A391-1127-16,000-L180

TEXAS AGRICULTURAL EXPERIMENT STATION

B. YOUNGBLOOD, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 373 DECEMBER, 1927

DIVISION OF FARM AND RANCH ECONOMICS
in cooperation with
THE BUREAU OF AGRICULTURAL ECONOMICS AND THE BUREAU OF PUBLIC ROADS, UNITED STATES DEPARTMENT OF AGRICULTURE

Harvesting Grain with the Combined Harvester-Thresher in Northwest Texas

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
T. O. WALTON, President

STATION STAFF†

ADMINISTRATION:
*B. YOUNGBLOOD, M. S., Ph. D., *Director*
A. B. CONNER, M. S., *Acting Director*
R. E. KARPER, B. S., *Acting Vice-Director*
J. M. SCHAEDEL, *Secretary*
M. P. HOLLEMAN, JR., *Chief Clerk*
J. K. FRANCKLOW, *Assistant Chief Clerk*
CHESTER HIGGS, *Executive Assistant*
C. B. NEBLETTE, *Technical Assistant*

CHEMISTRY:
G. S. FRAPS, Ph. D., *Chief; State Chemist*
E. C. CARLYLE, B. S., *Chemist*
S. E. ASBURY, M. S., *Assistant Chemist*
WALDO H. WALKER, *Assistant Chemist*
VELMA GRAHAM, *Assistant Chemist*
R. O. BROOKE, M. S., *Assistant Chemist*
T. L. OGIER, B. S., *Assistant Chemist*
J. G. EVANS, *Assistant Chemist*
ATHAN J. STERGES, B. S., *Assistant Chemist*
G. S. CRENSHAW, A. B., *Assistant Chemist*
JEANNE M. FUEGAS, *Assistant Chemist*

HORTICULTURE:
————————, *Chief*
H. NESS, M. S., *Berry Breeder*

RANGE ANIMAL HUSBANDRY:
J. M. JONES, A. M., *Chief; Sheep and Goat Investigations*
J. L. LUSH, Ph. D., *Animal Husbandman; Breeding Investigations*
W. H. DAMERON, B. S., *Wool Grader*

ENTOMOLOGY:
F. L. THOMAS, Ph. D., *Chief; State Entomologist*
H. J. REINHARD, B. S., *Entomologist*
R. K. FLETCHER, M. A., *Entomologist*
W. L. OWEN, JR., M. S., *Entomologist*
FRANK M. HULL, M. S., *Entomologist*
J. C. GAINES, JR., M. S., *Entomologist*
C. J. TODD, B. S., *Entomologist*
F. F. BIBBY, B. S., *Entomologist*
S. E. MCGREGOR, JR., *Acting Chief Foulbrood Inspector*
A. B. KENNERLY, *Foulbrood Inspector*
GILLIS GRAHAM, *Foulbrood Inspector*

AGRONOMY:
E. B. REYNOLDS, M. S., *Chief*
A. B. CONNER, M. S., *Agronomist; Grain Sorghum Research*
R. E. KARPER, B. S., *Agronomist; Small Grain Research*
P. C. MANGELSDORF, Sc. D., *Agronomist; in charge of Corn and Small Grain Investigations*
D. T. KILLOUGH, M. S., *Agronomist; Cotton Breeding*
H. E. REA, B. S., *Agronomist; Cotton Root Rot Investigations*
E. C. CUSHING, B. S., *Assistant in Crops*
P. R. JOHNSON, B. S., *Assistant in Soils*

VETERINARY SCIENCE:
**M. FRANCIS, D. V. M., *Chief*
H. SCHMIDT, D. V. M., *Veterinarian*
J. D. JONES, D. V. M., *Veterinarian*

PLANT PATHOLOGY AND PHYSIOLOGY:
J. J. TAUBENHAUS, Ph. D., *Chief*
L. J. PESSIN, Ph. D., *Plant Pathologist and Laboratory Technician*
W. J. BACH, M. S., *Plant Pathologist*
J. PAUL LUSK, S. M., *Plant Pathologist*
B. F. DANA, M. S., *Plant Pathologist*

FARM AND RANCH ECONOMICS:
L. P. GABBARD, M. S., *Chief*
*B. YOUNGBLOOD, M. S., Ph. D., *Farm and Ranch Economist*
G. L. CRAWFORD, M. S., *Marketing Research Specialist*
C. A. BONNEN, M. S., *Farm Management Research Specialist*
V. L. CORY, M. S., *Grazing Research Botanist*
***T. L. GASTON, JR., B. S., *Assistant; Farm Records and Accounts*
***J. N. TATE, B. S., *Assistant; Ranch Records and Accounts*

RURAL HOME RESEARCH:
JESSIE WHITACRE, Ph. D., *Chief*
MAMIE GRIMES, M. S., *Textile and Clothing Specialist*

SOIL SURVEY:
***W. T. CARTER, B. S., *Chief*
H. W. HAWKER, *Soil Surveyor*
E. H. TEMPLIN, B. S., *Soil Surveyor*
T. C. REITCH, B. S., *Soil Surveyor*

BOTANY:
H. NESS, M. S., *Chief*

PUBLICATIONS:
A. D. JACKSON, *Chief*

SWINE HUSBANDRY:
FRED HALE, M. S., *Chief*

DAIRY HUSBANDRY:
————————, *Chief*

POULTRY HUSBANDRY:
R. M. SHERWOOD, M. S., *Chief*

****AGRICULTURAL ENGINEERING:**

MAIN STATION FARM:
G. T. MCNESS, *Superintendent*

APICULTURE (San Antonio):
H. B. PARKS, B. S., *Chief*
A. H. ALEX, B. S., *Queen Breeder*

FEED CONTROL SERVICE:
F. D. FULLER, M. S., *Chief*
S. D. PEARCE, *Secretary*
J. H. ROGERS, *Feed Inspector*
W. H. WOOD, *Feed Inspector*
K. L. KIRKLAND, B. S., *Feed Inspector*
W. D. NORTHCUTT, JR., B. S., *Feed Inspector*
SIDNEY D. REYNOLDS, JR., *Feed Inspector*
P. A. MOORE, *Feed Inspector*

SUBSTATIONS

No. 1, Beeville, Bee County:
R. A. HALL, B. S., *Superintendent*

No. 2, Troup, Smith County:
W. S. HOTCHKISS, *Superintendent*

No. 3, Angleton, Brazoria County:
R. H. STANSEL, M. S., *Superintendent*
FRANK M. HULL, M. S., *Entomologist*

No. 4, Beaumont, Jefferson County:
R. H. WYCHE, B. S., *Superintendent*

No. 5, Temple, Bell County:
HENRY DUNLAVY, M. S., *Superintendent*
B. F. DANA, M. S., *Plant Pathologist*
H. E. REA, B. S., *Agronomist; Cotton Root Rot Investigations*

No. 6, Denton, Denton County:
P. B. DUNKLE, B. S., *Superintendent*

No. 7, Spur, Dickens County:
R. E. DICKSON, B. S., *Superintendent*

No. 8, Lubbock, Lubbock County:
D. L. JONES, *Superintendent*
FRANK GAINES, *Irrigationist and Forest Nurseryman*

No. 9, Balmorhea, Reeves County:
J. J. BAYLES, B. S., *Superintendent*

No. 10, Feeding and Breeding Station, near College Station, Brazos County:
R. M. SHERWOOD, M. S., *Animal Husbandman in Charge of Farm*
L. J. MCCALL, *Farm Superintendent*

