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Combining Grain in Weed-Free Fields

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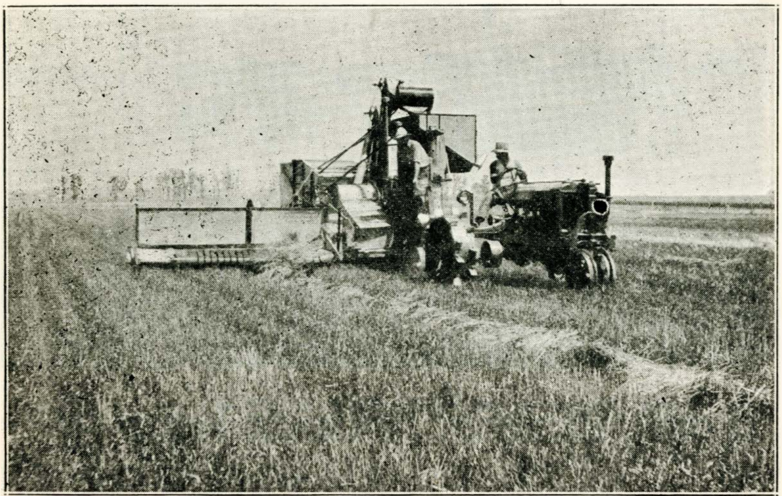

"Picking up the Windrow of Grain in the Experimental Project in 'Combining' at the South Dakota State College Experiment Station, Brookings, S. Dak."

Agricultural Engineering Department
Agricultural Experiment Station
South Dakota State College of Agriculture
and Mechanic Arts
Brookings, S. D.

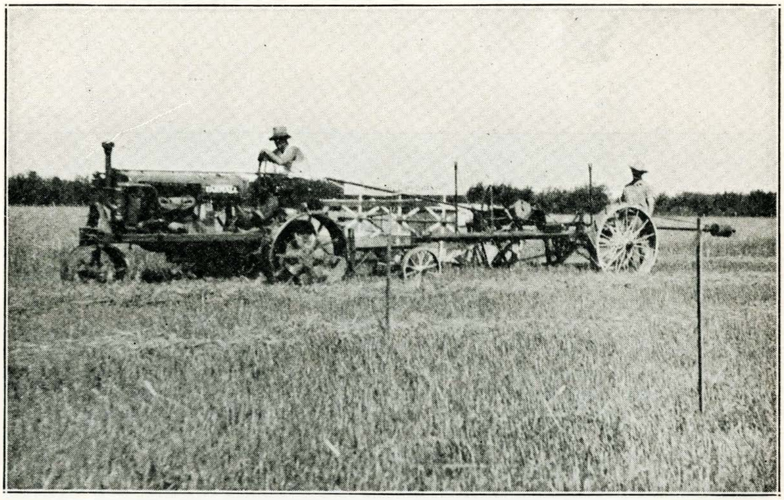

Fig. 1—"THE 'SWATHER' OR WINDROWING MACHINE."
This machine cuts the standing grain without tieing it and lays it down in windrows across the field. The machine shown in the picture cuts a 12 ft. swath.

Combining Grain In Weed-Free Fields

Progress Report on Combine Project for 1929

By
D. E. Wiant & R. L. Patty

The work done on the combined harvester-thresher by this station during the past two seasons indicated that windrowing grain or similar method is likely to be a very desirable practice in South Dakota. Previous work indicates that a very large percentage of the high moisture content found in grain that was direct combined is due to green weeds. Pigeon grass and other weeds found in the stubble bottom, green tips from the Russian thistle and other weeds seem to be the source of most of this excess moisture. The windrow method would solve this problem and reduce the moisture content of the grain itself.

The windrow method has recently been made more practicable by new machinery designed especially for this process. This machinery consists of a "swathing" or windrowing device and a pick-up attachment for the platform of the combine. The swather cuts the standing grain in wide swaths (without tieing it) according to width of cut of machine being used, and deposits it in windrows. When the grain is dry in the windrow the combine is driven along and threshes the grain as the windrow is picked up by the "pick-up" attachment.

