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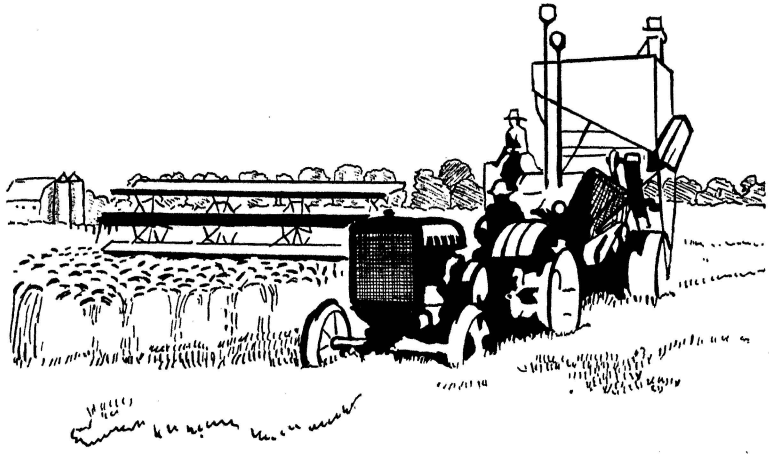
The Combine Harvester In Missouri



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The Combine Harvester In Missouri

MACK M. JONES

The material presented in this bulletin is the result of studies of harvesting methods conducted by the Missouri Agricultural Experiment Station during the harvest seasons of 1928 and 1929. The main object of these studies was to determine if the combine method of harvesting is practical and economical under Missouri conditions.

The idea of cutting and threshing grain in one operation is not new. In 1836 a patent was issued to H. Moore and J. Hascall, of Kalamazoo, Michigan, on a machine for harvesting, threshing, cleaning, and bagging grain. It appears that this machine harvested and threshed grain in an acceptable manner, but its use in Michigan was abandoned on account of climatic conditions and the difficulty in preventing the threshed grain from spoiling. Records indicate that this machine was shipped to California, via Cape Horn, where it was used in harvesting grain first in 1854. The process of cutting and threshing grain in one operation was further improved and developed in California, and has been rather common there since about 1880.

For many years it was considered that combines could be used only in those regions where there is little or no rain during the harvest and threshing season, and that they could not be used in the humid regions of the middle west. However, during the World War, combines were introduced into territory east of the Rocky Mountains, and their spread throughout the corn belt and into the Eastern states has been rather rapid. In 1928 there were nearly 1000 combines in states east of the Missouri river, exclusive of the Dakotas.

In 1927 about 15 combines were used in Missouri; in 1928 the number increased to a few more than 60; and in 1929 there were about 115 in use. In both 1928 and 1929, a number of farmers in Missouri who had planned to buy combines, did not do so because as the season advanced the prospects for the wheat crop became poorer. The machines in Missouri are located about as indicated on the map in Fig. 2. It will be noted that most of them are in the river bottoms with a few machines in the southwest level prairie section of the state.

SIZE OF COMBINES USED IN MISSOURI

Most of the combines used in Missouri are of the 10-foot size. There are a few 9-foot machines, a few of the 12-foot size, and a few of the 15-foot and 16-foot sizes. Most of the owners are satisfied with the size of

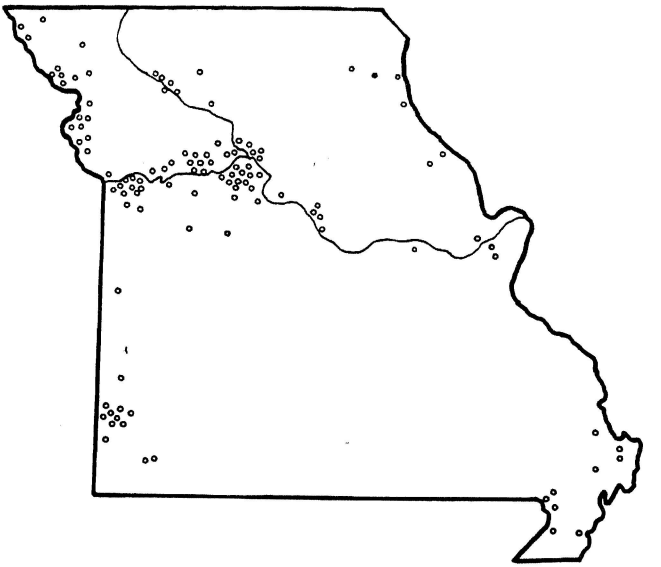

Fig. 2. Location of Combine Harvesters in Missouri, 1929.

their machines. A few, principally owners of 9-foot machines, would buy larger sizes if they were in the market for new ones.

RATE OF HARVESTING

A reasonably good day's work in the opinion of 14 owners of 10-foot machines in 1928, varies from 15 to 30 acres, and averages 23.3 acres. Most of the estimates fall between 20 and 25 acres per day. In 1929, the average rate of harvesting for 18 different 10-foot machines varied from 11.3 to 37.1 acres per day and averaged 22.1. Eight 12-foot machines averaged 22.7 acres per day, and one 15-foot machine averaged 45. Four 9-foot machines averaged 22.8.

Several factors besides the size of the combine affect the rate of harvesting, the main ones being the condition of the ground, the amount of straw that must be handled by the combine, and the length of the working day which is determined primarily by the humidity of the air. When there are heavy dews, combining is delayed sometimes to as late as eleven o'clock in the morning, and must stop at about sundown or a little before. In more favorable weather, combines may start as early as eight thirty or nine o'clock.

ACREAGE A COMBINE CAN HARVEST

In the opinion of most owners of 10-foot combines in Missouri, 100 acres is the smallest amount of small grain that would justify a farmer in

owning a combine. Some consider that a combine would be practical and economical for as few as 70 or 75 acres, and others set the minimum as high as 200 acres. The average of 39 opinions was 116 acres. Cost records (see page 39) indicate that 70 to 80 is about the smallest acreage that can be harvested economically with a combine.

The largest acreage of wheat that a 10-foot machine should be depended upon to harvest, in the opinion of these owners, varied from 150 to 450, and averaged 283 acres. At least one 10-foot machine in Missouri harvested 475 acres of wheat in 1928. The maximum acreage of wheat that can be harvested with a combine can be increased by windrowing* part of it before it is ready for direct combining; and also by growing varieties of grain that differ somewhat in their dates of maturity.

WHEN TO START COMBINING

The beginning of harvest with combines is usually 6 to 10 days after the time the grain is ready to be cut with binders. Sometimes the time is as short as three days, and sometimes as long as two weeks. The period depends primarily upon weather conditions. The rate of ripening is faster with dry, clear, hot weather. It is recommended that combining be deferred until the moisture content of the grain is as low as 14 per cent, unless there is some means of keeping the grain in sacks or in thin layers in bins for a few days, or otherwise drying the grain. Many grain buyers have means for testing the grain for moisture.

Wheat generally can stand without damage for two weeks after ripening and sometimes a little longer, depending upon the weather and the weed growth that may be starting up through the ripened grain.

Farmers who have used combines longest are most emphatic in stating that it pays to wait until the grain is thoroughly ripe and dry enough before starting the combine.

WEATHER CONDITIONS

It is seldom possible to harvest a very large crop without some delay from rains. Combining may not be affected so much by the total rainfall during harvest season as by the distribution of the rains. A small rain followed by clear weather causes very little delay, and a heavy rain followed by fair weather may cause less delay than a lighter rain folfowed by cool, cloudy weather. Small showers that would not stop shock threshing might stop combining. On the other hand, it is generally possible to combine sooner after a heavy rain than to thresh from the shock.

*See page 8.

Figure 3 indicates that the average number of rainy days at nine different points in Missouri for the month of July, over the 16-year period of 1914 to 1929 inclusive, was 5.35. Days on which one-tenth of an inch of rain or more fell are considered rainy, and days upon which less than this amount of rain fell are considered fair. Not all fair days, of course, can be considered suitable for combining. Probably on the average at least half or more of the days are suitable.

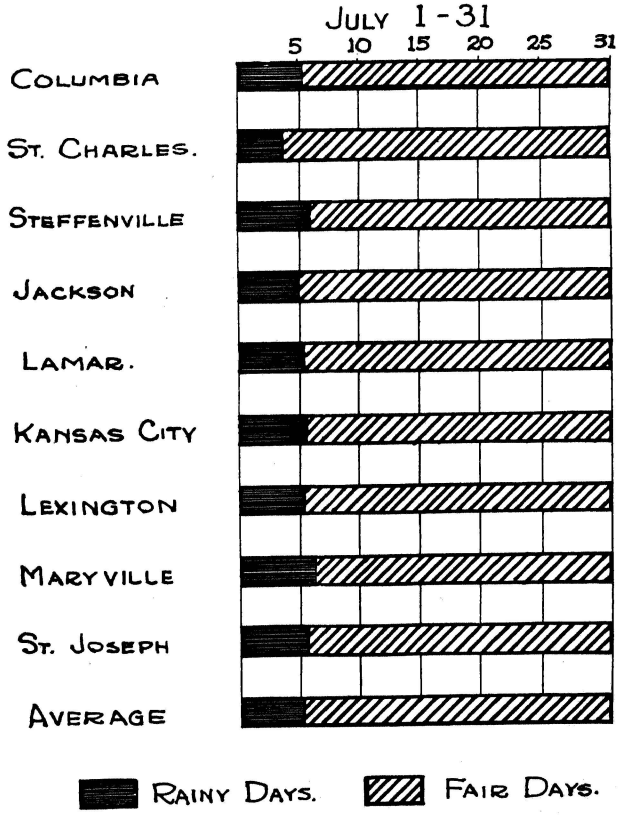

Fig. 3. Proportion of Rainy and Fair Days at Nine Different Points in Missouri during July over the 16-year period 1914 to 1929 inclusive. Days on which no rain or less than 1/10th inch fell are considered fair.

Although there is some increased hazard in leaving the grain stand an extra week or ten days in the field, it appears that this extra risk has been over-emphasized. When there is hail damage, it frequently occurs before the grain is ripe enough to cut with binders. In areas where there is danger of hail some combine owners carry hail insurance.

It appears that the combine method harvesting in Missouri is limited more by the type of farming, acreage of small grain and seed crops grown on a farm, etc. than by weather conditions.

LODGED GRAIN

Many who have not seen a combine work in lodged grain, doubt its ability to harvest such grain without serious loss. As a matter of fact, a combine can pick up and thresh lodged grain with very little loss, provided the trouble is not complicated by the presence of a heavy growth of green weeds. However, when grain lodges, it is usually rank, and weeds are not troublesome. Special pick-up guards for attaching to the regular guards have been found quite useful in enabling a combine to harvest lodged or leaning grain. Lodged grain is generally light and fluffy and sometimes causes some trouble due to uneven feeding into the feeder of the combine. In extremely bad cases a man or boy can ride on the back of the platform and make the straw feed with reasonable uniformity by an occasional push with an old broom or paddle. A combine generally has to travel slower in lodged grain, or take less than a full swath to prevent overloading of the threshing and separating mechanism, with resulting loss of grain not shaken out of the straw. A combine can save grain that is down and tangled too badly for a binder to successfully harvest.

When grain lodges, it frequently does so before it is ripe enough to harvest with a binder.

WEEDS

During the harvest seasons of 1928 and 1929, green weeds were probably the greatest single handicap to combining in Missouri. A thin stand of wheat and plenty of moisture in the soil are favorable to a rapid growth of weeds.

Green weeds cause trouble in two ways. The juice from the broken stems and leaves increases the moisture content of the threshed grain, and the small bits of stems and leaves gum the sieves and riddles and form a sort of blanket-like layer on the riddles, thus preventing the threshed grain from falling through readily. This results in some grain being carried over with the straw.

Although green weeds cause considerable trouble under certain conditions, they are not an insurmountable obstacle. Troubles from green weeds can be minimized by proper adjustment of the combine and when green weeds are present, they should be run through the cylinder and concaves and on out through the machine with as little crushing and tearing up of the stems and leaves as possible. This can be accomplished by setting the concaves low and using as few as possible to thresh

the grain from the heads. In fact, sometimes more grain can be saved by leaving a little in the heads, if by so doing fewer green weeds are cut and torn to pieces. It is important that the combine be kept running up to proper speed.

If the riddles tend to become gummed, the trouble may be reduced by using a stiff wire brush on them frequently. The use of plenty of wind is also recommended to keep the material on the sieves and riddles lifted, allowing the grain to sift through. Excessive wind may blow over a few of the lighter kernels but this is better than to allow the small bits of weed stems and leaves to form a blanket-like layer on the sieves and thus prevent some of the good grain from sifting through.

