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# Field Ensilage Harvester, Operation and Costs

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## *Operation and Costs*

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## History of the Field Ensilage Harvester

The building of the first field ensilage harvester is credited to Adolph and Andrean Ronning of Boyd, Minnesota in 1913.[1] Two years later the Ronning Machinery Company began building ensilage harvesters. This company continued to build machines until 1921. The first machines were horse drawn, and even obtained the power to turn the machinery from the ground wheels. Later the machine, still horse drawn, was powered by a 4-cylinder gasoline engine. The South Dakota State College farm owned and operated one of these machines some time before 1925, and the old motor from this machine is still used in classwork in the Agricultural Engineering department.

As the demand for field ensilage harvesters increased, almost all large machinery companies developed a machine for their line of farm tools. Most of the smaller companies that were manufacturers of silo fillers also produced the field type machine. *The Farm Implement News Buyers Guide* for 1950 lists 15 separate manufacturers who make either a corn harvester, a forage harvester, or a combination machine which will harvest both types of crops. Usually the manufacturer will also build the blower elevator to elevate the chopped forage into the silo.

Few, if any, new ideas have been developed for the field ensilage cutter. The gathering points, gathering chains, and sickle are usually very much like similar parts on the corn binder. The cutting head is usually patterned after that of a conventional silo filler.

[1]Schwantes, A. J. and Torrance, J. B., University of Minnesota Agricultural Experiment Station, No. 290, 1932.

Fig. 1. A field ensilage harvester of the flywheel type, with power-take-off drive

# Field Ensilage Harvester

## *Operation and Costs*

By H. H. De Long[1]

Since the invention of the field ensilage cutter in 1913 there has been a slow but steady acceptance by the Midwestern farmer. Up to 1925 there had been some 3000 machines manufactured. This was still 5 to 10 years before the advent of the power-take-off (PTO) equipped tractor and the rubber-tired tractor, which partly explains its slow progress at first. During part of the depression years of the '30's, production statistics were not made available. But in 1944 the annual production of row crop field ensilage harvesters was 237; in 1946, 7,034; and in 1949, 19,357.[2]

The earliest successful method of filling silos with corn silage was to cut the standing corn with the corn binder, use teams and racks to haul the bundles to the silo, and cut and elevate the corn with the standard ensilage cutter. This was a successful method but for one thing—the hard physical work involved for the men handling the heavy corn bundles.

Contrasted with this is the field ensilage harvester method. Here the field harvester cuts the standing corn

[1]Agricultural Engineer, South Dakota Agricultural Experiment Station.

[2]*Farm Implement News*, Annual Statistical issue, July 10, 1950.

and chops it in one operation, delivering the ensilage to a trailed wagon or to a truck driven along with the harvester. The ensilage is then hauled to the silo, elevated or blown into the upright silo or dumped into the pit or trench silo. All handling of heavy corn bundles has been eliminated, although the unloading of the wagons, and tramping of the silage still takes considerable man power.

The binder method has one slight advantage over the field harvester method in that the binder can be started first and supply a quantity of corn ahead of the silo filling operations. When both were running, a short stoppage of one machine would not hold back the work of the other. This is not true of the field cutter and the blower at the silo, for the operation of one depends on the operation of the other.

The corn binder with the bundle elevator helped to eliminate some of the lifting of bundles, but some operators felt that the racks had to travel too far for a load in light corn. The 2-row corn binder with its elevator reduced the wagon travel per load. This machine when operating in tall hybrid corn produced a rack loading problem. Farmers remember this rack loading job from a 2-row binder in hybrid corn as hard and unpleasant.

In 1932 Schwantes and Torrance[3] found a 20 percent reduction in cost of the field harvester method of ensiling corn over the binder and ensilage cutter method. The major saving was from reduced labor. This, however, was in the days of steel-wheeled tractors and field harvesters with operating speeds of two to three miles per hour. Not all of the tractors had power-take-off drives at that time. Hauling was also done with teams and ordinary wagons, with resulting small loads and slow travel. In spite of the machines of those times, there was a reduction of cost, but the chief benefit was the elimination of the drudgery of handling the bundles.