The windrow method would solve the green materials problem as well as reduce the moisture content of the grain before picking it up and threshing it. But any system which supplants the straight combine method should, in addition to reducing the moisture content of the weeds and grain, give maximum length of harvest day and harvest period; give maximum capacity in acres per day; keep the losses down to straight combine or binder separator loss level, keep the cost within reasonable bounds, and at the same time introduce no additional loss hazard.

This Year's Work In Clean Weed-Free Grain

A weed-free field was selected for the first years' work with the windrow method of harvesting for the purpose of ascertaining how much of the moisture in combined grain is due to green weeds. Next year's work will be done on comparatively weedy fields. The work was outlined in such a way that the more important questions which arise in connection with this method of harvesting could be studied. No attempt was made to determine cost of any phase of harvesting other than to find whether or not the time and power requirements for windrowing would interfere with the picking-up operation and make further investment in labor and power necessary.

Purpose of the Study

The individual problems were, to determine: (1) The effects of windrowing grain at different times of the day on the rate of drying-out in the windrows; (2) Relation of width of windrowed swath to rate of drying out; (3) How early in the day grain can be picked up an threshed; (4) The losses for straight combine and windrow methods of harvesting; (5) The most efficient rate of travel for picking up; (6) The most practical ratio between the width of windrow swath and size of combine; (7) The effects of unfavorable weather on windrows; (8) When to combine direct and the length of the combine period.

Field and Equipment Used

A 15 acre field of late oats on the College farm was used for the study. This oats was very uniform— about 30 inches high, contained 15 per cent barley by weight, and was absolutely weed free. A 10-foot harvester-thresher of reliable make with a 30 bushel tank was used in the field with a light 10-20 tractor, a 12 foot ground windrower, and a 6½ foot pick-up. A Brown-Duval moisture tester was used to determine the moisture content of the grain. Grain samples for the moisture test were taken from the field in two-quart glass jars carefully sealed.

Brief of Plan Followed

The field was mapped out, the windrower was used at different dates and at different times of the day and the moisture content of the grain taken at these times. The width of swath cut was varied to give heavy and light windrows. A portion of each windrow was threshed at regular intervals during the day and the moisture content of the grain taken in order to determine how early in the day grain could be picked up. When the moisture content was low enough to make storage safe, part of the grain was combined. Shattering losses and pick-up losses were determined for different rates of picking-up and for different sizes of windrows. Blanket tests were made to determine separator losses at different rates of travel, for different sizes in windrow, and for the varying conditions under which the oats was direct-combined. The condition of the standing grain was noted and a small amount of the grain was left uncut and the condition noted as the grain ripened and crinkled down. Parts of several windrows were left intact to observe effects of weathering and a complete report was kept of weathering conditions.

The Effect of Windrowing Grain At Different Times of the Day On the Rate of Drying

In order to determine whether or not the rate of drying of windrowed grain would depend on the time of day that the windrows was cut, and also to determine the length of time required for the windrows to dry sufficiently to make storage of grain safe, twelve-foot windrows were cut every hour during the day and the moisture content taken, with results as shown in tabel I.

There was a heavy dew July 26. No dew July 27, 28 or 29, but slightly cloudy between 8:00 a.m. and 10:00 a.m. July 29. The mean temperature for this period was 87 degrees F.

TABLE I.—THE RATE OF DRYING OUT OF WINDROWS ACCORDING TO THE TIME OF DAY CUT

Windrow Number	Time of Day Windrow was cut. 7/26	% Moisture at time cut. 7/26	% Moisture content One Day Later	% Moisture content Two Days Later	% Moisture content Three Days Later
1	8:15 A. M.	20.3	10.9	9.2	9.4
2	9:15	18.1	10.7	9.6	9.3
3	10:15	17.4	10.7	9.1	9.1
4	11:15	15.7	10.7	8.8	10.1
5	12:15 P. M.	14.5	10.9	10.3	10.3
6	1:15	13.9	11.2	10.0	9.7
7	2:15	12.9	10.8	10.6	10.3
8	4:15	9.8	11.2	10.1	9.7
Average		15.32	10.86	9.71	9.73

Note: The allowable moisture content in grains as considered safe for storage today are as follows: Oats and barley 14½ percent, wheat 13½ pecent, rye 13 percent, and flax 11 per cent.