THE WINDROW SYSTEM OF COMBINING

The windrow system doubtless offers one of the best methods of combating the trouble from green weeds, and it probably can be used to advantage in Missouri more than it has been in the past. The system consists essentially of cutting the grain with a windrower, which is similar to a large binder with the binding attachment removed. The cut grain is deposited by the windrower in a uniform windrow upon the

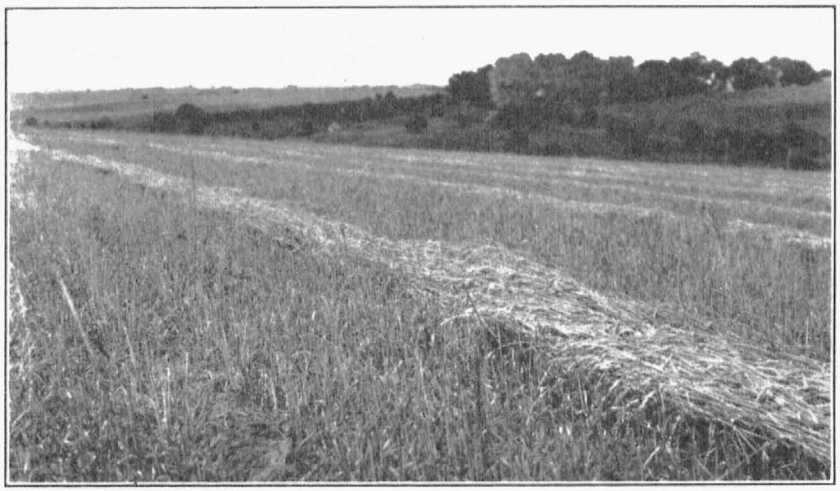

Fig. 4. A field of windrowed grain on a Saline county farm. The windrow system of combining promises to be one of the best methods of combating troubles due to green weeds and unevenly ripened grain.

stubble, where it remains for from a few days to a few weeks. After curing in the windrow, the grain is picked up and threshed by a combine equipped with a pick-up attachment. The weeds or any unripened grain cure out in the windrow and cause no difficulty in threshing.

The windrow system of course requires a little more machinery and it slightly increases the total time, labor, and expense of harvesting. (See page 29.) Windrowing itself can be done very rapidly, and in bad cases where weeds would cause considerable delay in direct combining, the total time required with the windrow system may actually be less.

The windrow system can be used to increase the acreage a combine can conveniently handle. The windrower can be started as soon as the wheat is ready to be cut with the binder; and in a few days, when the grain is ready to be combined direct, the remainder may be so harvested, leaving the windrowed grain to the last.

Windrowing may slightly increase the losses of harvesting where the losses normally would be low anyway; but where conditions are unfavorable, such as in weedy grain, the losses with the windrow method are lower than with direct combining. Tests to determine the amount of grain shattered while in the windrow, have indicated very small losses from this cause.

Fig. 5. Threshing wheat from the windrow on a Buchanan county farm. The windrow system enables a combine to harvest a larger acreage in a season.

Windrowing usually cannot be done successfully where the grain is very light or where the stubble is cut low. The windrows should be supported on thick, heavy, high stubble, and should be large enough so that they can be easily picked up and fed into the combine by the pick-up attachment.

It is generally considered that there is less danger of damage from hail when the grain is in the windrow than when left standing. Grain in the windrow can withstand considerable rain and wet weather without

serious damage except for some bleaching. In case of prolonged wet weather, there is usually less trouble from moulding and sprouting than in shocked grain.

Doubtless there are some seasons when the use of windrowers would not be necessary, but there are some seasons when their use is necessary to insure the most successful use of combines. Windrowers are recommended where there is danger of trouble from weeds or in case of uneven ripening of the grain.

Only a comparatively few combine owners in Missouri have used the windrow system, but those who have are quite enthusiastic about it. In all probability the use of the windrow system will increase in Missouri.

RELIABILITY

Modern combines are generally very well constructed and loss of time due to breakdowns is small. Most of the delays reported by Missouri combine owners were due to minor troubles which were repaired on the farm or in some nearby town. In a few cases repair parts had to be ordered from some branch house, which caused more delay, but in no case was a delay of more than two days reported. Combines, as many other farm machines, have been improved considerably in the past few years and made more durable and reliable, and less and less breakage and mechanical trouble may be expected from the later models.

CUSTOM WORK

About half of the combine owners in Missouri have done some custom work with their machines, and a few have done nothing but custom work. In practically every case, custom work has proven satisfactory both to the combine owner and to the grain owner. Various rates have been charged. Some charge by the acre and some charge by the bushel, and some make a charge that is based on both the acreage and bushels threshed. In many cases the rate was fixed at a figure somewhat lower than it would cost to thresh the grain with a custom thresher. Probably the most satisfactory rate for combining wheat from the standpoint of both parties, is $2.00 per acre plus 10 cents per bushel. Such a rate is fair under most conditions of harvesting, even with extremely thin light grain where a per-bushel rate would be unfair to the combine owner; and with extremely heavy grain where a per-bushel rate would be unfair to the grain owner.

Where a farmer does not have enough grain of his own to justify owning a combine, it is sometimes possible for him to do enough custom work to justify the purchase of a machine.

USING THE COMBINE TO THRESH FROM THE SHOCK OR STACK

A combine works quite satisfactorily as a stationary thresher. The reel and sickle are removed and then the bundles are pitched onto the platform, where the bands are cut by hand. If a considerable amount of stationary threshing is to be done, it will probably pay to get a self feeder. Some farmers have used the combine to thresh small fields of shocked grain, moving the combine from shock to shock, and throwing the bundles into the machine.

SAVING THE STRAW

Most combines as used in Missouri are equipped with straw spreaders to scatter the straw evenly on the stubble. This is a very good practice where the straw is not wanted for bedding. The straw is broken up sufficiently by the combine so that it settles down into the stubble and soon starts to decay. There is normally no difficulty in plowing under the straw.

In case the straw is to be saved, the straw spreader is detached and the straw allowed to drop out of the combine in a windrow; or a straw buncher is substituted for the spreader and the straw deposited in bunches around the field. If the straw is windrowed it is easily loaded onto a wagon with a hay loader, and if slings are used to unload the straw, the cost of saving it will probably be no more than the cost of shocking the grain after a binder. This method has the added advantage that the best straw in the field may be saved for bedding, and the straw left on those parts of the field where organic matter is especially needed in the soil.

If the straw is bunched or if it is windrowed, it may be easily and economically gathered up with sweep rakes or buck rakes and brought to a stacker or baler. In case of baling, the baler can be moved frequently to prevent long hauls with rakes.

CROPS COMBINED IN MISSOURI

Wheat.—Most of the combines in Missouri have been purchased primarily for harvesting wheat, although most of them have been used for small acreages of several other crops. It appears that most of the varieties of wheat commonly grown in Missouri can be combined reasonably well, and there seems to be no general preference of one variety over another, except possibly in the southwestern part of the state where most combine owners prefer Fulcaster or some other variety to Dunbar. The main objection to Dunbar wheat is that it does not stand well after it is ripe, especially if there happens to be a prolonged period of wet weather. Stiff straw and early maturity are of course qualities desired in a wheat that is to be harvested with the combine.

Oats.—A number of Missouri farmers have successfully harvested oats with the combine. There is no particular difficulty in harvesting oats, provided they are standing well. Oats usually do not stand as long after maturity as wheat, and for this reason, it is well to cut them as soon as possible after they ripen. Some farmers have found it advisable to stop combining wheat, if necessary and combine the oats when they are ready, and then finish the wheat harvest after the oats. The windrow and pick-up system works well in oats, and is to be recommended where there is much danger of lodging or green weeds.

Soybeans.—Although only a very small percentage of the soybean seed crop of Missouri has ever been harvested with combines, there are a number of cases where combines have been successfully used. Probably the principal reason why more beans have not been combined in Missouri, is that much of the soybean seed is grown in small acreages and in sections where there has been little wheat or other small grain crops grown. Those farmers who have combined soybeans have generally been well satisfied with this method of harvesting. Many farmers owning combines in other corn belt states, particularly Illinois and Indiana, have purchased them primarily because of their superiority for harvesting soybeans.

The combine method saves more beans than other methods of harvesting. The shattering losses of beans when cut with a mower, or a binder, generally are high, and in the past few years there has been considerable loss of beans due to moulding and sprouting in the shock. With a combine, the greatest loss, of course, is the cutter-bar loss, and this can be minimized by cutting low—within four or five inches of the ground.

Even though the losses are higher than for other crops usually harvested with the combine, they are usually much lower than the losses when other methods of harvesting are used.

Where the beans are to be harvested with a combine, it is recommended that a variety be grown that does not shatter badly. Thicker planting tends to reduce the number of pods formed near the ground, and consequently the loss of beans below the cutter bar.

Combines, of course, should be properly adjusted and have the cylinder speed reduced to thresh beans satisfactorily. Windrowing has not proven successful for soybeans. Usually the stubble is not thick enough to properly support a windrow, and in case of much wet weather the beans are subject to serious damage from sprouting.

Clovers.—Combines have been used successfully in Missouri for harvesting red clover, alsike clover, and sweet clover. Best results have been obtained with the windrow system. Some farmers have considered direct combining of sweet clover unsuccessful. Others have combined it direct, but with some difficulty. The main trouble is that the plant

grows rather rank and bushy, and there is trouble in getting it to feed into the feeder of the combine in a uniform stream. Clipping the clover in the spring prevents it from growing so rank and helps when the crop is to be straight combined. It has sometimes been necessary to station a man on the back of the platform to help feed the clover from the platform into the feeder by means of a paddle, pole, or old broom. Another trouble encountered in straight combining sweet clover is uneven ripening. Windrowing, of course, allows all green material to cure before it is threshed and thus obviates this difficulty.

In seasons of excessive rainfall, there are likely to be green shoots coming up in red clover even when the seed is ripe. Such a condition makes straight combining difficult, but offers no trouble when the crop is windrowed. Where red clover is combined direct, it may, depending upon conditions at the time, be necessary to rethresh the seed later through the combine used as a stationary thresher, or a clover huller, in order to remove all the seed from the hull. Of course, the combine, properly adjusted, will thresh the seed from the heads of clover, but it may not get all the seed from the hull. If the clover is threshed from the windrow after the straw has had ample time to cure, and if the straw is not tough at the time of threshing it is generally possible to get most of the seed out of the hull at the time of threshing. It is not absolutely necessary, of course, to have the seed perfectly hulled if it is to be sown on the home farm, but it would be desirable if it were to be sold on the market.

Other Crops.—Practically any seed crop can be harvested with a combine if it is properly equipped and adjusted. Barley and rye have been harvested in Missouri, and it appears that there is no particular difficulty in handling these crops.

Timothy has also been harvested successfully with combines in Missouri. In a number of cases, timothy has been harvested at the same time as the wheat, the timothy seed being caught in the weed seed sack, while the wheat goes to the grain tank or grain sacks.

Grain sorghums, alfalfa, rice and other crops have been harvested in other states with the combine.

CONDITION OF COMBINED GRAIN

It will be noted from Tables 1 and 3 that in the 1928 loss tests, the average moisture content of samples of grain threshed from the shock is slightly higher than that of the samples of grain threshed with combines. The moisture content of the grain from the shock ranged from 11.0 per cent to 17.3 per cent and averaged 15.0 per cent; while the moisture content of the combined grain ranged from 11.0 per cent to 19.1 per cent and averaged 14.2 per cent. The samples of grain from the shock were

dryer in 1929 than those samples from combines. The shock grain tests averaged 11.9 per cent and the combine tests averaged 14.7 per cent. Cases were observed where grain was threshed too damp both by combines and threshing machines. On the whole, combined grain in Missouri has been generally of as high quality as average grain threshed from the shock and has been accepted by most buyers on the same basis.

Experience indicates that it is generally best to delay combining until the grain is thoroughly ripe, and not to combine too soon after a rain. Those farmers who have used the combine the longest, usually follow this rule more closely than those operating combines for the first time.

MISSOURI OWNERS SATISFIED WITH COMBINE METHOD

Most combine owners in Missouri are well satisfied with the combine method of harvesting, and would not consider going back to the old system. However, many of them stated that certain improvements and changes in their machines would be desirable. The improvements are listed below in the order of frequency mentioned:

1. Lighter in weight.
2. Higher wheels and wider tires on wheels.
3. More capacity in the threshing and separating mechanism.
4. More convenient method of transporting over narrow roads and bridges and through narrow gates.
5. Reel adjustable with a lever in reach of the operator.
6. More clearance between wheels and separator body to prevent clogging with mud.
7. More clearance for crossing ditches and gullies.
8. A quicker method of unloading the grain tank.
9. Higher straw spreader.

All of the improvements of course are not needed on all combines, but since they have been suggested as desirable improvements of some, it would be well to compare these features on different models when considering buying a machine.

Of course, other desirable features of a combine are a strong, sturdy construction, liberal use of anti-friction ball or roller bearings, adequate provision for lubrication, ability to secure prompt, reliable and efficient repair service in case it is needed, etc.

ADVANTAGES AND DISADVANTAGES OF COMBINING

The following are the advantages and disadvantages of the combine method of harvesting as enumerated by Missouri owners. They are listed in the order of frequency mentioned.