No. 11, Nacogdoches, Nacogdoches County:
H. F. MORRIS, M. S., *Superintendent*

***No. 12, Chillicothe, Hardeman County:**
J. R. QUINBY, B. S., *Superintendent*
***J. C. STEPHENS, M. A., *Junior Agronomist*

No. 14, Sonora, Sutton-Edwards Counties:
E. W. THOMAS, B. S., *Superintendent*
————————, *Veterinarian*
V. L. CORY, M. S., *Grazing Research Botanist*
***O. G. BABCOCK, B. S., *Collaborating Entomologist*
O. L. CARPENTER, *Shepherd*

No. 15, Weslaco, Hidalgo County:
W. H. FRIEND, B. S., *Superintendent*
————————, *Entomologist*
W. J. BACH, M. S., *Plant Pathologist*

No. 16, Iowa Park, Wichita County:
E. J. WILSON, B. S., *Superintendent*
J. PAUL LUSK, S. M., *Plant Pathologist*

Teachers in the School of Agriculture Carrying Cooperative Projects on the Station:
G. W. ADRIANCE, M. S., *Associate Professor of Horticulture*
S. W. BILSING, Ph. D., *Professor of Entomology*
V. P. LEE, Ph. D., *Professor of Marketing and Finance*
D. SCOATES, A. E., *Professor of Agricultural Engineering*
H. P. SMITH, M. S., *Associate Professor of Agricultural Engineering*

†As of December 1, 1927.
*On leave.
**Dean, School of Veterinary Medicine.
***In cooperation with U. S. Department of Agriculture.
****In cooperation with the School of Agriculture.

SYNOPSIS

An analysis of 72 records secured from wheat growers in northwest Texas who used combines in 1926 shows that the cost of harvesting is lowered, the amount of labor required is reduced, and the period of harvesting and threshing is shortened by use of the combine. The cost of harvesting and threshing with the combine ranged from $1.42 to $2.06 an acre and from 5 to 13 cents a bushel. The number of hours of labor per acre required for harvesting and threshing where the wheat is bound or headed and threshed with the stationary thresher was 4.6 when the binder was used, 3.8 when the header was used, and only .75 when the combine was used. The time required for harvesting with combines ranged from 8 to 36 days, with an average of 18.5 days. The greater percentage of the crop was harvested during a period of 15 to 20 days.

The combine is being used in a limited way for harvesting grain sorghums, the second most important crop of this section. With improvements of this crop making it more adaptable to machine harvesting and with increased experience of the operator and proper mechanical adjustment of the machine, it seems probable that this crop will be harvested more extensively with the combine.

Harvesting with the combine is being extended to other sections of the state and its use is likely to be increased, especially through the use of smaller machines.

CONTENTS

BULLETIN NO. 373 DECEMBER, 1927

HARVESTING GRAIN WITH THE COMBINED HARVESTER-THRESHER IN NORTHWEST TEXAS

H. P. SMITH* and ROBERT F. SPILMAN†

The rapid increase in the number of combined harvester-threshers used in northwest Texas has been remarkable in its effect on methods of harvesting wheat. Combines were first introduced in this section in 1919, and 7 machines were sold the first year. The manufacturers' sales reports to July, 1927, show that since the introduction in 1919, 2,682 combines have been sold in the state of Texas.

The reason for the small number of combines being sold the first few years after they were introduced was that there was a general agricultural depression from 1921 to 1923, the method of harvesting was new, there was a lack of experienced operators, and the machine had not been perfected. While the principles of the combine have remained the same since it was first introduced, numerous refinements have been made which have increased its effectiveness. As a result, sales have increased rapidly in the extensive wheat-growing section of northwest Texas, and during the 1927 season a number of machines were sold in other sections of the state where small grains are grown less extensively.

Information secured from the manufacturers shows that approximately 100 machines have been sold in the trade territory of Dallas and San Antonio.

OBJECT OF STUDY

Many progressive wheat growers want to know whether or not it would be profitable for them to discard the binder or header and purchase a combine. The object of this study was to find out what might be accomplished with the different types and sizes of combines under actual farm conditions, their cost of operating, and the economic changes likely to be brought about by the introduction of the combine.

SOURCE AND METHOD OF SECURING INFORMATION

The Counties of Ochiltree and Hansford were selected as the best section for study because of the large number of combines used there in 1926. More combines were sold at Perryton, Texas, the county seat of Ochiltree County, than at any other place in Texas in 1926.

Data were secured by personal interviews with 85 wheat growers who used combines to harvest their grain. These 85 wheat growers owned and used 90 combines. On account of the incompleteness of some of

*Associate Professor, Department of Agricultural Engineering, School of Agriculture, Agricultural and Mechanical College of Texas.

†Graduate Assistant, Division of Farm and Ranch Economics, Texas Agricultural Experiment Station, and Agent Bureau of Agricultural Economics, United States Department of Agriculture, while assisting with the collection of the data.

the 85 schedules, several were discarded; consequently, the data appearing in this Bulletin pertain to only 72 of the combines studied. Special effort was made to obtain records on all the available makes, types, and sizes in order to make the study represent, as nearly as possible, the prevailing conditions of the section.

DESCRIPTION OF THE SECTION STUDIED

The area studied in Ochiltree and Hansford Counties is located on the High Plains of northwest Texas, which is a part of the Great Plains region of the United States. The counties are bounded on the north by the Oklahoma Panhandle, and are included in the north tier of counties of the section which is known as the Texas Panhandle.

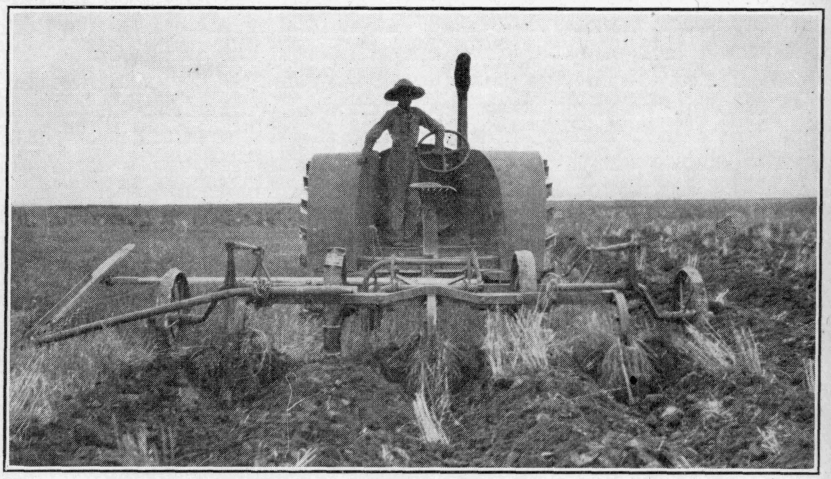

Figure 1.—Listing wheat land with a tractor and three-row lister. This is one of the methods of handling the stubble land after harvesting.

In general, the section consists of treeless plains, sometimes smooth but generally rolling, with some rather extensive areas of rough broken lands.* It lies within the sub-humid region of the Great Plains. Data presented in Table 1 show the average annual rainfall for 13 stations in northwest Texas, covering periods from 15 to 40 years, to be 20.04 inches.