The table shows that within one day after cutting the moisture content of the different windrows dropped to a common level and after reaching this point further drop was practically uniform throughout, and that it was found satisfactory to windrow grain in the early morning.

While this refers to drying only, no trouble or inconvenience was experienced in cutting when there was a heavy dew. This weed-free grain was ready to pick up and thresh one day after it was cut.

Relation of Width of Windrow Cut To Rate of Drying

To find the rate of drying of windrows according to their bulk, (width of swath) 12, 19, 20 and 24 feet windrows were cut. The windrows were cut between 1 and 3 p.m. and the percent of moisture content determined. The following chart shows the percent of moisture content at different dates.

TABLE II—RELATION OF WIDTH OF SWATH IN WINDROW TO RATE OF DRYING

Width of cut in feet	When cut	% Moisture Content when cut	Date Windrow Threshed	Per cent Moisture Content (Average)	Date Sample Threshed	Per cent Moisture Content	Date Sample Threshed	Per cent Moisture Content
12	July 26	12.5	July 27 11:00 a. m.	11.2	July 28 11:00 a. m.	10.1	July 29 11:00 a. m.	9.7
20	July 26	12.5					July 24 6:00 p. m.	8.2
24	July 26	12.5			July 28 12:00 m		July 29 8:00 a. m.	**12.3**
							July 29 6:00 p. m.	9.2

This chart shows that the percent of moisture content dropped practically the same in each windrow, regardless of the width of swath cut. The windrows were free from weeds.

The width of swath or size of windrow did not affect the rate of drying. The oats in the 24-ft. windrow was ready to pick up and thresh just as soon as the oats in the 12-ft. windrow. Or in other words, in this particular field, the time required for a windrow to dry out was not governed by the size of the windrow. The heavy windrows stayed up on the stubble better than the light ones.

To Determine How Early in the Day Windrow Grain Can Be Picked-Up and Threshed

Ten 12-ft. windrows were cut July 26. Samples were threshed and the moisture content was taken as shown in the following table. After three days the grain in the windrow was in such dry condition that it was advisable to pick up the remaining amount with the exception of a windrow left for observation.

TABLE III—RELATION OF MOISTURE CONTENT OF GRAIN IN WINDROW TO TIME OF DAY

Swath Number	Date Cut	Date Sampled	Per cent Moisture content at 8 a. m.	Per cent Moisture content at 10 a. m.	Per cent Moisture content at 12 m.
7	July 26	July 27	14.9	13.5	10.8
8	July 26	July 28	12.1	9.3	10.6
9	July 26	July 29	13.5 *	10.5	10.3

*Slightly cloudy at this time.

This test is not complete enough to be termed conclusive, but it did show that the per cent of moisture at 10 a.m. was about as low as it would get. Grain picked up and threshed at 8 o'clock in the morning was satisfactory for storing. It must be kept in mind, however, that this oats was absolutely weed-free.

The Most Efficient Rate of Travel for Picking-Up And the Most Practical Ratio Between Size of Windrow and Size of Combine

Studies were made to find: (1) The efficiency of the pick-up at different rates of travel and for different sizes of windrows, and (2) The threshing efficiency for various sizes of windrows.

The rate of travel is taken up first. The following table gives the pick-up losses through shattering in the windrow according to rate of travel.

TABLE IV—PICK-UP LOSSES ACCORDING TO RATE OF TRAVEL

Width of Swath in Windrow	Average Per cent of Loss at 2 miles per hour	Average Per cent of Loss at 3 miles per hour
12'	1.95	5.10
19'	2.10	Extremely high

When picked-up at 2 miles per hour the windrows stayed intact, but at 3 miles per hour the windrows were torn apart. This tearing apart shatters grain and gives the wind a chance to interfere.