Advantages

1. Saving in cost of harvesting.
2. Saving in labor and easier work.
3. Saving in time; allows more time for haying and corn cultivation.
4. Leaves straw spread evenly on ground.
5. Enables earlier fall plowing.
6. Saves more grain than other methods.
7. Grain may be put on market earlier generally at a higher price.
8. No spoiling of grain in the shock.
9. Can save grain that cannot be cut with binder.
10. Can economically harvest a poor crop that would not pay to cut with binder.
11. Can harvest any seed or grain crop.
12. Makes possible two crops per year.

Disadvantages

1. Hindered by wet weather.
2. Hindered by green weeds and unevenly ripened grain.
3. Delay of starting harvest, and therefore greater risk of storm damage.
4. High investment in machinery required.
5. Difficult to transport machine over narrow roads.
6. Packing of ground when wet.
7. No straw pile.
8. Machine hard to shed.

COMBINE HARVESTING AND THRESHING LOSSES

Harvesting and threshing losses when a combine is used, consist principally of the cutter-bar loss or the grain not picked up and placed on the platform, and the threshing loss or the grain carried or blown over with the straw. In order to determine the extent of these losses, tests were made on 24 combines in 1928 and on 23 combines in 1929.

In making the tests to determine the threshing losses, a large canvass sheet was carried along behind the combine as it was operating in the field, and all the straw was caught while the machine travelled a certain distance. The machine was not stopped at either the beginning or the end of the test. The threshed grain delivered by the combine was caught

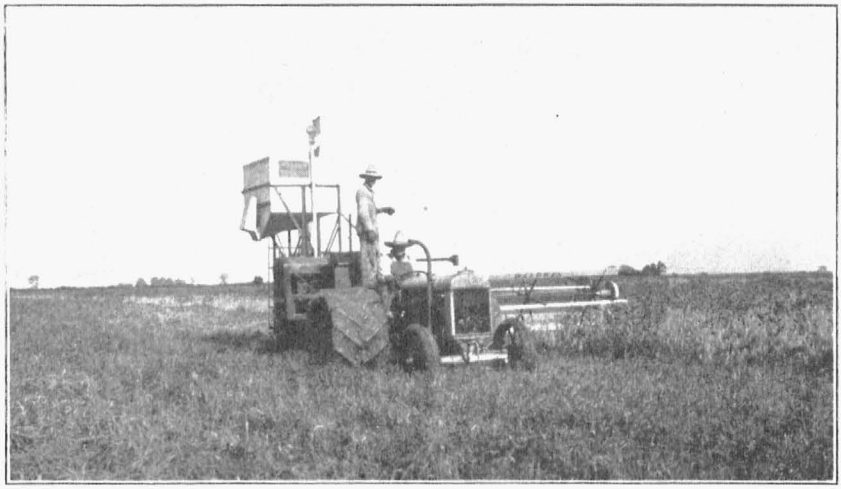

Fig. 6. Direct combining a feld of wheat on a Carroll County farm. The principal advantage of combining over the binder-thresher method, is saving in time, labor and expenses.

in a sack at exactly the same time the straw was caught. The straw on the canvass was then run through a small test threshing machine and any grain left by the combine was recovered and weighed. Knowing the amount of grain threshed and the amount of grain lost by the combine while cutting a certain distance, the percentage of loss is easily calculated.

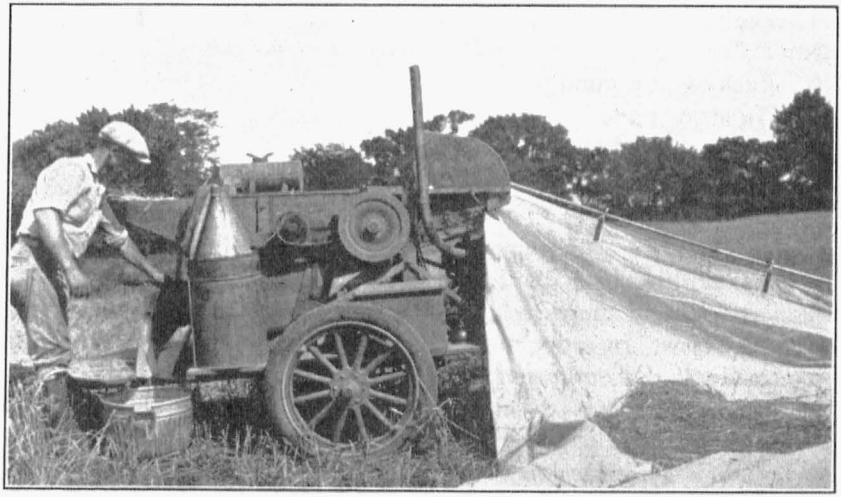

Fig. 7. Rethreshing a sample of straw caught from a combine to determine the threshing losses.

In making the tests, the recovered grain was divided into three parts, that left in the heads, the whole threshed grains carried over with the straw, and the cracked grain carried over with the straw. Separating the recovered grain into these three groups gave an indication as to how the losses might be reduced or eliminated. For instance, too much grain left in the heads indicated too few concave teeth, or not close enough adjustment of the concaves, or too slow a cylinder speed. Too much loose grain in the straw indicated improperly adjusted air blast or improper adjustment of the screens or riddles. Presence of cracked grain indicated too close adjustment of the concave teeth, improper spacing of concave and cylinder teeth, or too heavy tailings return due to improper adjustment of air or riddles.

The test thresher was a small two-cylinder pea and bean huller with slight modifications, mounted on a two-wheel pneumatic-tired trailer. A small gas engine was mounted on the same trailer and used for power for operating the thresher. The outfit was easily transported, and the thresher being small and simple, was easily cleaned of all grain after threshing each sample.

The cutter-bar losses or harvesting losses were determined by carefully picking up all the grain on a certain number of small areas selected at random in the stubble just after the combine had passed. Usually each test consisted of picking up the grain from six areas of one square yard each. The recovered grain was threshed and cleaned by hand.

Results of the Combine Tests.—Table 1 is a summary of results 24 tests made in 1928 and Table 2 is a summary of 23 tests made in 1929. It will be noted that the average machine or threshing loss in 1928 was 1.93 per cent, and in 1929 it was 2.39 per cent. Expressed in bushels per acre, the losses in 1928 averaged 0.41 and in 1929 they averaged 0.29 bushels per acre. The total acre yield in the 1929 tests was considerably lower than in 1928. This fact together with the less favorable harvesting weather of 1929, accounts mostly for the difference in the losses for the two years.

The cutter-bar losses averaged 0.95 bushel per acre in the 1928 tests, and 1.32 bushels per acre in 15 tests in 1929. Running the cutter-bar of a combine lower, of course, reduces the cutter-bar losses, but in extra heavy straw or in weedy grain, the extra load on the separating mechanism of the combine frequently results in an increased threshing loss. Considering the rather unfavorable harvest season in both years, the losses are not considered excessive.

TABLE 1.—LOSS TESTS—COMBINE METHOD, 1928

Test No.	Size of Combine, Ft.	Net Yield Bu./A.	Total Yield Bu./A.	Total Loss		Machine Loss		Cutter-Bar Loss		Moisture %	Test Weight	Conditions of Tests, Etc.
				Bu./A.	% Total Yield	Bu./A.	%	Bu./A.	% Total Yield			
1	8½	12.1	13.8	1.7	12.3	Trace	.4	1.6	11.6	19.1	57	Dead ripe; standing fair; ground soft.
2	10	16.3	18.4	2.1	11.4	.3	1.6	1.8	9.8	16.3	58	Dead ripe; leaning badly.
3	10	12.4	13.0	.6	4.6	.1	1.0	.5	3.8	13.8	58	Leaning slightly; ground soft.
4	10	25.2	25.8	.6	2.3	.1	.5	.5	1.9		58½	Standing well; slightly weedy.
5	10	20.6	21.7	1.1	5.1	.3	1.4	.8	3.7	12.2	60	Standing fair; slightly strawbroken
6	10	30.1	30.7	.6	7.0	.3	1.1	.3	1.0	12.7	60	Standing well; considerable green timothy.
7	10	44.1	45.2	1.1	2.4	.1	.3	1.0	2.2	14.6	60½	Standing well; heavy grain.
8	10	41.8	43.3	1.5*	3.5	.6	1.5	.6	1.4	11.0	61	Windrowed; heavy grain.
9	9	20.9	22.1	1.2	5.4	.1	.4	1.1	5.0	13.5	60	Leaning slightly; some green timothy.
10	10	40.5	43.0	2.5	5.8	1.6	3.9	.9	2.1	12.2	60½	Leaning slightly.
11	9	29.6	30.1	.5	1.7	.1	.4	.4	1.3	12.4	60	Standing well; weedy in places.
12	10	19.3	20.0	.7	3.5	.4	1.9	.3	1.5	13.4	60½	Standing well; ripe; weedy.
13	10	25.0	25.6	.6	2.3	.2	.7	.4	1.6	12.2	61	Standing fair; weedy.
14	10	13.4	14.6	1.2	8.2	.5	3.3	.7	4.8	14.1	58½	Leaning considerably; very weedy; ground soft.
15	12	12.9	15.9	3.0	18.9	.3	2.0	2.7	17.0	14.2	58	Leaning badly; ground soft.
16	12	17.1	18.3	1.2	6.6	.5	2.9	.7	3.8	18.1	56	Standing fair; weedy.
17	10	22.8	24.8	2.0	8.1	.2	.7	1.8	7.3	15.7	55	Leaning badly; weedy.
18	9	16.3				.4	2.2			14.9	55½	Leaning badly; very weedy.
19	10	13.3	14.6	1.3	8.9	.8	5.9	.5	3.4	15.1	55	Leaning badly; extra weedy, thin grain.
20	10	33.2				.3	1.0			13.1	56	Leaning very badly; heavy grain.
21	12	29.0	30.2	1.2	4.0	.6	2.0	.6	2.0	16.5	59	Leaning slightly; sweet clover 10 to 20 in. high.
22	9	12.7	14.4	1.7	11.8	.4	3.1	1.3	9.0	13.1	58½	Leaning badly; thin grain; weedy.
23	10	21.8	25.2	3.4	13.8	1.3	5.8	2.1	8.3	14.3	55½	Leaning slightly; weedy.
24	10	16.9	18.0	1.1*	6.1	.4	2.4	.4	2.2	14.0	56	Windrowed; heavy growth of sweet clover.
AVG.		22.9	24.0	1.40	6.76	.41	1.93	.95	4.76	14.2	58¼	

*Includes. 0.3 bu. per A. windrow loss.

TABLE 2.—LOSS TESTS—COMBINE METHOD, 1929

Test No.	Size of Combine, Ft.	Net Yield Bu./A.	Total Yield Bu./A.	Total Loss		Machine Loss		Cutter-Bar Loss		Moisture %	Test Weight	Conditions of Test, Etc.
				Bu./A.	% Total Yield	Bu./A.	%	Bu./A.	% Total Yield			
1	15					.4	3.8			13.4	57	Clover 16 inches to 18 inches high.
2	10					.5	4.1			15.4	57	50% hail damage before time for binder cutting.
3	10					.1	.7			14.2	59	Some hail damage.
4	10	14.7	17.5	2.8	16.0	1.2	7.3	1.6	9.1	15.5	53	Grain very tough, windrowed.
5	10	7.5	8.4	.9*	10.7	.3	3.9	.6*	7.1		52	Grain very tough.
6	12	12.4	14.1	1.7	12.1	.3	2.1	1.4	9.9	12.8	56+	Heavy straw; tangled somewhat.
7	10					.2	.9			14.4	57	Heavy straw; weedy.
8	16	13.4	15.0	1.6	10.7	Trace	.3	1.6	10.7	13.2	57	Standing well.
9	10	16.6	18.2	1.6	8.8	.5	2.8	1.1	6.0	14.8	56	Ground wet; grain tough.
10	10	15.4	18.0	2.6	14.4	.4	2.7	2.2	12.2	18.9		Ground wet; grain tough.
11	12	7.6	10.7	3.1	29.0	.6	7.2	2.5	23.4	14.5	55½	Standing fair.
12	10	12.9	13.6	.7	5.1	.2	1.2	.5	3.7	16.8	55½	Grain tough; ground wet.
13	10					.3	1.3			13.0	58	Somewhat strawbroken.
14	10	11.3	12.9	1.6	12.4	Trace	.2	1.6	12.4	17.2	57	Somewhat strawbroken.
15	10	17.5	19.2	1.7	8.9	.1	.5	1.6	8.3	14.0	58	Somewhat strawbroken.
16	10					.5	2.7			14.6	57½	Grain down badly.
17	9	6.1	6.8	.7	10.3	.1	2.2	.6	8.8	14.2	56	Grain thin; standing fair.
18	12					.1	.8			13.0	58½	Leaning; strawbroken.
19	10	7.3	8.8	1.5	17.0	.1	1.4	1.4	15.9	12.3	57	Standing fair.
20	12	8.8	9.3	.5	5.4	.1	1.5	.4	4.3	15.1	56	Thin light straw.
21	12	13.8	15.9	2.1	13.2	.2	1.5	1.9	11.9	14.3	56	Badly strawbroken; hail damage.
22	10	7.0	8.2	1.2	14.6	.4	5.2	.8	9.8	15.4	52	Thin; badly strawbroken.
23	12					.1	.8			16.9	53	Thin; weedy; down badly.
Avg.		11.1	13.1	1.62	12.57	.29	2.39	1.32	10.23	14.7	56.1	

*Includes .04 Bu. per A. windrow loss.