Hailstorms are frequent in the spring and summer months and often do considerable damage, but generally they are confined to small areas.

The soil types of the area studied are the Amarillo and the Richfield clays, loams, and sandy loams, and are fairly typical of the greater part of the High Plains.

*Reconnoissance Soil Survey of the Panhandle Region of Texas, U. S. D. A. Bureau of Soils by T. Carter, Jr., and G. N. Coffey, 1910.

Table 1.—Normal monthly and annual precipitation for 13 Stations in the northwestern section of Texas.*

Station	County	Number of Years for Which Records Have Been Kept	Normal monthly and annual precipitation in inches for the number of years the records have been kept												
			Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Albany	Shackelford	33	1.06	1.06	1.31	2.45	3.40	3.20	2.49	2.09	2.54	2.41	1.60	1.63	25.24
Amarillo	Potter	35	.60	.88	.65	1.72	3.67	2.99	3.17	2.84	2.36	1.71	1.16	.83	22.55
Canadian	Hemphill	18	.47	1.22	1.22	2.51	2.86	3.81	2.19	2.38	2.52	2.19	1.29	.82	23.48
Childress	Childress	29	.52	1.04	1.13	2.80	2.31	1.79	2.32	2.09	2.38	2.09	.97	1.88	21.95
Clarendon	Donley	20	.43	.84	1.04	2.56	3.30	3.87	2.27	2.92	2.95	2.40	1.25	.96	24.79
Claude	Armstrong	24	.40	.72	.70	2.24	2.55	2.47	2.73	2.69	2.40	2.27	.98	.63	20.78
Crosbyton	Crosby	40	.53	.83	.70	1.90	2.31	2.91	2.57	2.55	2.29	2.25	1.15	.61	20.60
Dalhart	Dallam	21	.26	.45	.74	2.03	2.79	2.95	2.32	2.53	1.32	1.57	.75	.61	19.40
Lubbock	Lubbock	16	.30	.56	1.05	1.99	1.70	3.08	2.14	1.87	2.65	2.45	.60	.70	19.09
Memphis	Hall	18	.43	.56	1.03	1.88	3.09	3.36	2.37	2.86	2.42	2.76	1.18	.74	22.68
Perryton	Ochiltree	19	.26	1.25	.63	1.59	2.21	2.92	1.90	2.82	2.13	1.89	.91	.81	19.32
Plainview	Hale	33	.99	.69	.66	2.04	2.42	3.24	3.71	2.66	2.39	1.94	1.17	.63	21.96
Spur	Dickens	15	.28	.56	1.04	1.03	3.15	2.53	1.54	2.37	2.74	2.97	1.04	.86	21.68

*"Climatological Data" United States Department of Agriculture, Texas Section, Annual Summary, 1926.

WHAT CAN BE ACCOMPLISHED WITH A COMBINE

Size of Combine. One of the most important factors influencing the accomplishments of a combine is its size. The size of a combine is determined by the width of the swath it will cut. The size of the machines used in northwest Texas ranged from 8 feet to 20 feet. The most common sizes of combines ranged from 12 to 16 feet.

Types of Combines. Two types of combines were being used in this section. They were the tractor-drawn auxiliary engine type and the power take-off type. The auxiliary engine combines are those that have an engine installed on the machine to operate both the harvesting and threshing mechanism, the whole being drawn with a tractor. Power take-off combines are those that receive their power from the tractor which pulls the machine.

There were no ground-driven types found in the section studied. Such machines have all the combine mechanism, driven by power received from a large wheel in contact with the ground.

Days Used During Season. During the season of 1926, the majority of combines of this section were operated about the same number of days. Table 2 shows that the smallest number of days of harvesting by any one outfit on which records were taken was 8 days; the largest number 36; and the average 18.5 days.

Table 2.—Acres cut per hour and per foot of width with machines of different types and sizes

Type of Machine	Size of Machine	Farms	Yield Per Acre	Rate of Travel	Length of Day	Cut Per Day	Cut Per Hour	Cut Per Hour Per Foot of Width
	Feet	Number	Bushels	Miles, Hour	Hours	Acres	Acre	Acres
Tractor-pulled auxiliary engine	12	5	25.2	2.8	11.0	29.9	2.7	.225
	15	10	29.0	2.8	10.0	29.1	2.8	.187
	16	19	28.6	2.6	10.4	37.4	3.6	.225
	20	1	34.0	2.2	12.0	53.0	4.4	.220
Power take-off machines	8	6	27.7	2.3	11.0	15.6	1.4	.175
	10	4	34.0	2.8	10.6	29.0	2.7	.270

Though all combines were operated about the same number of days, those of a given size did not harvest the same number of acres. Variation in the number of acres harvested was considerably wider than the number of days. The machines which were kept going most constantly and which harvested grain under more nearly ideal conditions harvested the largest acreage. When one field was finished there were plenty of other fields waiting for the first machine that could pull into the field. A few farmers who grew a larger acreage of wheat than is normally harvested with one combine preferred to harvest all of their own grain, even though it took longer and though there was considerable risk from

weathering, because the cash expenditure was less and because the profits were greater, in their opinion, than if they had hired a part of the harvesting done.

Rate of Travel. Table 2 shows that the rate of travel for all sizes of combines did not vary more than .6 of a mile per hour. The slowest machine traveled 2.2 miles per hour and was the largest of the auxiliary engine types. The next slowest was the smallest of the power-take-off types. The average rate of travel for all machines was 2.58 miles per hour. The rate of travel was practically the same for both low and high yields. If the combines showed signs of being overloaded in heavy grain, the operator did not slow down, but drew out and reduced the width of the swath being cut.

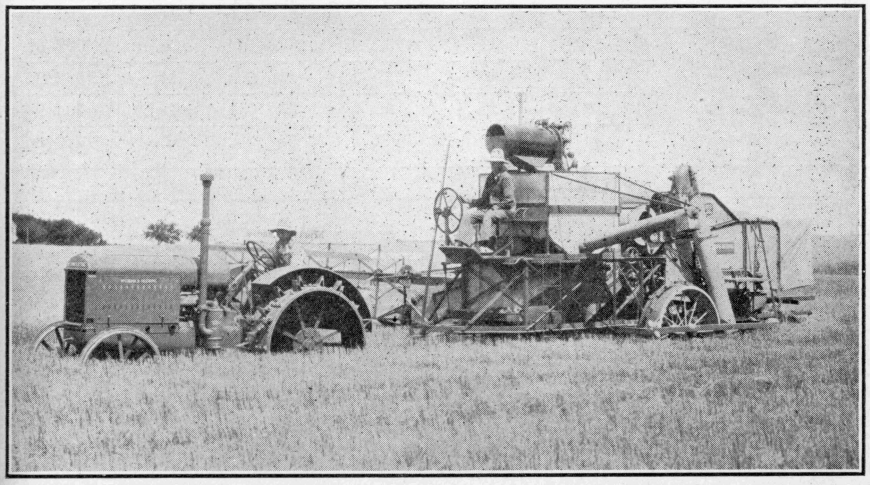

Figure 2.—An outfit similar to the above is capable of harvesting 35 acres per day.