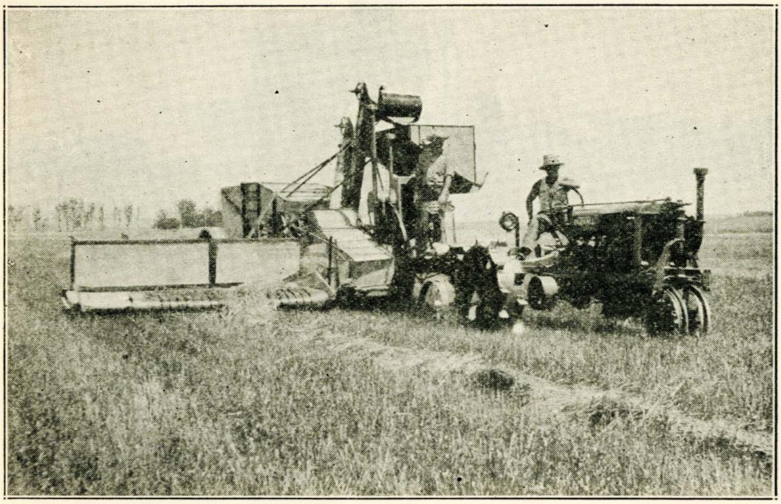

Fig. 2—"THE PICK-UP ATTACHMENT."
With this attachment the windrow is picked-up and threshed as the machine is drawn through the field. The Combine used is a ten-foot cut machine.

The increased shattering loss between a 12-ft. and a 19-ft. swath picked-up at 2 miles per hour was only .15 of one per cent, but the 10-foot combine was unable to thresh the 19-ft. swath at two miles per hour as shown in the Table No. IV, the 16-ft. swath figuring the heaviest windrow this machine could handle. The fact that in harvesting, the number of windrows decrease as the width of swath is increased, made the wider cut windrower desirable.

It was found that the rate of travel for the pick-up should be around two miles per hour; or at such speed that the windrows will not be broken up. At this rate of picking up, the heavier windrows are picked up as well as the lighter ones and better than very light windrows.

Threshing Efficiency as Determined For Various Sized Windrows

In determining how wide a swath a combine will thresh efficiently, the yield per acre must be taken into consideration.

The following table gives the rate of travel, width of cut, acres per hour and per cent of loss that is "carryover" for varying widths of cut and rates of travel—as found for a yield of 52.7 bushels per acre.

TABLE V—LOSSES AS DEPENDENT ON ACRES PER HOUR PICKED-UP

Width of Swath in Feet	Av. Loss In Per cent at 2 Mi per Hr	Av. Loss In Per cent at 3 Mi per Hr	Acres Per Hour Loss is Given for
12'	.56		2.91
12'		1.70	4.36
19'	2.23	Extremely High	4.60

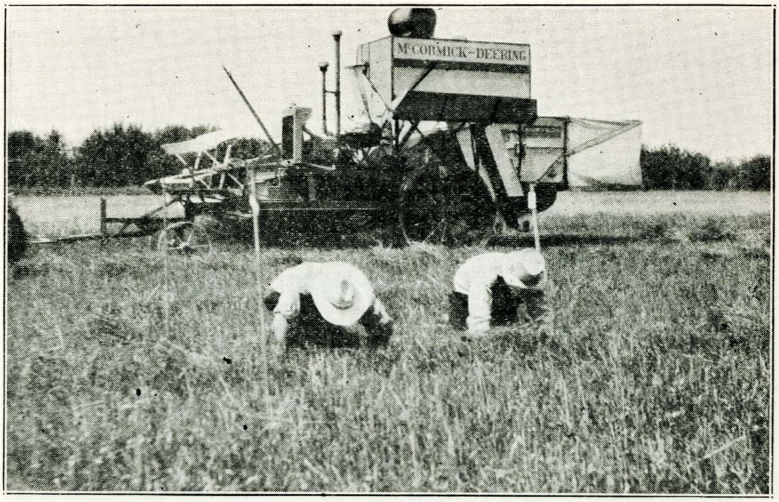

FIG. 3—"COUNTING THE CUTTING LOSSES IN THE FIELD."
With the windrow method these losses include shattering losses and also the losses in the windrow. With the direct combine there is only the one cutting loss.

The results of tests on picking-up table No. IV indicate that a rate of travel of 2 miles per hour should be the basis of this test.

