing of the raking operation is less critical than for mowed hay. The general opinion was that a better operator is needed for a swather than for a mower, but that a swather may be less tedious to operate. When a wheel-type rake is used, there may be more dirt in mowed hay than in swathed hay.

Cost Analysis

Because none of the swathers was more than two years old, little information was available regarding long-range maintenance costs. The most common complaints were frequent belt failures, numerous minor structural and mechanical problems, and—in a few cases—excessive maintenance for overloaded engines. Operators' estimates of gasoline consumption for swathers with conditioners averaged three gallons per hour.

Cost factors and operating conditions assumed in this analysis are summarized in the two tables on page 4. The repair costs were based on published information that is quite variable and, for swath-

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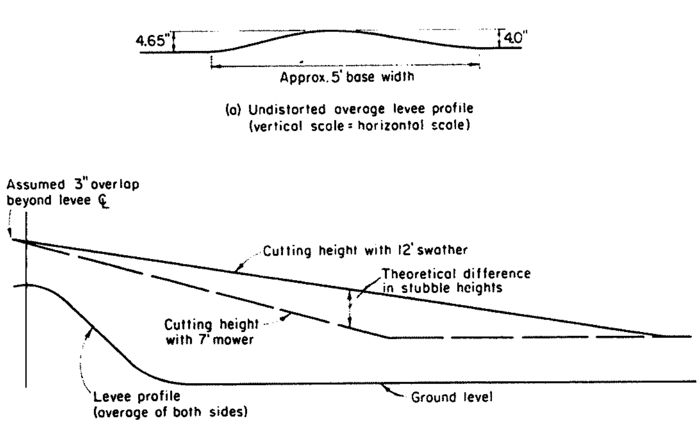
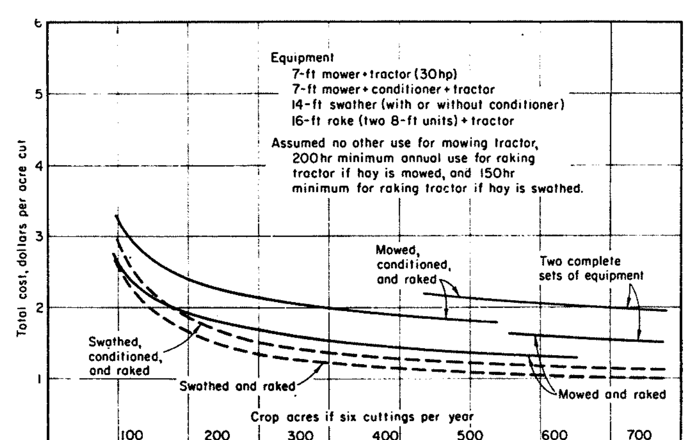


Levee profiles and relative cutting heights in tests at Davis.



Comparative costs for mowing and swathing.

SWATHERS

Continued from preceding page

ers, rather limited. Estimates of machine life also are somewhat arbitrary.

Comparative cutting and windrowing costs per acre for four harvesting methods are shown in the graph at the right on page 3. For the conditions assumed in this analysis, the break-even point for mowing and raking versus swathing-conditioning and raking is about 900 acres per year. This would represent 150 crop acres if six cuttings were made.

For the farmer who intends to condition his hay regardless of how it is cut, swathing is 50¢ to 60¢ per acre cheaper than mowing for more than 800 acres per year, and the break-even point is somewhat less than 500 acres per year.

With a swather the added cost for conditioning is only 15¢ per acre for 1,500 acres or more per year. By contrast, the extra cost for conditioning mowed hay in a combined operation is 45¢ to 55¢ per acre; it would be much greater if conditioning were a separate operation.

The conditioner attachment on a swather seems justifiable in most cases, since it reduces the curing time by one or two days, adds only a relatively small amount to the cost of swathing, and is reasonably trouble-free.

With 600 acres or more per year, raking represents 30%–35% of the total costs shown in the graph for swathing or swathing and conditioning. Thus, if eliminating the raking operation for swathed hay would eliminate a tractor, there would be a substantially greater saving from swathing in comparison with mowing. However, if a high-capacity baler is used, the saving could be partly or entirely offset by reduced baler capacity because of the smaller windrows.

At less than 400–500 acres per year, total costs per acre with a 12′ swather would be a little lower than with a 14′ swather. Greater acreages would favor the 14′ machine, with the difference at 3,000 acres per year amounting to 12¢ per acre. A 16′ double rake is more economical than a single 8′ rake if more than 500–600 acres are raked per year.