Acres Cut Per Day. Many farmers think of the capacity of a machine as the amount of work it can do during a day's time. Table 2 shows the average number of acres that were harvested with the various sizes and types of machines. The small 8-foot power take-off combine harvested 15.6 acres in 11 hours, while the 20-foot auxiliary engine type harvested 53 acres in 12 hours. The number of hours of cutting during the day varies somewhat from season to season, and the number of acres per foot of width is affected somewhat by the yield and the condition of the grain; but on the average, one should expect to accomplish as much as the table indicates for the various sizes of machines.

Hours Used Per Day. The number of hours combines were used for day as shown in Table 2. On the whole, all machines were operated about the optimum number of hours during the day. This number of hours, however, is probably greater in this section than in some others,

especially the more humid sections of the winter wheat region. Most operators delayed starting in the morning for a short while on account of the grain being somewhat damp. However, some operators were of the opinion that it would be practicable to harvest 24 hours during the day for a part of the season as the humidity would not be high enough to affect the functioning of the combine to any appreciable extent.

Table 3.—Opinion of owners as to the minimum and maximum acreages that should be handled with the different size combines.

Type of Machine	Width of Cut	Number of Farms	Minimum Acreage		Maximum Acreage	
			Farms Reporting	Acres	Farms Reporting	Acres
Power take-off	8	6	6	135.0	6	266.7
	10	4	4	175.0	4	462.5
Tractor pulled auxiliary engine	12	11	10	320.0	10	580.0
	15	20	20	295.0	20	662.0
	16	28	28	307.0	28	734.0
	20	3	3	356.0	3	716.0

Figure 3.—A twenty-foot combine in operation. A machine of this size will harvest and thresh 50 acres per day and is well adapted to large-scale wheat farming as found in the Texas High Plains Section.

Acres Cut Per Hour. The amount of work that can be accomplished in a day depends directly upon what can be done in an hour. Of course, the acreage cut per hour varies with the size and type of the machine. The acres cut per hour by the power take-off machines showed an average of 1.4 for the 8-foot machines and 2.7 for the 10-foot machines. Combines equipped with an auxiliary engine cut 2.7 acres per hour,

while the 15-, 16-, and 20-foot machines averaged 2.8, 3.6, and 4.4 acres per hour, respectively. The difference in the rate of cutting was due to the difference in size of the machine.

Acres Cut Per Season. The number of acres harvested per season is affected by the size and type of combine, age of machine, experience and initiative of the operator, and acreage available for harvesting. Table 5 shows that the 8-foot power take-off combine harvested an average of 268 acres for the season, while the 20-foot auxiliary engine combine harvested an average of 853 acres. The average for all types and sizes was 586.6 acres. Table 3 shows the opinions of the owners interviewed as to the minimum and maximum acreages that should be handled with the different sizes and types of combines. The figures given as opinions corresponded closely to the actual accomplishments.

COST OF OPERATING A COMBINE

The cost of operating a combine is determined by a number of factors and, therefore, cannot be estimated accurately for any one farm without detailed records covering all of the factors involved. Accordingly, the average utilization and most prevailing costs have been used in preparing Table 4, which is considered a good estimate of the cost of harvesting and threshing with a combine. The items used in determining the cost of operating the various sizes and types of machines are given in Table 5.

Fuel and Lubricants. The cost of operating a combine is greatly influenced by the price paid for fuel, lubricating oils, and greases. Gasoline was charged at 20 cents, kerosene at 16 cents, and lubricating oils at 80 cents per gallon. These were the prices most commonly reported by operators of combines.

Tractor Power. In calculating the cost of tractor power it was assumed that the average tractor would be used 700 hours during the year, and that $21.00* per drawbar horsepower would be the annual fixed cost of the tractor. The charge for harvesting was determined by dividing the total fixed cost for the year by the fraction of 180 over 700. As nearly as could be calculated, the average number of hours, for each combine, of actual harvesting during the year was 180. The sizes of the tractors used were: a 10 drawbar horsepower for the 8-foot, a 20 horsepower for the 20-foot, and a 15 horsepower for all other combines.

Labor. From Table 4 it is seen that labor is the largest single item of cost in operating the average combine. The size of the crew used to operate a combine varied slightly with the type and size of the outfit. The small 8-foot machine of the power take-off type required only one man to operate both the tractor and the combine. The 10-foot power take-off and the 12-foot auxiliary-engine types required one man on each

*Bulletin 415, University of California. "The Tractor on California Farms."

Table 4.—Cost per acre and per bushel of harvesting wheat with different size combines.

	Width of Cut in Feet											
	12		15		16		20		8		10	
	Per Acre	Per Bu.	Per Acre	Per Bu.	Per Acre	Per Bu.	Per Acre	Per Bu.	Per Acre	Per Bu.	Per Acre	Per Bu.
Fuel and lubricants for combining	.3427	.0236	.3961	.0143	.2941	.1014	.2506	.0084	.2646	.0096	.2462	.0072
Depreciation per acre	.3800	.0132	.6600	.0229	.5000	.0174	.5600	.0194	.5300	.0184	.3200	.0111
Interest at eight per cent	.1800	.0062	.1600	.0055	.1300	.0045	.1500	.0052	.1700	.0059	.1100	.0038
Repairs	.1300	.0045	.1500	.0052	.0800	.0027	.1100	.0038	.1400	.0048	.1000	.0034
Tractor fixed cost	.1200	.0041	.1600	.0056	.1100	.0038	.1300	.0045	.2000	.0069	.1700	.0059
Labor	.4200	.0145	.5300	.0184	.3900	.0101	.2900	.0101	.4000	.0139	.4800	.0167
Approximate costs for 1926	1.5700	.0061	2.0600	.0719	1.5000	.0488	1.4900	.0514	1.7000	.0595	1.4200	.0481
Approximate costs for average year	1.5700	.1040	2.0600	.1370	1.5000	.1000	1.4900	.0990	1.7000	.1130	1.4200	.0940

combine and the tractor. A helper was used on a small number of the 15-, 16-, and 20-foot machines. Five dollars a day was the most common wage reported for both combine operators and tractor drivers; therefore, this amount plus $1.35 a day for board was used in determining the cost of labor per acre.

Table 5.—Items of cost in harvesting wheat with a combine.

Type of Machine	Size of Machine	Fuel and Lubricating Oil			Other Items of Cost			Acres Harvested Annually
		Gallons Per Acre			Initial Cost of Machine (dollars)	Life of Machine (years)	Crew Required to Operate Machine	
		Gasoline for Combining	Kerosene for Tractor	Lubricating Oil				
Power take-off	8	.....	1.36	.06	1,002.00	7	1.0	268
	10	.....	1.29	.05	1,246.00	8	2.0	474
Tractor-pulled auxiliary engines	12	.52	1.95	.09	2,027.00	8	2.0	667
	15	.85	1.96	.09	2,077.00	6	2.4	520
	16	.62	.81	.06	2,252.00	6	2.3	738
	20	.58	.72	.04	2,919.00	6	2.6	853

Interest on Investment. An interest charge based on one-half the original investment at eight per cent is taken to represent the average interest charge for the entire life of the machine, the average of which was 8 years. The average acreage harvested annually is used in calculating the cost per acre, because the acreage harvested during the 1926 season was exceptionally large. In most cases, combines harvested a greater acreage than the maximum which operators believed should be harvested by one combine, as shown in Table 3.