Using this data and assuming losses for 16-ft. and 17-ft. windrows, as picked up at 2 miles per hour based on rate of change between and 4.36 and 4.60 acres per hour losses, we have the following results.

TABLE VI—LOSSES AND ASSUMED LOSSES AS DEPENDENT ON ACRES PER HOUR PICKED-UP

Width of Swath and Rate of Travel	Acres Per Hour	Per Cent Loss
12' at 2 miles per hour	2.91	.56
*16' at 2 miles per hour	3.88	.64
*17' at 2 miles per hour	4.12	1.17
12' at 3 miles per hour	4.36	1.70
19' at 2 miles per hour	4.60	2.23

*Assumed values

From these figures it would seem that a 16-ft. swath picked up at 2 miles per hour in *clean* grain would be near the allowable per cent of loss. According to this, a windrower should be possibly 4 to 6 feet wider cut than the cut of combine to be used, for high yielding grain, and in case of low yields, a two or four foot extension could be used.

The factor limiting capacity in this test was the inability of the combine thresher to handle the chaff fast enough. The straw was cleanly threshed but in the 19-ft. test the sieves were three-fourths covered with chaff and it was impossible to get all the oats out. A greater cleaning area would have increased the capacity. This machine did not have a recleaner.

The rate of threshing when picking up a 19-ft. windrow at 2 miles per hour was 242 bushels per hour. Kranich gives the capacity of a 24x42 inch separator as 140-200 bushels of oats per hour. The machine being used was 24x37 inches. When picking up a 16-ft. cut at 2 miles per hour the bushels per hour would be 205.

There seems to be no set ratio between width of cut, length of cylinder and area of cleaning surface in combine design. In choosing a combine these things should be considered in connection with usual high yields as well as acreage to be cut and power available. The 10-20 tractor which was used handled the combine at 3 miles per hour with a full 30 bushel tank. A few rounds were windrowed at 4 miles per hour (in high gear) while the dew was on the grain. The tractor handled the load quite readily.

Harvesting Losses For Straight Combine Method And Windrow Pick-Up Method

These losses were determined, not with the idea of making comparisons, but to find the ideal conditions for the use of the different harvesting equipment.

Losses for straight combining were determined at different days after binder cutting would have started, and the pick-up was used on different widths of swaths and operated at different rates of travel.

The losses given for windrow and pick-up and for threshing when picking up are losses under favorable conditions as to width of swath and rate of travel.

TABLE VII—COMPARATIVE LOSSES FOR COMBINE METHOD AND WINDROW AND PICK-UP METHOD. LOSSES IN PERCENT

COMBINE METHOD			WINDROW AND PICK-UP METHOD		
Av. Cutting loss over 4 day period. Per cent	Threshing losses	TOTAL LOSS	Av. Cutting and pick-up loss. Per cent.	Threshing losses	TOTAL LOSS
1.60	.56	2.16	2.0	.56	2.56
			(These losses are for 12' and 19' swaths picked-up at 2 Mi/Hr)		

Average cutting loss includes shattering and heads not cut or lost.

The losses for the various width of swaths and rates of travel are given in table No. IV and Table V.

The United States Department of Agriculture gives South Dakota "binder-separator loss" for 1926 as 3.7%. Comparing the combine loss of 2.16% and windrow and pick-up method loss of 2.56% with the U. S. D. A. figure, both the straight combining and windrow pick-up methods compared favorably.

Condition of Grain in Windrows

Three fairly heavy and three light windrows were left for observation. The heavy windrows showed no shattering, no growing of the grain, or any particular growth of grass until after September 10, an interval of six weeks. The straw became darker all the time and the grain turned some-what darker. A few days after September 10 a little shaking of the straw shattered considerable grain and a week later the grain was practically all shelled out. During this time we had a total of 4.12 inches of rain spread out over 17 days.

There was no way of telling what the shattering losses would have been at any time during this period, but we know that the heavy swath stayed in good condition for more than a month. The light swath seemed to work into the stubble and started to grow within two weeks after it was cut.