## Mechanical Features of Field Ensilage Cutters

The field ensilage cutter has few unique mechanical developments, the machine being a combination of the gathering points, gathering chains, and sickle of the corn binder, together with the cutting mechanisms of the standard silo filler. Elevation of the chopped forage to a trailed wagon is necessary, but less exacting than elevating the silage into a tall silo. Early silo fillers were of two types: namely, the "fly wheel" type with knives mounted as an integral part with the fan, and the "cylinder" type with cutting knife mountings resembling a lawnmower knife head, these entirely separated from the fan. Knives of either type of cutter passed close to a "shear bar," and the corn was moved to the knives by an apron and three or more heavy feed rolls which controlled the feeding rate and the length of cut.

On the earlier machines the gathering points and sickle, the feeder and cutting knives, and the wagon elevator were integrated into a unit and

[3]Schwantes, A. J. and Torrance, J. B., University of Minnesota Agricultural Experiment Station, No. 290, 1932.

mounted on steel wheels. The early ground-driven models were not successful, as considerable power was needed for a rapid and good job of chopping. If large quantities are to be processed, a 3-plow tractor is now used with the field harvesters driven through a power-take-off drive. This large tractor is necessary if it is to pull the machine, power the machine, and also pull the wagon.

Field ensilage cutters with their own gasoline engine power unit attached have been built for many years. They make the machine more costly, and operators with only one or two silos to fill hesitate to make the added investment. Elimination of the power-take-off shaft permits more freedom in turning, allows the operator to speed up or slow down ground speed without interfering with cutter operation, and leaves more power for traction loads. Custom operators, who have strenuous runs of silo filling, like the feature of the motor mounted on the machine.

The new machines are all mounted on rubber tires for less road shock and easier pulling. Most new machines are equipped to trail wagons from the rear, rather than on the side. However, the blower spout should be adjustable to deliver to the side in case a second tractor is used to pull the wagon, or in case a truck is driven alongside to gather the ensilage. The delivery spouts usually have devices to guide the flow of silage to the front or to the rear of the wagon, as is needed for loading.

The power-take-off driven machines, should have "over running clutches" to the main fly wheel and cutter head drive to allow these heavy parts to continue in motion when the

**Fig. 2. Rear view of the field ensilage harvester of the cylinder type**

tractor operator slows down momentarily or has to shift gears on the tractor. The cutting knives are very important and should be accurately mounted, accessible, easily removed for sharpening, and easily readjusted to the proper clearance. The instruction book should be followed carefully for this adjustment. One machine has a mounted knife grinder so that the knives can be ground right on the machine. The shear-bar is then set up to the uniformly ground knives.

A transmission or gear change is necessary on the feed rolls to allow for different lengths of cut. The shorter lengths will allow silage to pack more densely. However, for hay stored in the mow, it is desirable to have a longer cut. A quick gear shift should allow cuts of one-fourth, three-eighths, or one-half-inch. Changing sprockets should allow for cuts up to three-fourths or one inch. Thereafter, one half of the knives can be removed for longer cuts for hay. One must remove opposite knives, and be certain that the cutter head is still in balance.

The design of field ensilage cutters has not yet been stabilized to one standard pattern. The majority have heavy flywheel type knife head and fan combined. Some, however, use a smaller fan and a separate cylinder for the cutting knives. One machine uses a special knife on the cylinder cutter head to act as an elevating mechanism as well as the cutting part. Most machines use gathering chains like the corn binder, but some replace part of the chains with spiral augurs for gathering in stalks. Some machines have the gathering points to the left, and others to the right. Attempts to further simplify and reduce weight and selling price may keep design in a state of change for several years.