TABLE 3.—LOSS TESTS—BINDER THRESHER METHOD, 1928

Test No.	Size of Thresher	Net Yield Bu./A.	Total Yield Bu./A.	Total Loss		Machine Loss		Cutter-Bar Loss		Shock Loss		Moisture %	Test Weight
				Bu./A.	% Total Yield	Bu./A.	% Total Yield	Bu./A.	% Total Yield	Bu./A.	% Total Yield		
1	28	14.5	15.6	1.1	7.1	.1	.5	.8	5.1	.2	1.3	11.0	59½
2	32	16.5	17.4	.9	5.2	.1	.5	.5	2.9	.3	1.7	13.6	59½
3	21	18.1	18.8	.7	3.7	.1	.7	.4	2.1	.2	1.1	12.5	61
4	23	18.0	18.6	.6	3.2	.1	.3	.3	1.6	.2	1.1	14.6	61
5	32	26.0	26.9	.9	3.3	.2	.6	.5	1.9	.2	.7	15.4	57½
6	36	23.5	24.1	.6	2.5	.1	.5	.2	.8	.3	1.2	15.5	57½
7	28	14.6	15.8	1.2	7.6	Trace	.2	.7	4.4	.5	3.2	14.6	58½
8	32	14.6	15.9	1.3	8.2	.1	.6	1.0	6.3	.2	1.3	16.2	58
9	24	13.0*				Trace	.3			.4		15.7	59
10	20	10.3				.1	.6			.3		15.6	57½
11		12.5				.3	2.6			.2		16.5	56
12	32	13.9				1.3	8.6			.1		17.3	53
13	36	14.0*				.1	.8			.2		17.2	55
Avg.		16.1	19.1	.91	5.1	.20	1.29	.55	3.14	.25	1.45	15.0	57.9

*Estimated.

LOSSES OF BINDERS AND THRESHING MACHINES

Loss tests similar to those run on combines were also run on threshing machines. The straw from the threshing machine was caught in a canvass while a definite quantity of grain was being threshed. Cutter bar losses were made in the same manner as for combine tests, but at threshing time, in the 1928 tests, instead of the time the grain was cut with the binder. Shock losses were measured by carefully raking and cleaning around a number of shocks and then threshing the recovered grain and straw through the test thresher.

Tables 3 and 4 give summaries of the tests on threshers. It will be noted that the threshing losses, or machine losses are somewhat lower, or 1.29 per cent for threshing machines against 1.93 per cent for combines in 1928; and 1.89 per cent for threshing machines against 2.39 per cent for combines in 1929. In both methods, the losses were higher in 1929, due to less favorable harvesting and threshing weather, and to poorer grades and lower yields of grain.

Shock Losses.—Shock losses averaged 0.25 bushel per acre in 1928. Making cutter-bar and shock loss counts at threshing time instead of harvest time is not quite accurate, as some of the grain is covered by rains, some of it sprouts, and where there is a heavy growth of grass or weeds, it is practically impossible to recover all the lost grain. It should be pointed out also, that the shock loss as reported here, does not include any loss due to sprouting or damage of grain while in the shock. This loss is quite appreciable under certain conditions.

Binder Cutter-Bar Losses.—In the 1928 tests, cutter-bar losses in fields where threshing machines were tested, averaged 0.55 bushel per acre. The combined shock and cutter-bar losses averaged 0.80 bushel per acre against 0.95 bushel cutter-bar loss per acre for the combine method.

TABLE 4.—LOSS TESTS—THRESHING MACHINES, 1929

Test No.	Size of Thresher	Net Yield Bu./A.	Machine Loss		Moisture %	Test Weight
			Bu./A.	%		
1	32			1.9	12.5	58
2	32			1.7	10.8	53
3	34	16.1	.4	2.2	12.6	57
4	32	17.8	.9	4.6	12.5	58½
5	20			3.0	11.3	58
6	36	15.2	.2	1.0	12.0	55½
7	36			2.4	12.5	55
8	32	9.6	.1	.6	11.3	
9	36			1.1	11.3	58½
10	32			.7	11.4	58
11	22	15.4	.5	3.3	12.3	58
12	30	12.5	Trace	.3	11.5	59
13	22	8.0*	.1	.8	11.0	54
14	36	16.2	.6	3.6	12.6	54
15	22	15.5	.2	1.2		58½
16	20	21.7	.4	1.9	13.0	51
Ave.		14.8	.34	1.89	11.9	56.4

In 1929 cutter-bar loss tests in 25 fields at binder cutting time averaged 0.62 bushel per acre, compared to 1.32 bushels per acre for combines.

Comparison of Total Losses.—The total losses for the binder-thresher method averaged 0.91 bu. per acre or 5.1 per cent of the total yield in the 1928 tests, compared with 1.4 bu. per acre or 6.76 per cent for the combine method. In 1929, assuming the same shock loss as in 1928, and a cutter-bar loss of 0.62 bushel per acre as determined in 25 fields at binder cutting time, the total loss for the binder-thresher method was 1.2 bushel per acre, compared to a loss of 1.6 bushels per acre for the combine. In making these comparisons, it must be remembered that the results are based on a comparatively few tests, that the average total yields of the fields where the combine tests were made is different from the average yields where the binder-thresher method was used, and that it is practically impossible to measure total losses in all cases especially in the case of shock losses.

From these tests and from similar tests made in other states where conditions are somewhat similar to those in Missouri, it would seem that in general there is not a great deal of difference in the losses by the two methods of harvesting. In some cases and in some years the combine will save a larger percentage of the crop; in other cases, or in other seasons, the binder-thresher method will save more. It would appear that the question of which method to use should be decided by considerations other than the losses, such as saving in time, labor or expense.

COST OF HARVESTING WITH COMBINES

The cost of owning and operating a combine is one of the factors that largely determines whether or not its use will prove practical. Therefore, a major part of the studies reported in this bulletin deal with costs. Reasonably complete records were obtained on 24 machines in 1928 and on 41 machines in 1929. The results are summarized in Tables 5 and 6. It will be noted that the average cost for 22 owners, who combined direct in 1928, was $2.17 per acre or 13.3 cents per bushel. In the two cases of windrow harvesting in 1928, the average cost was $2.78 per acre and 13.2 cents per bushel.

In 1929 the records where the grain was combined direct (28 cases) indicate an average cost of $2.02 per acre, or 21.7 cents per bushel. In the four cases of windrow harvesting, the cost averaged $2.64 per acre or 30.5 cents per bushel.

The difference in the costs per bushel for the two years is due primarily to a difference in the yield of wheat. It will be noted that the costs per acre are about the same, but that the cost per bushel is con-

TABLE 5.—HARVESTING AND THRESHING COSTS—COMBINE METHOD, 1928

No.	Size of Combine, Ft.	Avg Acres Cut Per Day	Total Acres Cut, 1928	Acres Where Rec'ds Kept	Bu. Per Acre	Fuel Used, Gals. Per A.		Total Fuel, Oil & Grease Cost Per A.	Combine Machine Costs						Total Harvest and Threshing Cost	
						Tractor	Combine		Tractor Charge Per Acre[1]	Man Labor Cost Per Acre[2]	Est. Life of Combine, Yrs.	Avg. Annual Depreciation	Int'st, Taxes, Insurance, Housing[3]	Repairs[4]	Total Annual Cost	Annual Machine Costs Per Acre	$ Per Acre	Cts. Per Bu.
Direct Combining																		
1	10	25.0	275	80	29.7	1.05	.66	.28	.24	.32	10	132.50	66.25	27.50	226.25	.82	1.66	5.6
2	10	34.3	125	65	12.5	83	.33	.18	.18	.23	10	145.00	72.50	12.50	230.00	1.84	2.43	19.4
3	10	21.9	105	105	23.3	1.43	.57	.39	.27	.36	12	120.83	72.50	10.50	203.83	1.94	2.96	12.7
4	9	18.2	270	200	17.5	.99	.66	.30	.33	.44	10	122.50	61.25	27.00	210.75	.78	1.85	10.6
5	9	12.5	143	103	23.0	1.14	.92	.37	.48	.64	10	132.50	66.25	14.30	213.05	1.49	2.98	13.0
6	10	21.4	335	235	15.1	1.17	.70	.35	.28	.38	12	125.00	75.00	33.50	233.50	.70	1.71	11.3
7	9	16.7	210	200	9.4	.90	.90	.33	.36	.48	6	132.50	66.25	21.00	219.75	1.05	2.22	23.6
8	10	22.1	200	65	19.7	.97	.49	.30	.27	.54	10	140.50	70.25	20.00	230.75	1.15	2.26	11.5
9	10	37.5	150	150	14.6	.67	.50	.22	.16	.21	10*	145.00	72.50	15.00	232.50	1.55	2.14	14.7
10	10	36.0	120	72	21.8	.52	.17	.14	.17	.33	12	100.42	60.25	12.00	172.67	1.44	2.08	9.5
11	10	11.2	270	210	28.5	.97	1.21	.36	.53	.71	12	108.35	65.00	27.00	200.33	.74	2.34	8.2
12	10	25.8	260	220	13.3	1.57	.51	.40	.23	.31	10*	145.00	72.50	26.00	243.50	.94	1.88	14.1
13	9	24.8	210	177	19.2	.84	.54	.25	.24	.32	10*	122.50	61.25	21.00	204.75	.98	1.79	9.3
14	10	25.4	295	295	16.6	.73	.48	.23	.24	.47	10*	145.00	72.50	29.50	247.00	.84	1.78	10.7
15	10	22.9	191	191	16.7	.63	.46	.20	.26	.35	10*	131.30	65.65	19.10	216.05	1.13	1.94	11.5
16	12	24.6	156	140	27.0	1.38	.80	.37	.24	.49	8	187.50	75.00	15.60	278.10	1.78	2.88	10.7
17	10	13.3	230	200	21.5	.90	1.50	.40	.45	.60	9	144.44	65.00	23.00	232.44	1.01	2.46	11.4
18	10	40.3	475	230	11.3	.71	.25	.18	.15	.30	7	198.86	69.60	47.50	315.96	.67	1.30	11.5
19	10	25.0	360	320	22.5	.50	.50	.18	.24	.32	10*	140.50	70.25	36.00	246.75	.69	1.43	6.4
20	9	17.9	145	100	18.0	1.19	1.05	.37	.34	.45	10	160.00	80.00	14.50	254.50	1.76	2.92	16.2
21	10	24.8	75	75	10.0	1.00	0.00	.18	.24	.32	10	97.30	48.65	7.50	153.45	2.05	2.79	27.9
22	10	27.7	200	200	8.0	.64	.51	.21	.22	.29	10*	137.50	68.75	20.00	226.25	1.13	1.85	23.1
Avg.			218		18.1	.94	.65	.28	.28	.40						1.20	2.17	13.3
Windrow Combining																		
23	10	29.4	245	125	16.5	1.21	.62	.35	.35	.27	10*	145.00	72.50	29.40	246.90	1.01	1.98	12.0
24	10	21.1	100	100	25.0	.89	.78	.28	.43	.57	10*	145.00	72.50	12.00	229.50	2.30	3.58	14.3
Avg.			173		20.8	1.05	.70	.32	.39	.42						1.66	2.78	13.2

*No estimate of life given by owner but assumed at 10 years.

1. Tractor charge, 60 cents per hour (includes all costs except fuel, oil, and labor for operating).
2. Man labor charge, $4.00 per day.
3. Interest figured at 7% of average value (½ of original investment); insurance and taxes at 1%; and housing at 2% (or 1% of cost new).
4. Repairs figured at 10 cents per acre for combine only and at 2 cents per acre for windrow and pick-up attachment.