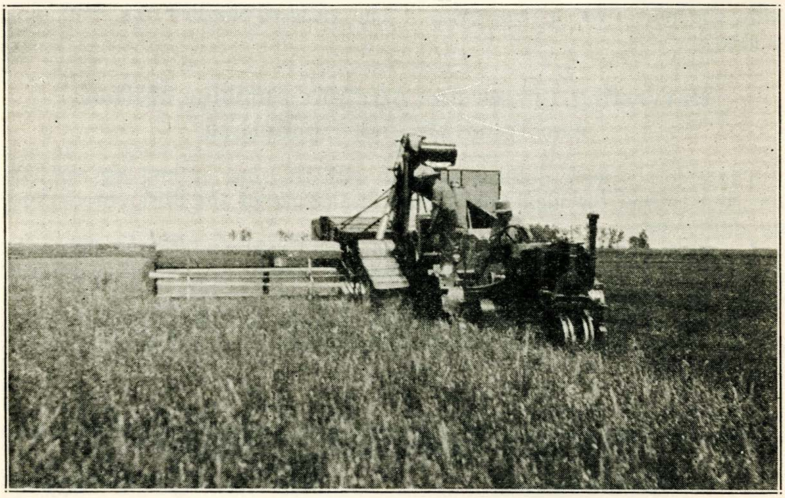

FIG. 4—"HARVESTING GRAIN BY THE COMBINE METHOD."
With this method the standing grain is cut and threshed at one operation. The machine shown is a 10' cut machine.

The following table gives the moisture content of the standing oats, after the binder stage was passed. This oats was ready for the binder July 22.

TABLE VIII—TREND OF MOISTURE FROM FOUR TO EIGHTEEN DAYS AFTER OATS WAS READY FOR THE BINDER

Days after oats was ready to cut with binder.	Time of day cut.	Moisture content in per cent.
4	2:15 p. m.	12.9
5	3:15 p. m.	12.5
6	12:00 m	11.3
7	6:00 p. m.	9.0
8	7:00 p. m.	10.0
12	12:00 m	13.5
18	4:30 p. m.	10.1

There was .10-inch of precipation on August 1st and .03-inch August 3rd with lower temperature. Oats combined direct August 9 at 4:30 P. M. had a moisture content of 10.1%.

On August 9 a count of crinkled heads showed that approximately 4.8% of the heads were crinkled and some would be lost even with low cutting, with possibly 1 to 2 per cent additional loss for shattering. The standing oats was darker. By August 30 the oats was matted down.

This oats was ready for the binder July 22 and just 4 days later, on July 26, the moisture content was low enough to warrant combining without windrowing. This is unusual as this interval is generally 10 days. The weed-free condition of the field was very largely responsible for this, although the weather conditions were also favorable. From July 26 to August 3 there would have been practically no increase in loss. The advantages of straight combining in this case were less work and cleaner oats as the windrowed grain has a noticeable amount of corn stubble in it.

Summary

Windrowing was begun as early as 8 o'clock A. M. in this clean field and found quite satisfactory.

In windrowing clean grain a wide swath which made a heavy windrow was not objectional as far as the drying out of the grain is concerned.

The losses for straight combining and also for windrow harvesting in clean grain were less than the average binder-separator losses of the present day methods of harvesting.

There was less loss when picking up at 2 miles per hour than when picking up at 3 miles per hour. When the windrow was picked up at a rate so fast as to tear it apart more grain was shattered and lost in the ground.

A combine pulled at approximately 2 miles per hour threshed a swath 4-ft. to 6-ft. wider than its cutting width without excessive loss in a field yielding 52 bushels per acre. When the rate of travel was increased or the width of swath increased the losses were increased, both as to shattering losses and the threshing losses.

A fairly heavy windrow stayed in good condition for a month, regardless of ordinary rains, while a light windrow worked down through the stubble and the grain started to grow within two weeks time.

This oats could have been direct combined any time from July 26 to August 9 without excessive loss. This includes a period of at least 13 days.

A study of the weed-free field would indicate that in such a field the "windrowing" method of harvesting was unnecesary and that direct combining of clean fields is an entirely satisfactory practice. It would indicate that green weed tips and green growth in the stubble bottom is responsible for even more of the moisture in grain that is combined-direct, than was anticipated. The study will be continued.