In comparing total cutting and windrowing costs for mowing and swathing, any differences in yield or hay value must be considered. With hay selling at $25 per ton, a yield difference of only 2% would represent 50¢ to 75¢ per acre.

For the operating conditions indicated in the upper table, the labor requirement to mow and rake is 0.50 man-hour per acre with conditioning and 0.44 without; to swath and rake with or without the conditioner is 0.26 man-hour; and to swath without raking is 0.19 man-hour. Thus, swathing and raking requires only 60% as much labor as mowing and raking, and about half as much as mowing-conditioning and raking.

Assumed Operating Conditions for Cost Analysis

Item	Mowing (no cond.)	Mowing and cond.	Raking after mowing	Swathing*	Raking after swathing
Ave. actual width covered, ft	6.5	6.5	16	13	26†
Percent of time lost in field	20	25	10	15	10
Ave. operating speed, mph	5	4.5	5	4	5
Calc. ave. acres per hr	3.15	2.65	8.7	5.35	14.2
Estim. max. acres per cutting‡	630	530	700	1,070	1,130

* 14-ft. swather, with or without conditioner.
† Effective raking width is two swather passes, since two swather windrows are rolled together.
‡ Based on assumed maximum operating time of 20 days per cutting, at 10 hours per day for mowing or swathing and 4 hours per day for raking.

Cost Factors Used in Analysis

Item	30-hp tractor	7-ft mower	Conditioner (incl. hitch on mower)	16-ft double rake	14-ft swather (no cond.)	14-ft swather w/cond.
First cost	$3,000	$475	$1,100	$1,400*	$4,000	$4,850
Hours to wear out	12,000	2,500	2,500	3,000	3,000	3,000
Years until obsolescence	10	10	10	10	8	8
Resale value, % of first cost	10	0	0	0	10	10
Taxes, insur., housing, per year, % of first cost	2.5	2	2	2	2	2
Repairs and maint. per hour	$0.25	$0.25	$0.10	$0.40	$0.50	$0.60
Fuel consumption, gal/hr.	†	..	..	..	2	3

* Two standard 8-ft rakes at $675, plus $50 for hitch.
† Tractor fuel consumption = 1.5 gal per hr with mower or rake and 2.5 gal per hr with mower plus conditioner.
Other cost factors: constant annual interest charge = 6% of average investment; fuel cost (gasoline) = $0.20 per gal; oil cost = 15% of fuel cost per hour; operator's wages = $1.25 per hr; straight-line depreciation assumed, with life based on hours to wear out or years until obsolescence, whichever occurs first.

Additional tests are planned, to determine the effect of height of cutting on yield for various stages of maturity, to compare swathing and mowing yields under adverse mowing conditions, and to obtain early-season drying rates.

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OXIDE SYNTHESIS

in the liver

In mammals, trimethylamine-N-oxide synthesis appears to be merely a means of detoxifying trimethylamine, which is formed in the normal metabolism of choline as well as by intestinal bacteria.

In liver, the trimethylamine-N-oxide forming system possesses many of the characteristics of the steroid-forming enzyme, squalene oxidocyclase, which is responsible for the formation of various hormones.

The biosynthesis of trimethylamine-N-oxide in liver has been shown to proceed in only one cellular fraction, the microsome. In carefully washed microsomes, the only requirements for conversion of trimethylamine to its N-oxide were oxygen and the specific reducing agent TPNH—dihydrotriphosphopyridine nucleotide—one of the biologically active forms of the vitamin niacin. Nicotinamide, previously considered necessary for the formation of trimethylamine-N-oxide, may be replaced by a sufficiently high concentration of TPNH. This suggests that the only function of nicotinamide in the reaction was to protect TPNH from oxidation or hydrolysis.

Liver is capable of synthesizing the N-oxide of nicotinamide also. No connection between the nicotinamide requirement for trimethylamine-N-oxide synthesis and the ready conversion of nicotinamide to and from its N-oxide has been experimentally demonstrable. It is hoped that knowledge of the biosynthesis of trimethylamine-N-oxide may help explain the mechanism by which animals incorporate molecular oxygen into various chemical compounds so that the formation of the steroid nucleus can be studied free of the complicating system of enzymes which activate molecular oxygen.—*Sterling Chaykin, Dept. of Animal Biochemistry, Davis.*