TABLE 6.—HARVESTING AND THRESHING COSTS—COMBINE METHOD, 1929

No.	Size of Combine, Ft.	Avg. Acres Cut Per Day	Total Acres Cut, 1929	Acres Where Rec'ds Kept	Bu. Per Acre	Fuel Used, Gals. Per A.		Total Fuel, Oil & Grease Cost Per A.	Tractor Charge Per Acre[1]	Man Labor Cost Per Acre[2]	Est. Life of Combine, Yrs.	Combine Machine Costs					Total Harvest and Threshing Cost	
						Tractor	Combine					Avg. Annual Depreciation	Intst, Taxes, Insurance, Housing[3]	Repairs[4]	Total Annual Cost	Annual Machine Costs Per Acre	$ Per Acre	Cts. Per Bu.
Direct Combining																		
1	15	45.0	330		12.3				.13		10	210.00	105.00	33.00	348.00	1.05		
2	10	18.8	300	300	8.7	.80	.64	.31	.32	.43	8.5	155.88	66.25	30.00	252.13	.84	1.90	21.8
3	10	25.0	100	100	16.3	1.00	.80	.37	.24	.32	12.5	128.00	80.00	10.00	218.00	2.18	3.11	19.1
4	10	25.0	400	400	8.5	.49	.44	.15	.24	.32	10	136.20	68.10	40.00	244.30	.61	1.32	15.5
5	10	11.7	340	175	8.6	1.71	.86	.46	.51	.68	10	134.00	67.00	34.00	235.00	.69	2.34	27.2
6	10		105	40	11.0	.57	.76	.40			10	140.00	70.00	10.50	220.50	2.10		
7	10		205								10	129.50	64.75	20.50	214.75	1.05		
8	10	19.3	243	135	6.5	1.30	.62	.68	.31	.42	10	137.50	68.75	24.30	230.55	.95	2.36	36.3
9	10	25.0	55	55	5.0	.99	.60		.24	.32								
10	10	11.3		90	10.6	1.98	1.00	.54	.53	.71	10	157.50	78.75					
11	10	19.7	355	355	12.0	1.41	96	.29	.30	.41	10	148.50	74.25	35.50	258.25	.73	1.73	14.4
12	10	37.6	225	225	22.2	1.11	.67	.34	.16	.32	10	140.00	70.00	22.50	232.50	1.03	1.85	8.3
13	12		204	150	14.3						10*	178.00	89.00	20.40	287.40	1.41		
14	9	10.0	186	140	15.7		1.07	.34	.60	.80	10*	165.00	82.50	18.60	266.10	1.43	3.17	20.2
15	10	27.5	195	55	10.9	.73	.36	.32	.22	.29	10	140.00	70.00	19.50	229.50	1.18	2.01	18.4
16	10	20.0	850	400		.75	.40	.23	.30	.40	7	178.57	62.50	85.00	326.07	.38	1.31	
17	12	18.0	555	225	12.0	1.50	1.11	.55	.33	.44	10	173.00	86.50	55.50	315.00	.57	1.89	15.8
18	10	25.9	245	220	8.6	.58	.62	.23	.23	.31	10	136.20	68.10	24.50	228.80	.93	1.70	19.8
19	10	15.0	262	262	10.0	1.00	1.00	.38	.40	.53	10*	136.20	68.10	26.20	230.50	.88	2.19	22.0
20	9		140								10	120.00	60.00	14.00	194.00	1.39		
21	12	33.3	1000	400	10.0	.61	.66	.24	.18	.36	10	170.00	85.00	100.00	355.00	.36	1.14	11.4
22	10	21.8	130	120	10.0	.92	.67	.32	.28	.37	10	140.00	70.00	13.00	223.00	.172	2.69	26.9
23	10	30.0	350	325	8.0	.66	.33	.22	.20	.27	10*	136.20	68.10	35.00	239.30	.68	1.37	17.1
24	12	15.3	455	430	6.9			.17	.39	.52	7.5	200.00	75.00	45.50	320.50	.70	1.78	25.8
25	9	23.4	304	234	9.1	.81	.50	.25	.26	.34	10	129.00	64.50	30.40	223.90	.74	1.59	17.5
26	12	32.0	160	160	10.2	.73	.44	.27	.19	.25	10	149.00	74.50	16.00	239.50	1.50	2.21	21.7
27	12	20.0	90	90	6.7	.83	.28	.24	.30	.40	20	76.50	76.75	9.00	162.25	1.80	2.74	40.9
28	10		209	190		1.08	.29				15	93.33	70.00	20.90	184.23	.88		
29	9	42.9	235	150	4.0	.40	.20	.12	.14	.19	10	160.00	80.00	23.50	263.50	1.12	1.57	39.3
30	10	15.0	100	30	15.0	.67	1.17	.42	.40	.53	10	135.00	67.50	10.00	212.50	2.13	3.48	23.2
31	12	23.2	366	116	11.9	.65	.52	.28	.26	.34	10	118.70	59.35	36.60	214.65	.59	1.47	12.4
32	8	15.4	259	231	4.2	1.54	.00	.26	.39	.52	10	95.00	47.50	25.90	168.40	.65	1.82	43.3

TABLE 6 (CONTINUED).—HARVESTING AND THRESHING COSTS—COMBINE METHOD, 1929

33	9	15.0	45	45	10.9	1.22	1.11	.50	.40	.53				4.50				
34	10		205								8	185.13	74.05	20.50	279.68	1.36		
35	10	23.0	270	230	8.7	1.20	.54	.33	.26	.35	10	140.00	70.00	27.00	237.00	.88	1.82	20.9
36	10	20.0	105	105	14.3	2.10	.00	.45	.30	.40	20	50.00	50.00	10.50	110.50	1.05	2.20	15.4
37	12	14.7	240	220	11.9	1.14	.68	.37	.41	.54	12	109.17	65.50	24.00	198.67	.83	2.15	18.1
38	10	21.4	440	150	13.3	1.56	.87	.40	.28	.56	12	120.83	72.50	44.00	237.33	.54	1.78	13.4
Avg.			277		10.6	1.03	.67	.34	.30	.42						1.06	2.02	21.7
									Windrow Combining									
39	Wind-rowing	30.0	150	150		.52	.00	.09	.20	.13								
	Thresh-ing	21.4		150	6.7	.69	.40	.15	.28	.37								
	Total					1.21	.40	.44	.48	.50	10*	177.00	88.50	18.00	283.50	1.89	3.31	49.4
40	Wind-row-ing	40.0	205	160					.08[5]	.10								
	Thresh-ing	22.9		160	8.9	.75	.31	.23	.26	.35								
	Total								.34	.45	11	165.90	91.25	24.60	281.75	1.37	2.39	26.9
38	Wind-row-ing	40.0		240		.48	.00	.07	.15	.10								
	Thresh-ing	24.0	440	240	7.9	1.29	.83	.34	.25	.50								
	Total					1.77	.83	.41	.40	.60	12	20.00	12.00	4.80	36.80[6]	.69[7]	2.03	25.7
41	Wind-row-ing	30.0		260		.50	.00	.07	.20	.13								
	Thresh-ing	16.3	275	260	14.2	.97	1.65	.47	.37	.49								
	Total					1.47	1.65	.54	.57	.62	10*	180.00	90.00	33.00	303.00	1.10	2.83	19.9
Avg.			268		9.4	1.48	.96	.46	.45	.54						1.26	2.64	30.5

*No estimate of life given by owner but assumed at 10 years.

1. Tractor charge, 60 cents per hour (includes all costs except fuel, oil, and labor for operating).
2. Man labor charged at $4.00 per day.
3. Interest figured at 7% of average value (½ of original investment); insurance and taxes at 1%; and housing at 2% (or 1% of cost new).
4. Repairs figured at 10 cents per acre for combine only and at 2 cents per acre for windrow and pickup attachment.
5. Three horses used to pull windrower; .75 horse hours per acre required; figured at 11 cents per horse hour.
6. Machine costs for windrowing and pickup equipment only; machine costs for combine given above under No. 38 in "direct combining" section of table.
7. Includes 15 cents per acre windrower and pick-up costs, and 54 cents per acre combine costs.

siderably higher in 1929. The yield in 1928 averaged 18.4 bushels per acre, and only 10.5 in 1929.

Depreciation.—The machine cost per acre depends largely upon how long the machine will last and upon how many acres it will harvest in its lifetime. No combines have been worn out in service in Missouri as yet, so the machine cost must be estimated on the basis of experience with combines in other sections of the country, and on the basis of experience in Missouri with machines of a like nature. The U. S. Department of Agriculture reports that combines in the Great Plains are estimated to last on the average about eight years. The average annual acreage harvested by the combines in Missouri doubtless will be much lower than in the Great Plains. The estimated life of combines most frequently given by Missouri owners is 10 years. The average life as estimated by 32 farmers in 1929 is 10.7 years.

The figures for depreciation used in arriving at the costs reported in Tables 5 and 6 are average depreciation values, and are determined by dividing the first cost of the combine by the estimated life as given by the owner. In case no estimate was given, 10 years was assumed as the life.

Interest, Taxes, Insurance, Housing.—The figures for interest, taxes, insurance, and housing in Tables 5 and 6 are computed by taking 10 per cent of the average value of the combine, or one-half of its first cost. Interest is figured at 7 per cent, which is about what a farmer would have to pay if he borrowed money to purchase machinery. The cost of housing a combine will vary considerably, but it is considered that 1 per cent of the new cost of a combine or 2 per cent of its average value throughout its life, would be a fair yearly charge to cover the cost of providing suitable and adequate shelter.

Insurance and taxes are figured at 1 per cent of the average value (one-half of first cost). Insurance will cost about 60 cents per $100, or or six-tenths of 1 per cent. It is true that most farmers probably would not insure their machinery, but carry the risk themselves; or in a sense, carry their own insurance at cost.

Repairs.—Combines have not been used long enough in Missouri to get first-hand information on the average cost of repairs. For the first one or two years this is an item of small consequence, but of course will increase as the combines get older. The U. S. Department of Agriculture has considered that 10 cents per acre would be a fair allowance to make for cost of repairs of combines in the Great Plains area. Limited experience with combines in Missouri indicates that this figure should be adequate for Missouri conditions, or probably more than adequate in the case of the newer models of combines.

Labor.—Most of the combines used in Missouri require two men, one to drive the tractor and one to operate the combine. In a few cases of power take-off driven machines, one man may handle the entire outfit. Experience with power take-off driven machines indicates that an auxiliary motor on the combine is generally more satisfactory on sizes cutting 10 feet or more.

In case the combine is equipped with a bagging attachment instead of a grain tank, an extra man is required to tie the sacks and care for the sacked grain.

An average of slightly more than one man-hour of labor per acre is required for combining, according to the studies reported herein. The records for 1928 show an average of 1.03 man hours per acre in 22 cases where direct combining was practiced; and in two cases of windrow combining, an average of 1.05 man hours per acre. In 1929 the man labor required in 30 cases of direct combining averaged 1.03 man hours per acre, and in four cases of windrow harvesting, 1.36 man hours per acre. In one case of windrowing in both years, the grain was sacked, requiring three men to operate the outfit, and thus increasing the amount of labor required.

Man labor costs in Tables 5 and 6 are based on a rate of 40 cents per hour, which is about the average wage paid harvest hands when board is considered. Most of the combines in Missouri are operated by the owner or by some year or month hand who is paid generally not over $4.00 per day including board.

Power.—Tractors of from 10 to 15 drawbar horsepower are commonly used to pull combines in Missouri. A few are pulled with horses or mules. In most cases a farmer already owned a tractor when he bought the combine, and simply used whatever size tractor he had.

The cost of tractor power used in Tables 5 and 6 is 60 cents per hour. This includes depreciation, interest, repairs, housing, and all costs except fuel, oil, grease, and labor for operating. If a tractor were hired for this work, it might cost slightly more in some cases, and less in others. Best information indicates that if a farmer owns a tractor of two or three-plow size such as is commonly used for pulling combines, and if he manages it well and has a normal amount of work for it to do, it probably will cost him less than 60 cents per hour, exclusive of fuel, oil, and labor for operating it.

Fuel and Oil.—The fuel and oil used for combining varies considerably with the condition of the grain. The 1928 records of 22 combines doing direct combining, indicate a consumption of an average of 0.94 gallon of fuel per acre in the tractor engine, and 0.65 gallon per acre in the combine engine; two cases of windrow harvesting averaged 1.05 gallons per acre in the tractor engine and 0.70 gallon per acre in the

combine engine. In 1929 the records of 31 machines doing direct combining was 1.03 gallons of fuel per acre in the tractor engine and 0.67 gallon per acre in the combine engine. Three records of windrow harvesting, indicate an average of 1.48 gallons per acre used in the tractor engine and 0.96 gallon per acre in the combine engine. The amount of fuel required does not seem to depend a great deal upon whether gasoline or kerosene is used.

From Tables 5 and 6 it will be noted that the total fuel, oil, and grease cost per acre in the 1928 records averaged 28 cents per acre for 22 cases of direct combining, and 32 cents per acre for two cases of windrow combining. In 1929 the figures were somewhat higher, being 34 cents per acre for 31 cases of direct combining, and 46 for three cases of windrow harvesting. The higher figures for 1929 are due largely to differences in prices of fuel. The 1928 costs are based on kerosene at 12 cents per gallon, gasoline at 15 cents per gallon, motor oil at 80 cents per gallon, and hard oil and grease at 1 cent per acre. In 1929, the actual price to the individual farmers was used in each case, the average being as follows: kerosene, 12.6; gasoline, 17.1; motor oil, 71.3; hard oil and grease, 1.2 cents per acre.

The total consumption of motor oil in both the tractor engine and the combine engine was a little more than 7 gallons per hundred acres according to the 1929 records.