Fig. 3. Parts of the most common design of field ensilage harvesters: A. gathering points, B. gathering chains, C. sickle, D. elevating chains, E. feeding rolls and apron, and F. flywheel with cutting knives and fan blades

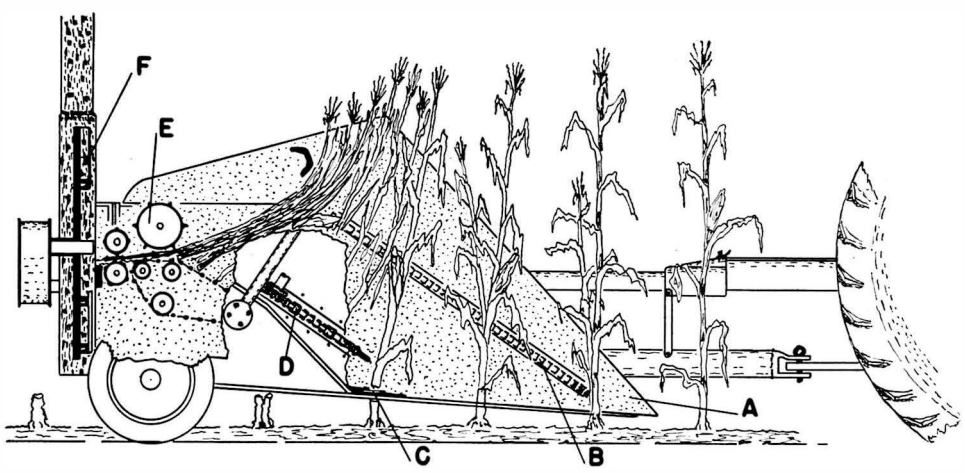

Fig. 4. A heavy duty field ensilage harvester with motor drive

## Machines Used at the Experiment Station

Many different types of silage harvest machinery have been used at the Agricultural Experiment Station, Brookings, South Dakota. Use of one of the very early field ensilage cutters was mentioned, but no records are available as to its use. For many years the corn binder and conventional silo filler were used. Teams and wagons were then used for hauling and bundles were pitched or loaded by hand. Later the 2-row power corn binder was used to increase the rate of the field work.

During the war time machinery and labor shortage, the college obtained a custom operator with field ensilage harvester, two tractors, and the blower elevator. In 1947 a heavy duty field harvester outfit was purchased by the college. This was of the PTO-driven type and was satisfactory except that the power of a 3-plow tractor was not always adequate to maintain sufficient speed for proper operation.

The following year a similar cutter was purchased which had an auxiliary motor mounted on it. This machine has performed very well and is being used the present season. A lightweight field cutter and blower elevator were tried out at one time, but their performance did not measure up to the standards necessary for a 10-silo

run. Such a silo filling run requires large capacity machinery, if it is to be done at the proper time.

Data have been collected at various times on these field cutters and blowers. Actual timings of loadings and unloadings must be modified to fit the pattern of the total day, as there are always some delays, especially when the pipes are changed from one silo to the next. For instance, a field harvester traveling 2¾ miles per hour during operation would average 1¾ m.p.h. for the day. A loading time of 12 or 15 minutes would indicate that 32 or more loads could be harvested in an 8-hour day. On most days this number is not reached unless a longer operating period is used. Unloading time at the silo averaged 7 minutes, but here the operation could go on only as fast as the field unit would deliver the corn. Any long delay on the part of one machine would also stop the other.

Table 1 gives the cost of operation for the 1947 observations. The machinery and man power used were: (1) a 3-plow tractor and field ensilage harvester (PTO-driven) with one operator, (2) three men, three 2-plow tractors and six wagons for hauling, and (3) one man to operate the 2-plow tractor and blower elevator, a helper to unload, and two men in the silo. The drivers of the tractors also helped unload when they were at the silo.

Wages for the tractor operators were placed at $8.00 per day and other workers at $6.00 per day. Depreciation, interest, repairs and overhead, and fuel costs were calculated by the method described in Extension Leaflet 100, "How to Figure Operating Costs of Farm Machines," South Dakota State College, Brookings.

The following assumptions have been made for the purpose of arriving at a cost per ton as well as a cost per day: (1) a corn silage yield of 10 tons per acre, (2) 8.35 acres per day, (3) 83½ tons of silage per day.[4] Many variables could change these figures for a given day's operation, such as higher or lower corn yield, a different rate of travel, or a different length of work day. Many other items such as breakdowns, delays, tangled corn, muddy fields, or short rounds and frequent turning could also change the daily accomplishments.