Repairs. Repair charges are based on the average charges for the life of the machines. Since it was not known what the repair costs for some of the newer types of machines will be for the complete life of the combine, the average cost per sickle-bar foot of machines on which complete records are available is used. Because of improvements in construction, the newer types of machines will likely show a lower repair cost than the older ones, but none of the costs for repairs exceed 15 cents an acre and are, therefore, considered to be conservative.

Cost Per Acre. The average cost per acre for the six different sizes of combines used in making Table 4 is $1.62. It is interesting to note that the cost per acre does not vary greatly for the different sizes of machines.

Cost Per Bushel. Table 2 shows the average yield per acre for the season of 1926 to be 28.8 bushels. By dividing $1.62, the average cost per acre, by 28.8, the average yield in bushels per acre, the cost per bushel is determined for the season of 1926, which was $.056. However, the yield per acre for the average year is only 15 bushels, as determined

from census reports for 1909, 1919, and 1924. The cost per bushel for the average year can be approximated by dividing $1.62, the cost per acre, by 15, which gives $.108. Consequently, the cost per bushel varies with the yield per acre, as shown in Table 6. As the yield decreases, the cost per bushel increases. However, the cost will not likely be the same on any two farms, since it will vary from year to year as the different items of cost vary.

Table 6.—Approximate cost of harvesting wheat with different yields per acre.*

Yield Per Acre	Cost Per Bushel	Yield Per Acre	Cost Per Bushel
3	.540	15	.108
5	.324	17	.095
7	.231	19	.085
9	.180	21	.077
11	.147	23	.070
13	.125	25	.064

*Calculations based on the cost of $1.62 per acre, which was the average for the six different size combines included in the survey.

THE COMBINE COMPARED WITH OTHER METHODS OF HARVESTING AND THRESHING

When wheat is harvested with a combine, the grain should be sufficiently mature and dry to stand storage. This is necessary because immature grain has a high percentage of moisture and will heat when stored.

Delayed Starting With Combine. The number of days harvesting was delayed after a binder could have been started was reported variously from 2 to 14, but the majority of farmers reported from 4 to 7 days. The number of days' delay after the header could have been started ranged from 2 to 7 days, but the majority of farmers reported only 3 to 4 days. The principal disadvantage of depending on the combine for all harvesting is the risk of loss because of hail, rain, or windstorms during the 4 to 7 days of waiting for the wheat to ripen enough to use the combine after the binder or header could have been started.

Comparison of Man Hours. It has been estimated from previous studies made on the cost of harvesting and threshing and also from this study that the total labor for harvesting and threshing would be reduced from approximately 4.6 man hours for cutting with a binder and threshing with a stationary thresher, and 3.8 man hours for harvesting with a header and threshing with a stationary thresher, to about .75 man hours per acre where the work is done with a combine.*

*Preliminary Report of the United States Department of Agriculture on "Harvesting Grain with a Combined Harvester-Thresher in the Great Plains Region, 1926."

Harvesting Losses. Harvesting and threshing losses were not studied in Texas, but they were studied in other states in cooperation with this study; so the following is quoted from the Preliminary Report of the United States Department of Agriculture on "Harvesting Grain with a Combined Harvester-Thresher in the Great Plains Region, 1926":

"Losses of grain resulting from the different methods of harvesting were determined in Oklahoma, Kansas, Nebraska, and Montana, by actual counts of the number of heads left on the ground in 259 fields cut by combines, 59 fields cut with the header, and 34 fields cut with binders. The yield per acre in fields cut with combines was determined from samples taken previous to harvesting. The losses on headed and bound fields were calculated on the basis of yields obtained from the combine fields.

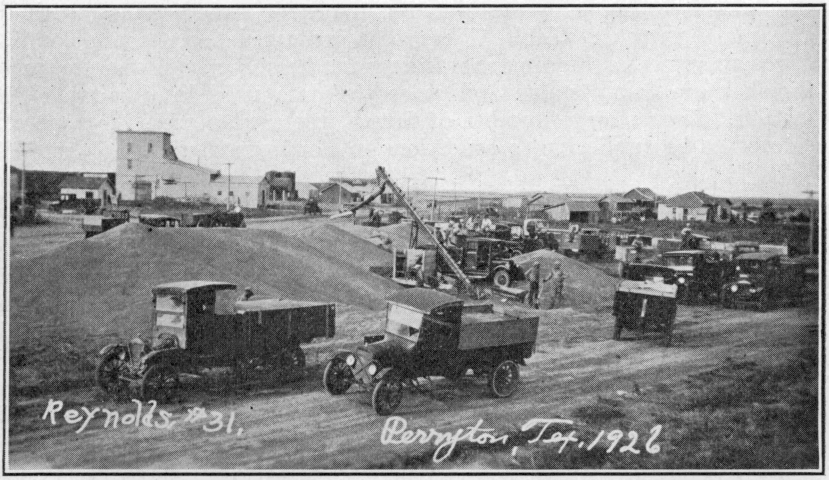

Figure 4.—Harvesting and threshing in one operation causes congestion of local point storage and marketing facilities. At Perryton more than 200,000 bushels of wheat were piled on the ground at one time during the season of 1926.

"Forty-one of the 190 fields of winter wheat cut with the combine had losses of less than 1 per cent, 106 less than 2 per cent, and 137 less than 3 per cent. Losses greater than 3 per cent occurred with an uneven or partly lodged crop, on rough land, with poor machines, through careless operation, or in very windy weather. The average loss from harvesting winter wheat with combines was 2.6 per cent. Fields cut with headers showed an average loss of 3.3 per cent, while fields cut with binders shows an average loss of 6.1 per cent. These per cent losses are based on a yield of 20.4 bushels per acre. The loss per acre was 32 pounds after the combine, 40 pounds after the header, and 74 pounds after the binder. Heads cut off and dropped on the ground were the greatest source of loss in combining and heading. Additional losses in

heading occurred in loading the header barge and hauling to the stack. The losses in binding include the cutting loss, the loss between the canvasses, losses from the binding platform, bundle carrier, heads dropped in shocking and hauling, and heads left in shock bottoms. Losses around the stacks and incident to threshing are not included."

Threshing Losses. "Blanket tests" of 33 combines and nine separators were made to determine which type of machine was the most efficient. The loss measured includes only the threshed grain which was blown or carried through with the straw. Thirteen of the 33 combines were carrying over less than 1 per cent of the grain threshed and 21 less than 2 per cent. All losses of over 2 per cent probably were due to poor adjustment and operation.

Costs. In order to contrast combined harvesting and threshing with that of harvesting with the binder and header and threshing with the stationary thresher, Table 7 has been prepared from available data. Since practices of binding, heading, and threshing with the stationary thresher are fairly stable and since the data used in this table were collected from a large number of farms over a wide area, they are considered to be applicable to conditions in northwest Texas.

Table 7.—Calculated cost of harvesting and threshing wheat when binder and header are used.