Summary of Combining Costs.—On the basis of average rates of harvesting, average amounts of fuel, labor, etc. required, and on the basis of machine costs as discussed in the preceding paragraphs, the following is a summary of typical average costs of owning and operating a 10-foot combine that costs $1375 new and will last 10 years.

AVERAGE ANNUAL FIXED COSTS

Depreciation, 10% of $1375	$137.50
Interest, taxes, insurance, housing, 10% of average value (½ of $1375)	68.75
Total	$206.25

AVERAGE OPERATING COSTS

Fuel in tractor, 1 gal. kero. per acre at 13c.	$0.13
Fuel in combine, .7 gal. gaso. per acre at 17c.	.12
Oil in combine and tractor, .07 gal. per acre at 75c.	.05
Hard oil and grease, per acre	.01
Labor, 1 man hour per acre, at 40c.	.40
Combine repairs, per acre	.10
Use of tractor, (60c per hr., 2¼ acres per hour)	.27
Total	$1.08

On the basis of the foregoing average figures, the total cost per acre for combining different acreages is presented in Table 7. It will be noted that the cost per acre is high for small acreages, and low for large acreages.

TABLE 7.—AVERAGE PER ACRE COST OF COMBINING

Acres Harvested Per Year	25	50	100	150	200	250	300	400	500
Annual Fixed Cost	8.25	4.13	2.06	1.38	1.03	.83	.69	.52	.41
Operating Cost	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
TOTAL	9.33	5.21	3.14	2.46	2.11	1.91	1.77	1.60	1.49

Cost of Windrow Combining.—The average figures presented in Table 7 are for direct combining. When the windrow system of combining is used, the cost is increased slightly, due to the extra labor, fuel, oil, etc. required, and due to the extra overhead costs of some additional machinery. Although only a few cost records are available under Missouri operating conditions, it appears that the additional cost of windrowing will run from 50 to 70 cents per acre. From Tables 5 and 6 it will be noted that in 1928 the two cases of windrow harvesting averaged $2.78 per acre compared to $2.17 for direct combining; and in the 1929 records four cases of windrow harvesting cost an average of $2.64 per acre compared to $2.02 for direct combining. The records in Table 6 indicate that windrowing with a 12-foot windrower may be done at about 30 or 40 acres per day, and the total cost for fuel, oil, and grease ranges from 7 to 9 cents per acre. The overhead or machine costs per acre for the windrowing and pick-up equipment, of course, will depend largely upon how much work is done with it per year. The average for the machine costs reported in Table 6 is $1.26 per acre compared to an average of $1.06 for direct combines.

HARVESTING AND THRESHING COSTS—BINDER-THRESHER METHOD

In order to get a comparison of the cost of harvesting and threshing by the combine method and by the binder-thresher method, reasonably complete records were obtained from 113 farmers in 1929 on costs of binding and threshing their grain. These results are summarized in Tables 8 and 9. It will be noted that the average cost per acre with the binder-thresher method is $3.85, compared to $2.02 for the combine method as given in Table 6. The average per-bushel cost of harvesting and threshing is 37.5 cents as compared with 21.7 cents for the combine method.

Binder Costs.—The binder depreciation costs were figured by dividing the new cost of the binder by the owner's estimate of the life of the machine. In case no estimate was made by the owner, the average value of 14 years was assumed, the actual average of 107 estimates being 14.46 years. In order to make the costs for different farmers in Table 8 comparable, the new cost of the binder was taken as the present cost of a new machine, the cost of a 10-foot binder being taken as $300,

TABLE 8.—BINDER HARVESTING COSTS

No.	Acres Cut 1929	Avg. Acres Cut Per Yr.	Size of Binder Ft.	Est. Life, Yrs.	Binder Costs						Harvesting Costs Per Acre, 1929					
					Avg. Yrly. Depreciation	Int'st, Taxes, Ins., Housing	Avg. Yrly. Repair Costs	Avg. Repair Cost Per 100 A.	Avg. Yrly. Oil Cost	Total Binder Cost 1929	Binder Cost Per Acre	Horse Labor	Tractor ork	Man Labor Binding & Shocking	Twine Cost	Total
1	65	75	8	25	10.00	12.50	7.50	10.00	.69	30.69	.41		.31	1.11	.39	2.22
2	135	135	8	9	27.78	12.50	2.50	1.85	1.23*	44.01	.33				.28	
3	110	85	8	16	15.63	12.50	2.75	3.24	.50	31.38	.37		.29	1.08	.28	2.02
4	42	40	8	10	25.00	12.50	3.00	7.50	.48	40.98	1.02	.22		.60	.14	1.98
5	80	75	8	10	25.00	12.50	4.17*	5.56*	.94	42.61	.57		.36	.84	.14	1.91
6	60	80	8	12	20.83	12.50	7.50	9.38	1.00	41.83	.52	.23		.71	.28	1.74
7	70	75	7	12	20.00	12.00	6.60	8.80	1.60	40.20	.54	.37		.90	.21	2.02
8	140	100	7	10	24.00	12.00	5.00	5.00	.71	41.71	.42	.36		.66	.21	1.65
9	170	125	10	10	30.00	15.00	1.50	1.20	.74	47.24	.38		.18	.54	.37	1.47
10	150	60	7	10	24.00	12.00	2.50	4.17	.56	39.06	.65		.21	.73	.32	1.91
11	180	100	10	10	30.00	15.00	5.56*	5.56*	.55	51.11	.51		.22	.68	.21	1.62
12	45	45	7	25	9.60	12.00	2.50	5.56	.45	24.55	.55	.17		.55	.42	1.69
13	200	180	8	10	25.00	12.50	20.00	11.10	.41	57.91	.32		.18	.61	.24*	1.35
14	46	46	8	12	20.83	12.50	7.50	16.30	.42*	41.25	.90		.25	.88	.28	2.31
15	95	110	8	10	25.00	12.50	10.00	9.10	.87	48.37	.44		.17	.60	.23	1.44
16	115	100	8	14*	17.86*	12.50	5.00	5.00	.43	35.79	.36	.26		.64	.21	1.47
17	45	45	7	20	12.00	12.00	2.00	4.44	.41*	26.41	.59	.29		.80	.28	1.96
18	115	100	7	15	16.00	12.00	4.00	4.00	.43	32.43	.32		.28	.62	.28	1.50
19	67	75	8	20	12.50	12.50	3.50	4.67	.23	28.73	.38		.16	.50	.14	1.18
20	50	50	7	16	15.00	12.00	3.00	6.00	.50	30.50	.61	.44				
21	120	100	8	10	25.00	12.50	10.00	10.00	1.00	48.50	.49				.28	
22	135	50	7	10	24.00	12.00	5.00	10.00	.56	41.56	.83		.33	.92	.21	2.29
23	75	100	7	18	13.33	12.00	4.00	4.00	1.00	30.33	.30		.23	.87	.21	1.61
24	38	40	7	15	16.00	12.00	5.00	12.50	.52	33.52	.84	.35		.72	.18	2.09
25	46	60	8	16	15.63	12.50	5.00	8.33	.39	33.52	.56	.34		.81	.14	1.85
26	125	100	8	8	31.25	12.50	2.00	2.00	.40	46.15	.46		.25	.80	.21	1.72
27	95	200	10	20	15.00	15.00	12.00	6.00	2.10	44.10	.23		.25	.80	.25	1.52
28	60	70	7	12	20.00	12.00	5.00	7.14	.58	37.58	.54	.28		.65	.21	1.68
29	45	50	8	15	16.67	12.50	2.00	4.00	.28	31.45	.65	.26		.72	.28	1.89
30	16	100	8	18	13.89	12.50	3.00	3.00	1.88	31.27	.31		.16	.50	.21	1.18
31	65	40	7	17	14.12	12.00	3.00	7.50	.15	29.27	.73	.37		.61	.14	1.85
32	95	60	7	15	16.00	12.00	10.00	16.67	.79	38.79	.65		.27	.70	.18	1.80
33	40	80	7	12	20.00	12.00	2.50	3.13	1.00	35.50	.44	.33		.92	.21	1.90
34	52	50	7	20	12.00	12.00	3.00	6.00	.19	27.19	.54		.25	.60	.21	1.60
35	55	80	8	15	16.67	12.50	4.00	5.00	.43	33.60	.42		.20	.68	.21	1.51
36	130	100	8	15	16.67	12.50	5.00	5.00	.96	35.13	.35	.23		.61	.21	1.40
37	110													1.16	.28	
38	47	50	7	20	12.00	12.00	2.78*	5.56*	.16	26.94	.54	.26		.47	.14	1.41
39	60	40	7	15	16.00	12.00	5.00	12.50	1.00	34.00	.85	.43		1.20	.14	2.62
40	65	65	10	10	30.00	15.00	2.50	3.85	.25	47.75	.73		.17	.63	.28	1.81

41	240	200	8	12	20.83	12.50	10.00	5.00	1.66	44.99	.23					
42	150	150	10	20	15.00	15.00	5.00	3.33	1.00	36.00	.24		.27	.71	.33	1.50
43	80	80	8	15	16.67	12.50	5.00	6.25	.50	34.67	.43		.25	.67	.23	1.54
44	55	50	6	30	7.33	11.00	1.00	2.00	.46	19.79	.40	.41		1.00	.14	1.94
45	115	100	8	15	16.67	12.50	5.00	5.00	.26	34.43	.34		.18	.45	.07	1.05
46	24	40	7	20	12.00	12.00	5.00	12.50	.50	29.50	.74	.28		.70	.09	1.88
47	75	80	8	15	16.67	12.50	3.00	3.75	1.06	33.23	.42	.28		.52	.28	1.55
48	70	75	10	15	20.00	15.00	10.00	13.33	.53	45.53	.61		.25	.80	.28	1.91
49	22	100	8	10	25.00	12.50	4.00	4.00	.91*	42.41	.42		.34	1.27	.21	2.24
50	300	370	10	10	30.00	15.00	2.00	.54	1.85	48.85	.13		.13	.30	.14	.70
51	125	200	10	12	25.00	15.00	3.00	1.50	1.44	44.44	.22		.20	.72	.25	1.39
52	230	200	10	10	30.00	15.00	2.00	1.00	1.30	48.30	.24		.16	.32	.56	1.28
53	270	270	10	7	42.86	15.00	10.00	3.70	1.00	68.86	.26		.11	.35	.21	.93
54	27	60	7	20	12.00	12.00	2.50	4.17	.77	27.27	.45			1.29	.35	2.09
55	70	70	8	15	16.67	12.50	3.89*	5.56*	.64*	33.70	.48	.22		.40	.28	1.38
56	100	80	7	20	12.00	12.00	4.45*	5.56*	.48	28.93	.36	.33		.62	.14	1.45
57	75	60	8	15	16.67	12.50	5.00	8.33	.40	34.57	.58	.29		.54	.21	1.62
58	130	130	10	14*	21.43*	15.00	7.23*	5.56*	1.18	44.84	.35		.18	.55	.21	1.29
59	400	200	10	12	25.00	15.00	11.00	5.50	1.00	52.00	.26		.18	.48	.21	1.13
60	190	50	8	10	25.00	12.50	10.00	20.00	.40	47.90	.96		.25	.80	.14	2.15
61	36	75	6	30	7.33	11.00	7.50	10.00	.94	26.77	.36	.36		.88	.21	1.81
62	30	50	7	10	24.00	12.00	5.00	10.00	.59	41.59	.83	.44		1.20	.21	2.68
63	125	125	8	12	20.83	12.50	10.00	8.00	1.50	44.83	.36		.32	1.00	.21	1.89
64	40	40	6	18	12.22	11.00	1.50	3.75	.30	25.02	.63	.45		.81	.14	2.03
65	58	150	8	15	16.67	12.50	8.34*	5.56*	.78	38.29	.26		.19	.50	.25	1.20
66	15	25	6	23	9.57	11.00	2.50	10.00	.33	23.40	.94	.29		.85	.25	2.33
67	35	85	8	10	25.00	12.50	7.00	8.24	.48	44.98	.53	.33		.70	.25	1.81
68	45	125	8	14*	17.85*	12.50	6.00	4.80	1.29	37.64	.30	.29		.67	.28	1.54
69	100	140	10	6	50.00	15.00	10.00	7.14	1.27	76.27	.55		.15	.64	.28	1.62
70	70	90	7	10	24.00	12.00	5.00	5.56	.53	41.53	.46	.32		.68	.28	1.74
71		150	10	8	37.50	15.00	12.50	8.33	3.21	68.21	.46					
72	220	160	8	18	13.89	12.50	7.50	4.69	.98	34.87	.22	.26		.50	.21	1.19
74	65	100	8	16	15.63	12.50	3.00	3.00	.31	31.44	.31	.37		.67	.21	1.56
75	29	40	8	18	13.89	12.50	2.00	5.00	.36*	28.75	.72		.34	.95	.21	2.22
76	24	30	6	11	20.00	11.00	1.67*	5.56*	1.25	33.92	.11	.41		1.00	.28	1.80
77	35	100	7	20	12.00	12.00	2.50	2.50	.31	26.81	.27	.32		.40	.28	1.27
78	40	60	7	12	20.00	12.00	3.00	5.00	.50	35.50	.59	.36		.72	.28	1.95
79	20	50	7	21	11.43	12.00	1.50	3.00	1.25	26.18	.51		.38	1.00	.35	2.25
80	18	60	6	20	11.00	11.00	3.00	5.00	.12	25.12	.42		.34	1.06	.35	2.17
81	45	100	7	14	17.14	12.00	10.00	10.00	.74	39.88	.40	.35		.93	.28	1.96
82	12	50	7	18	13.33	12.00	2.50	5.00	1.07	28.90	.58		.42	1.34	.28	2.62
83	33	100	7	16	15.00	12.00	5.00	5.00	1.75	33.75	.34		.27	.57	.35	1.53
84	87	90	10	12	25.00	15.00	5.00*	5.56*	.83	45.83	.51		.19	.90	.25	1.85
85	120	120	10	12	25.00	15.00	4.00	3.33	.49	44.49	.37		.19	.62	.20	1.38
86	83	135	7	20	12.00	12.00	4.00	2.96	.92	28.92	.21	.29		.66	.25	1.41
87	80	100	10	10	30.00	15.00	5.56*	5.56*	.91*	51.47	.51		.17	.54	.21	1.43
88	50	65	8	15	16.67	12.50	1.00	1.54	.27	30.44	.47	.26		.64	.42	1.79
89	120	120	10	9	33.33	15.00	6.67*	5.56*	.76*	55.76	.46		.11	.90	.28	1.75
90	250	250	10	8	37.50	15.00	13.90*	5.56*	2.00	68.40	.27		.08	.46	.20	1.01
91	52	60	8	15	16.67	12.50	7.00	11.67	.20	36.37	.61		.24	.72	.23	1.80
92	18	100	6	16	13.75	11.00	2.50	2.50	.50	27.75	.28	.37		.73	.28	1.66
93	35	65	8	25	10.00	12.50	3.50	5.38	.27	26.27	.40	.25		.63	.28	1.56
94	75	100	7	12	20.00	12.00	3.00	3.00	.90	35.90	.36	.35		.72	.18	1.61
95	100	115	8	10	25.00	12.50	10.00	8.70	.84	48.34	.42	.29		.66	.21	1.58

TABLE 8 (CONTINUED).—BINDER HARVESTING COSTS

No.	Acres Cut 1929	Avg. Acres Cut Per Yr.	Size of Binder Ft.	Est. Life, Yrs.	Binder Costs						Harvesting Costs Per Acre, 1929					
					Avg. Yrly. Depreciation	Int'st, Taxes, Ins., Housing	Avg. Yrly. Repair Costs	Avg. Repair Cost Per 100 A.	Avg. Yrly. Oil Cost	Total Binder Cost 1929	Binder Cost Per Acre 1929	Horse Labor	Tractor Work	Man Labor Binding & Shocking	Twine Cost	Total
96	40	90	8	12	20.83	12.50	.50	.56	.42	34.25	.38		.25	.80	.21	1.64
97		70	8	15	16.67	12.50	3.00	4.29	1.55	33.72	.48					
98	35	40	7	12	20.00	12.00	5.00	12.50	.36*	37.36	.93	.32		.63	.14	2.02
99	60	60	7	14	17.14	12.00	3.34*	5.56*	.55*	33.03	.55	.29		.53	.19	1.56
100	60	70	7	15	16.00	12.00	7.50	10.71	.64*	36.14	.52				.24*	
101	35	70	6	20	11.00	11.00	2.50	3.57	.64*	25.14	.36	.30		.73	.28	1.67
102	100	75	7	10	24.00	12.00	4.17*	5.56*	.68*	40.85	.54	.24		.62	.21	1.61
103	50	150	7	15	16.00	12.00	10.00	6.67	1.37*	39.37	.26	.25		.47	.14	1.12
104	37	38	7	14*	17.14*	12.00	2.11*	5.56*	.35*	31.60	.83	.40		.70	.24*	2.17
105	80	100	8	10	25.00	12.50	5.56*	5.56*	.91*	43.97	.44	.28		.69	.39	1.80
106	90	75	8	11	22.73	12.50	7.50	10.00	.68*	43.41	.58	.29		1.15	.28	2.30
107	90	95	8	8	31.25	12.50	12.00	12.63	.86*	56.61	.60		.25	.60	.21	1.66
108		65	7	13	18.46	12.00	3.61*	5.56*	.59*	34.66	.53	.33		.90	.35	2.11
109	60	70	7	8	30.00	12.00	3.89*	5.56*	.64*	46.53	.66	.42		.98	.32	2.38
110	60	130	8	16	16.67	12.50	2.00	1.54	1.18*	32.35	.25		.29	.75	.35	1.64
111	110	120	7	10	24.00	12.00	5.00	4.17	1.09*	42.09	.35	.29		.53	.21	1.38
112	33	70	7	27	8.88	12.00	8.00	11.43	.64*	29.52	.42	.44		.86	.35	2.07
113	18	40	7	15	16.00	12.00						.30		.60	.14	
Avg.	85.0	93.3		14.4				6.34			.48	.32	.23	.73	.24	1.72

*Assumed as average or based on average values.

TABLE 9.—THRESHING COSTS

No.	Acreage	Bu. Per A.	Threshing Costs: Machine Charge Cts. Per Bu.	Threshing Costs: Machine Charge Total	Threshing Costs: Man Labor Cost	Threshing Costs: Horse Labor Cost	Threshing Costs: Fuel Cost	Threshing Costs: Meals for Hands	Threshing Costs: Horse Feed	Threshing Costs: Total Threshing Cost	Threshing Costs: Total Threshing Cost, Cts. Per Bu.	Total Harvest and Threshing Costs: Per Acre	Total Harvest and Threshing Costs: Cts. Per Bu.
1	65	13.0	.25	168.00					4.32	172.32	25.64	.78	3.47
2	115	16.9	.20	389.00						389.00	20.0		
3	95	11.2	.20	213.20						213.20	20.0	4.26	38.0
4	30	6.0	.22	39.60					12.60	52.20	29.0	3.72	62.0
5	70	7.1	.15	75.00					3.00	78.00	15.6	3.02	42.5
6	52	10.6	.18	99.18			6.50	11.25		116.93	21.2	4.00	37.7
7	30	9.0	.22	59.40			11.00		11.00	81.40	30.1	4.73	52.6
8	110	14.0	.20	309.00					5.00	314.00	20.3	4.50	32.1
9	170	15.9	.15	405.00						405.00	15.0	3.85	24.2
10	60	21.2	.19	241.49			16.25			257.74	20.3	6.21	29.3
11	35	11.4	.225	90.22			4.00		6.00	100.22	25.0	4.48	39.3
12	40	20.0	.20	160.00						160.00	20.0	5.69	28.5
13	200	9.8	.20	392.80						392.80	20.0	3.31	33.8
14	30	16.5	.20	99.00						99.00	20.0	5.61	34.0
15	90	10.1	.18	162.90			13.50			176.40	19.5	3.40	33.7
16	100	11.5	.18	207.00			10.80			217.80	18.9	3.65	31.7
17	38	11.3	.18	77.04					7.20	84.24	19.7	4.18	37.0
18	45	8.9	.08	32.00	39.80	6.40	25.80	8.00	2.00	114.00	28.5	4.03	45.3
19	40	6.6	.08	21.12	23.80	9.80		4.20	2.80	61.72	23.4	2.72	41.2
20	15	12.4	.07	13.02	9.25	2.25		6.50	1.50	32.52	17.5		
21	115	8.4	.20	193.60						193.60	20.0		
22	100	11.0	.08	88.00	56.00	16.80		10.00	3.00	173.80	15.8	4.03	36.6
23	65	15.0	.08	78.00	45.00	7.00	9.38		1.75	141.13	14.5	3.78	25.2
24	38	9.7	.07	25.90	16.00	4.80		4.50	3.00	54.20	14.6	3.52	36.3
25	26	9.0	.06	14.04	16.25	7.00	4.80		3.50	45.59	19.5	3.60	40.0
26	125	9.8	.085	103.70	43.20	14.40		1.25	2.40	164.95	13.5	3.04	31.0
27	50	7.9	.07	27.65	31.25	11.25	6.20		1.62	77.97	19.7	3.09	39.1
29	25	11.8	.06	17.64	21.60	3.60	4.50	7.35	2.60	57.29	19.4	4.18	35.4
30	16	8.8	.08	11.20	6.00	1.50	2.00		.20	20.90	14.8	2.49	28.3
31	65	5.2	.08	27.20	19.50	1.80	4.00	2.40	4.80	59.70	17.6	2.77	53.3
32	83	7.3	.08	48.72	54.00	12.00	10.00	17.50	5.10	147.32	24.2	3.56	48.8
33	40	11.0	.07	30.80	16.50	5.40	5.00	5.25	2.45	65.40	14.9	3.54	32.2
34	30	10.0	.07	21.00	13.00	4.20	1.80	2.10	.20	42.30	14.1	3.01	30.1
35	45	14.1	.12	76.44	31.50	12.60	5.60		4.50	130.64	20.5	4.41	31.3
36	115	10.0	.06	69.00	66.00	16.00	12.80	11.00	4.80	179.60	15.6	2.96	29.6
37	110	9.1			57.60	25.60		8.40	3.00				
38	17	6.5	.08	8.88	4.80	1.20	.65			15.53	14.0	2.32	35.7

TABLE 9 (CONTINUED).—THRESHING COSTS

No.	Acreage	Bu. Per A.	Threshing Costs: Machine Charge Cts. Per Bu.	Threshing Costs: Machine Charge Total	Threshing Costs: Man Labor Cost	Threshing Costs: Horse Labor Cost	Threshing Costs: Fuel Cost	Threshing Costs: Meals for Hands	Threshing Costs: Horse Feed	Threshing Costs: Total Threshing Cost	Threshing Costs: Total Threshing Cost, Cts. Per Bu.	Total Harvest and Threshing Costs: Per Acre	Total Harvest and Threshing Costs: Cts. Per Bu.
39	18	5.6	.08	8.00	16.80	12.00		9.50	5.50	51.80	51.8	5.50	98.2
40	42	16.7	.09	63.00	28.80	3.60	3.40	6.50	2.10	107.40	15.3	4.37	26.2
42	150	18.0	.08	216.00	147.00	56.00		28.00	6.00	453.00	16.8	4.57	25.4
43	80	11.4	.08	73.12	48.00	16.00	11.25	11.20	2.40	161.97	17.7	3.60	31.6
44	32	4.0	.06	7.68	3.00	1.20	2.00	2.00	.50	16.38	12.8	2.46	61.5
45	55	6.7	.10	37.00	29.70	4.40		3.15	.80	75.05	20.3	2.40	35.8
46	24	2.9	.08	5.52	8.75	.88		1.50		16.65	24.1	2.50	86.2
47	47	10.6	.07	35.00	39.90	7.60	9.75	12.00	3.00	107.25	21.5	3.78	35.7
48	40	11.4	.09	41.04	19.20	7.20	4.05	4.20	1.20	76.89	16.9	3.86	33.9
49	22	16.0			18.00	8.00	3.23	5.60	1.50				
50	20	5.0	.08	8.00	4.00	1.50		1.40	.60	15.50	15.5	1.48	29.6
51	100	14.5	.07	101.50	63.00	24.00	19.80	2.00	1.50	211.80	14.6	3.51	24.2
52	80	11.4	.10	91.20	63.00	10.50		8.40	3.50	176.60	19.4	3.49	30.6
53	140	9.3	.08	104.00	108.00	18.00	9.10	16.00	5.00	260.10	20.1	2.79	30.0
54	14	15.6	.08	17.52	9.00	3.60	2.50			32.62	14.9	4.42	28.3
56	80	5.4	.08	34.48	30.00	3.20		6.00	1.20	74.88	17.4	2.39	44.3
57	60	8.8	.09	47.25	31.50	6.00		17.50	2.00	104.25	19.9	3.36	38.2
58	100	3.0	.08	24.00	39.00	18.00		17.50	2.25	100.75	33.6	2.30	76.7
59	70	8.9	.06	37.38	33.60	7.70	3.13	3.75	1.80	87.36	14.0	2.38	26.7
60	160	7.7	.09	110.70	62.40	10.40		4.00	4.00	191.50	15.6	3.35	43.5
62	30	4.7	.08	11.20	21.60	4.80	3.00	3.25	3.20	47.05	33.6	4.25	90.4
63	80	12.6	.08	80.40	72.00	30.00		2.50	5.00	189.90	18.9	4.26	33.8
64	33	9.8	.07	22.75	15.00	3.68		3.25	1.25	45.93	14.1	3.42	34.9
65	40	10.4	.08	33.20	26.25	7.00	5.00	4.00	2.50	77.95	18.8	3.15	30.3
66	15	9.8	.08	11.76	10.50	1.50		2.25	.75	26.76	18.2	4.11	41.9
67	20	7.0	.08	11.20	7.50	2.10	12.00	.90	.40	34.10	24.3	3.52	50.3
68	45	15.2	.06	41.10	33.00	18.00		8.25	4.50	104.85	15.3	3.87	25.5
69	100	10.4	.12	124.80	73.50	23.10	14.80	7.70	5.50	249.40	24.0	4.11	39.5
70	70	12.5	.06	52.50	44.00	12.00	8.75	14.00	2.00	133.25	15.2	3.65	29.2
72	220	8.7	.05	96.00	113.75	48.75				258.50	13.5	2.37	27.2
74	65	7.1	.08	36.72	42.25	17.55	4.80	7.70	2.25	111.27	24.2	3.27	46.1
77	35	6.5	.10	22.70	12.60	1.40		2.10	.64	39.44	17.4	2.40	36.9
78	40	9.6	.08	30.72	19.80	13.20		4.00	2.40	70.12	18.3	3.70	38.5
80	18	18.4	.06	19.92	8.80	4.80	3.74	1.20	4.00	42.46	12.8	4.53	24.6
81	45	16.7	.13	97.50	54.60	14.70	7.20	10.50	2.80	187.30	25.0	6.12	36.6
82	12	22.9	.13	35.75	15.60	7.20	2.60	5.00	1.50	67.65	24.6	8.26	36.1
83	33	15.2	.08	40.00	39.53	8.10		12.80	4.40	104.83	21.0	4.71	31.0