Cost When Wheat is Headed and Threshed	Hours Per Acre		Cost Per Acre and Per Bushel (Dollars)			
	Man	Horse	Man	Horse	Threshing and Twine	
Heading and stacking	2.8	4.3	1.26	.69	.....	.....
Threshing from the stack	1.5	.....	.68	.....	1.61	.....
Totals	4.3	4.3	1.94	.69	1.61	.....
Grand total	.....	.....	.....	.....	.....	3.55
Cost per bushel	.....	.....	.....	.....	.....	.24
Cost When Wheat is Bound and Threshed.						
Binding wheat	.7	2.8	.32	.45	.....	.....
Shocking	.9	.....	.40	.....	.....	.....
Hauling to the thresher	1.6	3.2	.72	.51	.....	.....
Threshing from wagons	1.4	.....	.63	.....	1.61	.....
Twine	.....	.....	.....	.....	.21	.....
Totals	4.6	6.0	2.07	.96	1.82	.....
Grand total	.....	.....	.....	.....	.....	4.85
Cost per bushel	.....	.....	.....	.....	.....	.33

The requirements per acre of man and horse labor used in these calculations are taken from United States Department of Agriculture Bulletin 1198. The data were collected in 1920 from 467 winter belt farms in Kansas, Missouri, Nebraska, and Oklahoma. In calculating the per acre and per bushel cost, man labor was figured at 45 cents an hour, horse work at 16 cents an hour, and twine at 17 cents a pound.

The average yield per acre was 14.6 bushels. Threshing costs were figured at 11 cents a bushel for dependent threshing. The farmer furnished all the crew except the engineer and separator man, and the cost of all the additional labor is included in the above calculations. In this case the fuel cost is included in the cost of threshing at 11 cents a bushel.

SPECIAL EQUIPMENT FOR THE COMBINE

All operators should study the mechanical features of the combine because of their influence on the operation of the machine. Failure to consider the proper type, the size, the attachments, and the adjustments on the combine may affect the accomplishments of the machine to such an extent that the efficiency will be materially reduced. A study of the

Figure 5.—The combine has brought about the development of a new plow known generally as the one-way disc plow. It is capable of cutting a strip 10 feet wide to a maximum depth of 7 inches. 20 to 30 acres can be plowed in a day with an outfit of this kind.

tables giving the number of the different types and sizes of machines used in this section shows that the most popular machine in 1926 was the auxiliary engine type.

Advantages of the Power Take-off Combine. The larger size machine is most commonly used on the larger farms. In some sections the smaller power take-off machines are attracting considerable interest of the smaller farmers, and to a less extent the larger farmer, because of their general satisfactory service and economy in labor, fuel, and low initial cost. By taking the power direct from the tractor the expense of owning and keeping up an auxiliary engine the year round to be used fifteen to twenty days during the year is avoided.

Cutter-Bar Extension. The width of the cutter-bar may be varied on most machines by using or removing the extension cut. The use of the extension in harvesting of wheat with low yields, thereby increasing the number of acres which can be harvested per day and lowering the cost of harvesting low-yielding wheat, is especially advantageous.

Self Feeders and Straw Spreaders. Self feeders and straw spreaders may be used in order to equip the combine better for stationary work, but they have been used to a very limited extent in this section. The more common uses of the combine as a stationary thresher are to thresh small fields of wheat and other small grains, or to thresh shock rows of wheat which result from opening up a field preparatory to combining. Special bundle and windrow pick-up feeders have been developed which allow the combine to be used to thresh shock rows and windrowed grain without further handling. This also eliminates the necessity of moving the straw, since it is spread on the ground as the machine moves along.

Equipment for Threshing Miscellaneous Crops. Threshing small quantities of milo heads and cleaning various kinds of seed for planting purposes are other uses of the combine. A few farmers reported using the combine for threshing grain sorghums which had been cut with a header. Grain sorghums which are harvested with the header are usually stacked in small ricks in order that they may cure out properly. The combine may be used to good advantage in threshing these ricks, as it can easily be moved from one rick to the next.

The combine also has been used to thresh the heads from bundles of grain sorghum by laying the bundles across the cutter bar, which has been twisted to an upright position. The heads are cut off and carried by the platform canvas to the cylinder. The labor of threshing bundles in this way is less, since the combine may be moved along the shock row, thus eliminating one or more handlings of the bundles.

Many farmers reported using their combines for harvesting oats, rye, and barley in addition to grain sorghums. Frequently, the machines were changed from one crop to another without making any adjustments. This practice could possibly be tolerated without serious losses when changing from wheat to oats, rye, or barley, but the best results cannot be obtained with grain sorghums. Most of the machines were

equipped with a straw spreader to spread the straw uniformly over the land rather than to concentrate it in a narrow windrow. When the straw is not spread, considerable difficulty is often experienced by the failure of the tillage tools to handle it. This is especially true when there is a large amount of straw and stubble on the field.

Handling the Grain. All the grain in this region was handled in bulk, being run directly into a wagon or grain tank. Only the new machines were equipped with grain tanks; many of the older ones used wagons. When the grain is hauled direct to market or to the farm granary equipped with a wagon-dumping device, there is a distinct advantage in using the grain tank, as all labor of scooping is eliminated. The capacity of the grain tank ranged from 30 to 60 bushels.

Grain Weighers. During 1927 a successful specially designed grain weigher for combines was placed on the market.

THE IMPORTANCE OF CUSTOM CUTTING

Many owners of combines after harvesting all their own grain would harvest for their neighbors, charging them a fee for the service. This practice of harvesting for pay is termed custom cutting. The importance of custom cutting cannot be overestimated, since it enables the owner of a combine to lower the cost of harvesting his own grain by earning enough to partially take care of the original investment, and since it reduces the fixed cost of owning a combine. It also enables the small farmer whose acreage would not justify owning a combine to buy an outfit, not only to harvest his own grain but also to harvest his neighbors'.

The extent to which custom cutting was practiced during the season of 1926 was rather uniform for owners of all types and sizes of combines. From one-third to one-half of all owners of combines interviewed did custom cutting. The number of acres harvested in this way was about one-third to one-half the entire acreage harvested. On the whole, custom cutting increased the acreage and the days of harvesting for the operator who followed this practice.

One disadvantage of custom cutting is that those who depend upon hiring their grain harvested have to wait longer than those who own combines. This involves considerable risks of damage from weather and shattering if the grain becomes overripe before it can be harvested.

HARVESTING GRAIN SORGHUMS WITH THE COMBINE

Though this study is limited largely to the harvesting of wheat, some information was secured on harvesting grain sorghums and is included because of their importance. The extent to which grain sorghums are grown in this section, the expense of handling a large bulk of grain per acre, and the absence of any satisfactory mechanical means of harvesting such grain cause the plains farmer to experiment with the combine. There are several characteristics of the grain sorghums that make it

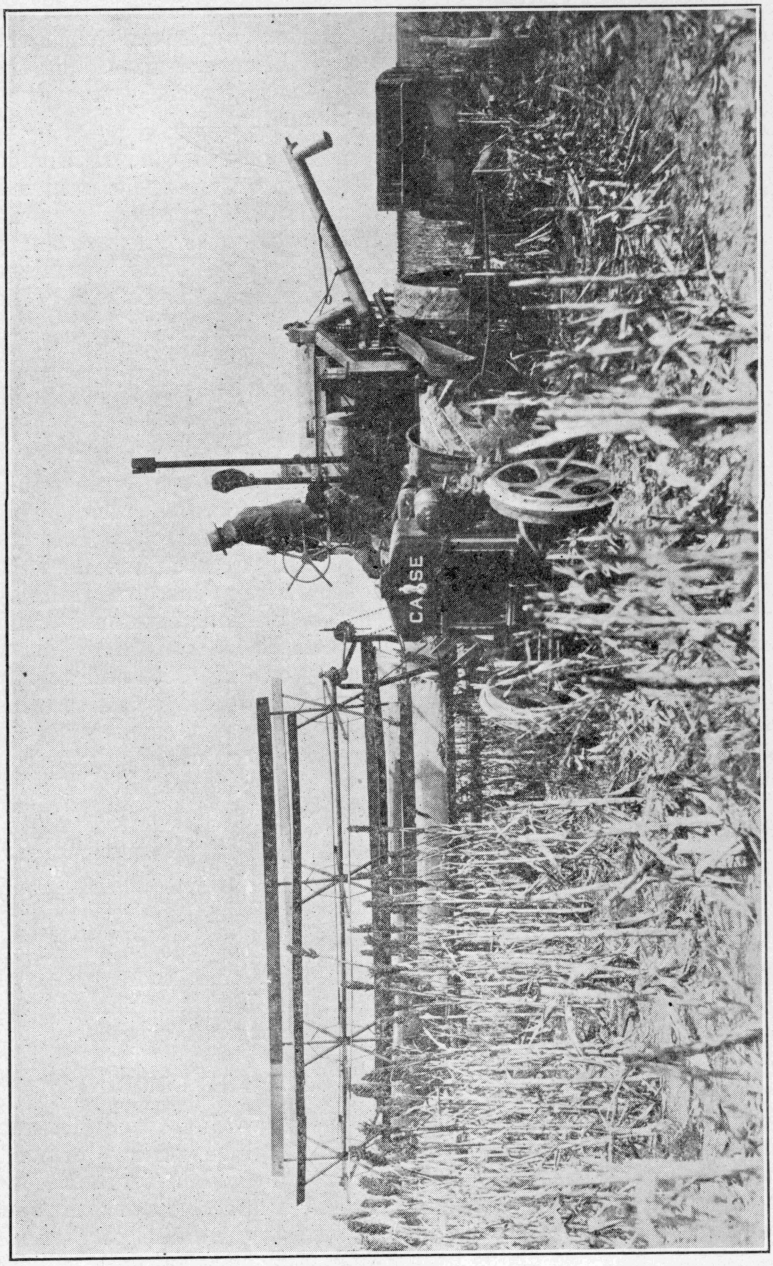

Figure 6.—A method of harvesting grain sorghum which is increasing in popularity, and which materially reduces the labor required for harvesting this crop.

difficult to harvest them with the combine. Chief among these are the lack of uniformity in ripening and the tendency of the stalk to lodge after frost.

It is necessary to let the grain stand in the field until after frost in order to dry sufficiently for storage. Even then the grain sometimes heats in the bin because of excess moisture. The possibilities of heating while in storage are further increased by the cracking of the grain while threshing. From experience it seems that harvesting grain sorghums with the combine is much more difficult than harvesting small grains. To adjust the machine properly for harvesting grain sorghums, it is necessary to change several sprockets in order to slow down the speed of the moving parts. The necessary sprockets are not always available at the local dealers, and the operators frequently neglect to inform themselves properly as to the adjustments needed and how to make them.

During the fall of 1926 grain sorghums were harvested with varying results in northern Oklahoma and southern Kansas. Much of the grain went to market direct from the combine, but some of it was piled out on the ground in order to dry for a few days before marketing or storing. A part of it was stored in ordinary bins on the farm, and the moisture content and other factors affecting storage are now being studied.

SPECIFICATIONS OF PRINCIPAL MAKES OF COMBINES USED IN TEXAS

In order to enable those interested in comparing the various makes of combines, Table 8 is given showing the specifications of the principal makes most used in Texas. From a study of this table, the various parts of combines can be compared and the one selected that comes nearest meeting the needs of the individual. The prospective purchaser can also study the make-up of all combines before buying. Of course, there will be minor changes from time to time, but the general make-up of the machines will remain the same.

Table 8.—Specifications of combines used in Texas.*

NAME	Holt		McCormick-Deering		Massey-Harris		Minn. T. M.	Red River Special		Gleaner	Advance-Rumely		Baldwin	Case		
Type	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie	Prairie
Width of cut	12–15′	16½-20′	10′	12–15′	10′	12–15′	16′	15′	20′	8′ 3″	12–16′	20′	10′	9′	9′	12–16′
Height lowest stubble	3″	3″	4″	6″	4″	4″	4″	4″	4″	4″	4″	4″	4″	4″	4″	4″
Height highest stubble	42″	42″	32″	33″	28″	28″	36″	36″	36″	48″	32″	36″	36″	36″	36″	36″
Width of canvas	40″	40″	36″	36″	36″	36″	36″	40″	40″	None	36″	40″	None	30″	30″	36″
Width of cylinder	20″	26″	24″	24″	33″	33″	24″	22″	28″	18″	26″	26″	22″	22″	22″	24″
Width of thresher rear	31″	36″	37″	38″	33″	37″	42″	34″	40″	24″	42¾″	38¾″	28″	22″	22″	42″
Recleaner	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	.....	Yes	Yes	Yes
Auxiliary weed screen	Yes	Yes	Yes	Yes	Optional	Optional	Optional	Yes	Yes	Yes	Optional	No	.....	.....	.....	.....
Length separator surface	144″	160″	96″	126″	.....	144″	126″	114″	114″	165″	124″	121″	.....	118″	118″	118″
Length chaffer sieve	59″	61″	38¼″	42″	32″	49″	39″	50″	50″	30″	47″	67″	.....	43 5/8″	43 5/8″	45 3/8″
Length of cleaning sieve	25″	28″	31″	25″	32″	49″	32″	26½″	26½″	30″	27″	23″	.....	34 3/8″	34 3/8″	31″
Make of motor	Wisconsin	Wisconsin	Tractor	Own	Buda	Cont'al	Waukesha	Hercules	Hercules	Fordson	Hercules	Hercules	Ford "T"	Waukesha	Tractor	Case
Number of cylinders	4	4	.....	4	4	4	4	4	4	.....	4	4	4	4	.....	4
Bore and stroke	4 1/8×5″	4 1/8×5″	.....	3¾×5″	3¾×5 1/8″	4¼×4½	4×5″	4×5″	4½×5¾″	.....	4×5″	4×5″	3¾×4″	3½×4½″	.....	4 1/8×5″
R. P. M.	1000	1250	.....	900-1100	1300	1450	1250	.....	.....	.....	1382	1382	1050	1200	.....	1050
Drive to cylinder	Belt	Belt	Take-Off	Direct	Chain	Chain	Belt	Belt	Belt	Belt	Belt	Belt	.....	Belt	Take-Off	Belt
Front wheels... Number	1	1	.....	Fore-Car	2	2	2	1	1	None	1	1	.....	1	1	1
Front wheels... Diameter	30″	34″	.....	26″	23″	24″	30″	36″	36″	.....	32″	34″	.....	30″	30″	32″
Front wheels... Width	10″	12″	.....	4¼″	4″	4″	6″	10″	12″	.....	10″	12″	.....	6″	5″	10″
Main wheels... Number	2	2	1	1	2	2	2	2	2	None	2	2	1	2	2	2
Main wheels... Diameter	54″	54″	54″	54″	52–52″	52½–52½	54″	54″	54″	.....	52″	54″	54″	42″	42–42″	54″
Main wheels... Width	12″	12″	12″	14″	12– 6″	15–10″	12″	10″	12″	.....	12″	12″	14″	12″	12–6½″	12″
Header wheel.. Diameter	48″	48″	54″	54″	.....	.....	54″	48″	48″	None	52″	54″	54″	34″	34″	54″
Header wheel.. Width	7″	7″	9″	9″	.....	.....	6″	6″	6″	.....	6″	6″	6″	3″	3″	6″
Cylinder bearings	Hyatt	Hyatt	Ball	Ball	SKF	SKF	SKF	Hyatt	Hyatt	New Dept	Ball	Ball	.....	Ball	Ball	Ball
Fan bearings	Hyatt	Hyatt	Roller	.....	SKF	SKF	Babbitt	Hyatt	Hyatt	Hyatt	Ball	Ball	.....	Babbitt	Babbitt	Babbitt
Beater bearings	Hyatt	Hyatt	Roller	.....	Plain	Plain	Babbitt	Hyatt	Hyatt	Hyatt	Ball	Plain	.....	Babbitt	Babbitt	Babbitt
Front wheel bearings	Hyatt	Timken	Roller	Roller	Plain‡	Plain‡	Timken	Hyatt	Hyatt	.....	Roller	Roller	.....	Plain	Plain	Plain
Main wheel bearings	Plain	Plain	Roller	Roller	Roller	SKF	Timken	Hyatt	Hyatt	.....	Roller	Roller	.....	Plain	Plain	Plain
Header wheel bearings	Plain	Plain	Roller	Roller	.....	.....	Timken	Plain	Plain	.....	Roller	Roller	.....	Plain	Plain	Plain
Length overall	23′ 0″	24′ 6″	20′ 6″	23′ 7″	.....	24′ 0″	21′ 8″	.....	.....	18′ 3″	21′ 7¾″	.....	.....	19′ 3″	19′ 3″	22′ 4″
Width overall.. Cutting	24′ 3″	31′ 2″	19′ 6″	25′ 0″	.....	23′ 5″	27′ 0″	.....	.....	11′ 4″	.....	32′ 6″	.....	19′ 11″	19′ 11″	27′ 6″
Width overall.. Transport	8′ 0″	8′ 4″	.....	19′ 0″	.....	13′ 5″	9′ 6″	.....	.....	11′ 4″	8′ 10½″	10′ 1½″	.....	14′ 7½″	13′ 4″	15′ 9″
Extreme height	11′ 0″	11′ 6″	10′ 6″	12′ 10″†	.....	10′ 6″	11′ 6″	.....	.....	8′ 0″	14′ 4½″	11′ 0″	.....	8′ 3″	8′ 3″	8′ 3½″
Weight	7800	9600	.....	.....	.....	.....	8450†	.....	.....	2600	.....	.....	4800	.....	.....	.....