84	87	12.9	.08	90.08	78.90	35.00	9.75	15.60	6.40	235.73	20.9	4.55	35.3
85	120	6.6	.08	62.88	86.10	12.30	13.93	8.40	1.44	185.05	23.5	2.92	44.2
87	80	7.6	.08	48.48	42.00	7.00		8.00	3.50	108.98	18.0	2.80	36.8
88	50	16.0	.10	80.00	46.80	20.80		7.00	1.50	156.10	19.5	4.91	30.7
89	120	20.0	.09	216.00	105.60	38.40	20.90			380.90	15.9	4.94	24.7
90	250	10.4	.08	208.00	108.00	42.20		16.00	2.10	376.30	14.5	2.52	24.2
91	52	8.7	.08	36.00	24.00	8.40		7.00	1.75	77.15	17.1	3.28	37.7
92	18	13.9	.07	17.50	4.80	1.80		2.50	3.00	29.60	11.8	3.30	23.7
93	35	14.0	.07	34.16	36.00	7.20	7.00	7.00	2.70	94.06	19.3	4.25	30.4
94	75	11.3	.07	59.50	81.00	24.00	10.80	16.00	4.00	195.30	23.0	4.21	37.3
95	100	7.1	.08	57.12	76.50	13.50	15.00	23.00	2.50	187.62	26.3	3.46	48.7
96	40	12.5	.06	30.00	45.50	31.50		14.00	1.20	122.20	24.4	4.70	37.6
98	35	13.6	.08	38.00	24.00	10.00	6.00	6.40	3.50	87.90	18.5	4.53	33.3
99	60	11.7	.08	56.00	45.00	8.00	6.50	5.25	2.80	123.55	17.7	3.62	30.9
100	60	7.0	.09	37.80	15.00	6.00	6.00	6.80	2.40	74.00	17.6		
101	35	11.4	.10	40.00	21.00	7.00		4.90	2.45	75.35	18.8	3.82	33.5
102	100	16.0	.18	288.00			6.40			294.40	18.4	4.56	28.5
103	50	13.6	.08	54.40	36.00	16.00	12.00	12.80	4.80	136.00	20.0	3.84	28.2
104	37	9.5	.08	27.92	22.50	10.00	7.50	6.00	5.60	79.52	22.6	4.32	45.5
105	80	18.8	.20	300.00			6.00			306.00	20.4	5.63	29.9
106	90	20.0	.09	162.00	120.00	16.00	12.00	8.00	8.40	326.40	18.1	5.93	29.7
107	90	25.6	.18	414.00						414.00	18.0	6.26	24.4
110	60	10.0	.08	48.00	30.00	7.50	19.20	15.00	3.15	122.85	20.5	3.69	36.9
111	110	10.0	.08	88.00	40.00	13.50	10.00	9.50	3.00	164.00	14.9	2.88	28.8
112	33	10.2	.08	26.80	22.50	9.10	6.00	14.70	2.70	81.80	24.3	4.55	44.6
113	18	13.3	.07	16.80	27.00	3.00	5.25	3.15		55.20	23.1		
Avg.		11.4									19.7	3.85	37.5

an 8-foot binder as $250, a 7-foot binder as $240, and a 5-foot or a 6-foot binder as $220.

The annual interest, taxes, insurance, and housing costs were calculated as for the combines, namely 10 per cent of the average value (one-half of the first cost).

The annual repair cost on 93 binders, cutting an average of 95 acres each per year, averaged $5.27 per binder. The average per acre repair cost for these 93 cases was 6.3 cents. The binders cutting the higher acreages per year had lower repair costs per acre. The weighted average repair costs, determined by dividing the grand total cost of repairs on these 93 farms by the grand total acres cut on these farms, is 5.6 cents per acre.

Oil costs for 86 binders averaged 91 cents per 100 acres cut.

The average yearly total binder cost per acre for 110 binders was 48 cents.

Man and Horse Labor.—Man labor for operating the binder averaged 0.82 man-hour per acre, and man labor for shocking averaged 1.01 man-hours per acre.

Horse labor averaged 2.8 horse-hours per acre where the binders were horse drawn. When tractor drawn, the tractor hours per acre averaged .46. The use of a tractor decreases the required amount of man-labor per acre, provided one man can handle both the tractor and the binder; but where two men are used, the total man labor may be increased somewhat.

In figuring the cost of tractor work in Table 8, a rate of 50 cents per hour was used. The tractor charge used in the combine costs is 60 cents per hour, but pulling a binder is somewhat lighter work, and therefore a smaller charge is in order. Man labor is figured at 40 cents per hour.

Twine.—The twine used per acre varies considerably, the average for 107 records being 1.7 pounds per acre. In figuring the costs in Table 8 a price of 14 cents per pound is used.

Threshing Costs.—The threshing costs are summarized in Table 9. It will be noted that the threshing costs averaged 19.7 cents per bushel.

Table 9 also shows that the total harvesting and threshing costs for 93 cases averaged $3.85 per acre and 37.5 cents per bushel.

Summary of Binder-Thresher Costs.—On the basis of average rates of harvesting, average amounts of labor, etc. required, as discussed in the preceding paragraphs, the following is a summary of average costs of harvesting with the binder-thresher method.

AVERAGE ANNUAL FIXED CHARGE FOR BINDER (8-FOOT)

Depreciation, (Useful life 14 years), 7.14% of $250	$17.85
Interest, Taxes, Insurance, Housing, 10% of average investment (½ of $250)	12.50
Total	$30.35

AVERAGE VARIABLE COSTS, BINDER-THRESHER METHOD

Man labor cutting, .82 man-hours per acre at 40c	$0.33
Horse labor cutting, 2.8 horse-hours per acre at 11c	.31
Twine, 1.7 pounds per acre at 14c	.24
Binder repairs, per acre	.06
Binder oil, per acre	.01
Man labor shocking, 1 man-hour per acre at 40c	.40
Threshing, per acre, (11.5 bu. per acre) at 20c per bu.	2.30
Total	$3.65

TABLE 10.—TOTAL HARVESTING COSTS PER ACRE, BINDER-THRESHER METHOD (11.5 Bu. per Acre)

Acres Harvested Per Year	25	50	100	150	200	250	300
Annual Fixed Cost	1.21	.61	.30	.20	.15	.12	.10
Other Costs	3.65	3.65	3.65	3.65	3.65	3.65	3.65
TOTAL	4.86	4.26	3.95	3.85	3.80	3.77	3.75

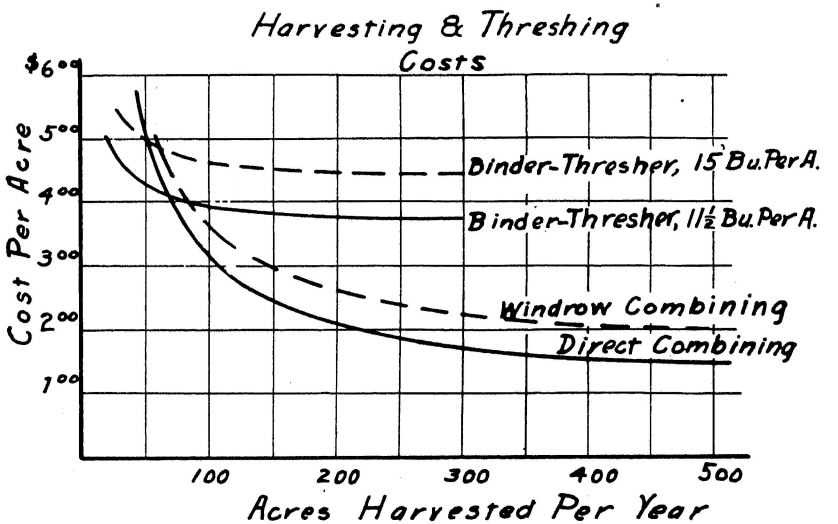

Fig. 8. Comparison of Harvesting and Threshing Costs.

COMPARISON OF HARVESTING AND THRESHING COSTS

Tables 7 and 10 give comparisons of the cost of harvesting and threshing by the binder-thresher method and by the direct combine method. These figures are presented graphically in Figure 8. The dashed line, representing the cost of windrow combining, is also shown. It is simply the cost of direct combining with an addition of 50 cents per acre to cover cost of windrowing. The dashed line representing the cost

of harvesting by the binder-thresher method for a 15 bushel-per-acre yield, is made by adding to the cost of a 11½ bushel yield enough (70 cents) to allow for threshing the extra 3½ bushels.

From this chart it will be noted that the binder-thresher costs do not drop off much as the acreage increases, and is practically constant for acreages above 150. The cost of combining drops rapidly as the acreage increases. It will be noted also that for acreages above 80 to 100 the cost of harvesting and threshing is lower with the combine method, regardless of whether the grain is combined direct or windrowed.

The per acre cost of combining is not greatly affected by the per acre yield, except in extremely thin light grain, and in extremely heavy grain. In general it will cost very little more to harvest grain yielding 18 or 20 bushels than grain yielding 10 or 12 bushels per acre. This is not true with the binder-thresher method, as the cost of threshing, which is a large part of the total cost, varies almost directly with yield. If it costs $3.80 per acre to bind and thresh grain yielding 12 bushels per acre, it will cost approximately $4.40 to bind and thresh grain yielding 15 bushels per acre, the increase of 60 cents representing largely the cost of threshing the additional three bushels.

SUMMARY

1. About 15 combines were used in Missouri in 1927; about 65 in 1928; and about 115 in 1929. Most of the combine owners are satisfied with the combine method.
2. Combines have been successfully used for harvesting wheat, oats, rye, barley, timothy and soybeans; and also sweet, red, and alsike clover when windrowed.
3. The ten-foot size of combine seems to be the most popular and practical in Missouri. Twenty to twenty-five acres per working day during harvest season is a good average day's work.
4. Combines of the 10-foot size are most commonly pulled with tractors of 10 to 15 drawbar horsepower.
5. One man on the combine and one on the tractor is the average operating crew. If the grain is sacked an additional man is required. Experience to date indicates that a crop can be harvested and threshed with a combine with no more labor than would be required to shock the grain if cut with a binder.
6. Badly lodged grain can be picked up with a combine with less loss than with a binder. Combines generally have to travel slower in lodged grain than in grain that stands well.
7. The difference in the grain lost by the combine method and the binder-thresher method is small.

8. Missouri combine owners estimate that their machines will last about ten years.
9. Green weeds growing up in the ripened grain was the most serious handicap to combine operations in Missouri in 1928 and 1929.
10. The windrow system of harvesting has been successfully used by some Missouri farmers in combating the trouble from green weeds, and it appears that it could be used to advantage by many others.
11. Combined grain compares favorably in quality with grain threshed from the shock.
12. It appears that the combine method of harvesting in Missouri is limited more by the type of farming and the acreage of small grain and seed crops grown, than by weather conditions.
13. In the opinion of most Missouri combine owners, a farmer should have about 100 acres of small grain to justify owning a 10-foot combine. The maximum acreage of wheat that a machine of this size should be depended on to harvest, in their opinions, is about 300.
14. Custom work has been found satisfactory for a number of Missouri combine owners, and also for those whose grain was so harvested. A charge of $2.00 per acre plus 10 cents per bushel for combining wheat is generally considered to be fair to both parties.
15. Average harvesting costs on acreages above 75 or 80 are lower with a combine than with the binder-thresher method. For acreages below this, the binder-thresher method is usually cheaper.
16. The average cost of harvesting with the combine method on 28 Missouri farms in 1929 was $2.02 per acre or 21.7 cents per bushel. The average cost of harvesting and threshing with the binder-thresher method on 93 farms in 1929 was $3.85 per acre or 37.5 cents per bushel.