*Farm Implement News; Chicago, April 14, 1927. ‡Ball thrust bearings also. †With grain tank.

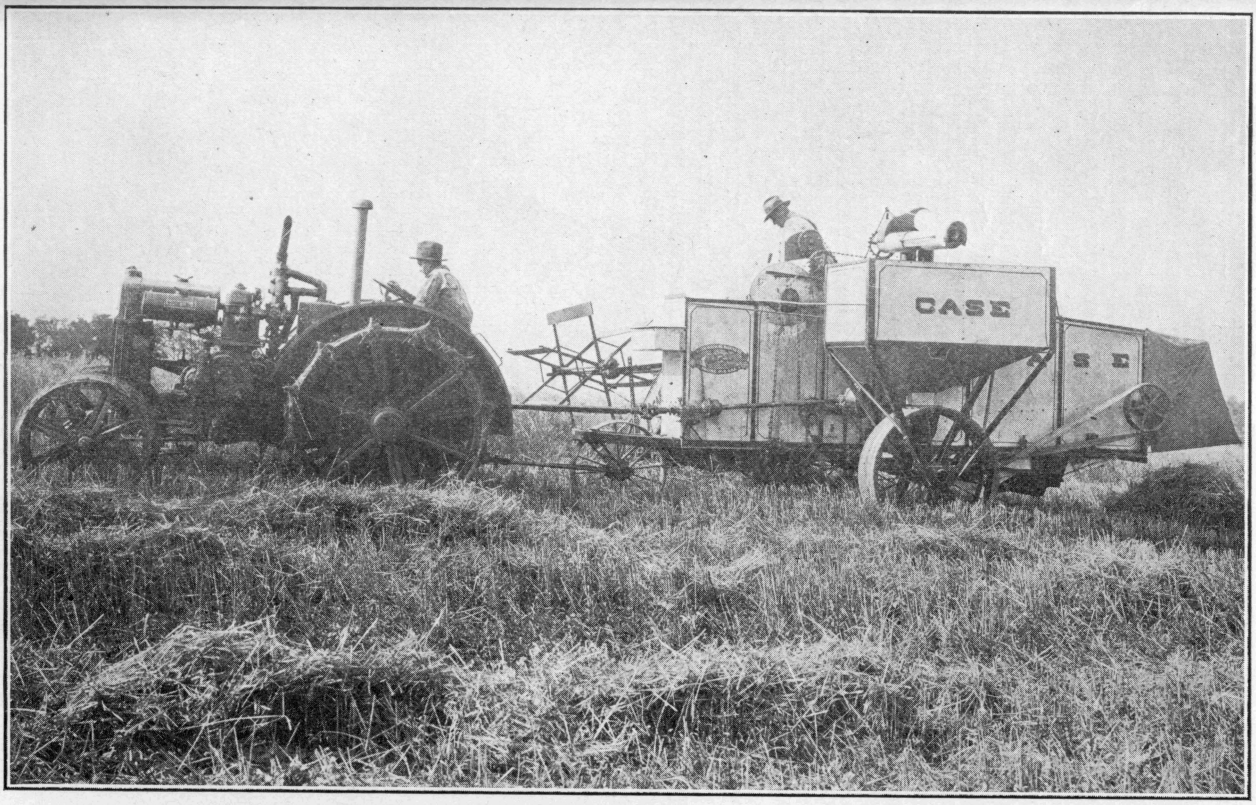

Figure 7.—Power take-off combine reduces the initial investment where the tractor is already owned. A ten-foot machine of this type can harvest 30 acres a day.

SUMMARY

The number of combines used in northwest Texas has increased from 7 in 1919 to 2,682 in 1927.

Harvesting with a binder or header may begin earlier, 4 to 7 days for the binder, and 3 to 4 days with the header, than with the combine. The number of man hours per acre required to harvest and thresh with a stationary thresher when a binder and header are used, is reduced from 4.6 for the binder and 3.8 for the header to .75 when harvesting and threshing are performed in one operation by the combine.

Costs per acre of operating a combine are estimated from available data as follows: repairs 10 to 15 cents, fuel and lubricants 25 to 36 cents, depreciation 32 to 36 cents, interest 11 to 13 cents, tractor fixed cost 11 to 20 cents, and labor 29 to 53 cents. The total cost per acre ranged from $1.42 to $2.06.

The average number of days of harvesting was 18.5.

The most common sizes of combines used ranged from 12 to 16 feet and were of engine type. The number of acres harvested per day varied from 15.6 for the 8-foot power take-off to 53 for the 20-foot auxiliary-engine type.

Eleven hours per day was the average number of hours of harvesting.

From one-third to one-half of all machines did custom cutting.

Fairly satisfactory results may be secured in harvesting grain sorghums with the combine if the proper adjustments are made and if the machine is handled with care.