The cost per day is perhaps the most desirable figure to use. Labor is based on that time period and is more than 50 percent of the total cost.

In Table 1 is shown a detailed breakdown of the cost of operation of the large crew and large battery of machines, which can fill silos rapidly and complete a sizable run in the proper season. Few individual farms would have this complete set of machines or men. Also, few farms have 8 or 10 silos. The logical solution is for several farmers to work together on a run and pool their tractors and wagons. The field ensilage cutter and blower would probably be owned by one man.

Table 1 is broken down into the various columns so that an owner of one

[4]The figure of exactly 10 tons per acre is used for easy conversion of figures to other tonnage yields. Possible silage yields might be 8, 10, or 12 tons per acre, or even go beyond this range. Examples of conversion:
(a) With yield of 8 tons/A, multiply 83½ T/day x 0.8 = 66.0 T/day, or $1.10/T ÷ 0.8 = $1.47/T
(b) With yield at 12 tons/A, multiply 83½ T/day x 1.2 = 100 T/day, or $1.10/T ÷ 1.2 = $0.91/T.

machine can see how his cost compares to a neighbor's who may contribute some other machine. If one man owned the 3-plow tractor and the field cutter (1947 prices) and operated these machines, daily costs would amount to $13.13 plus $8.88 or $22.01. The cost of any other item could be singled out. The grand total cost seems very high, but the cost per ton is not excessive.

Depreciation, interest and repairs for the harvester and blower come to a high daily figure. This is because the days that they are used per year are not many. In Table 1, for instance, the daily machine cost for the first tractor is $1.76 and for the field harvester, which had a lower first cost, is $8.88. The tractor was used 150 days per year, and the harvester only 15 days, both with a life of 15 years assumed. If carefully serviced, and adequately housed, the harvester might last many more than 15 seasons. However, machines have a way of becoming obsolete in 12 or 15 years. The custom operator could invest about $300 more and get a hay pickup attachment that would enable the operator also to make grass silage. This would reduce the daily depreciation because it would allow the use of the machine more days per year.

When it is necessary to operate with fewer men, it can be done by alternating the operations, running the cutter until all available wagons were filled, and then unloading. Here the inventory of machinery would be lower, the daily wage total lower, but the length of time to fill the silo would increase. When the filling goes on intermittently, however, sometimes the silage is not tramped and leveled in the silo. This saves the cost of one or two men. Refilling the space formed by settling is necessary when this is done. When the machinery is not moved from farm to farm, this is not a difficult task.

## Changing Costs

Machinery, labor, and fuel costs change from time to time. At present, costs are higher than in 1947. For this reason a second table (Table 2) has been arranged with increased costs. The complement of machines is very much like those in Table 1 except that the field harvester is motor driven. This first cost of $2250 represents a very heavy duty type of machine. The motor adds approximately $600 to the cost. Such a machine has added capacity as it can travel at a greater ground speed. The average blower outfit can handle the silage from this type of machine without additional power.

Labor costs have also increased, as have fuel costs. Machine prices are distinctly higher. If all new tractors and machinery were used, the daily cost would run to $132.89. In many cases, only part new equipment would be combined with older equipment. In this case some of the values in Table 1 could be combined with values in Table 2.

In both instances, labor costs form over half of the total cost. One possible way to reduce this cost is by using

**Table 1. Cost of Operation of Field Ensilage Harvester and Complete Crew, 1947**

| Values from which costs are calculated | Tractor | Harvester (PTO) | 3 Tractors | 6 Wagons | Tractor | Blower | Silo | Total | |
|---|---|---|---|---|---|---|---|---|---|
| First cost | $1800 | $800 | $3600 | $1800 | $1200 | $300 | | $9500.00 | |
| Years of life | 15 | 15 | 15 | 20 | 15 | 15 | | | |
| Days used per year | 150 | 15 | 150 | 100 | 150 | 15 | | | |
| Interest rate on ½ first cost, % | 6 | 6 | 6 | 6 | 6 | 6 | | | |
| Hours per day | 8 | 8 | 8 | 8 | 8 | 8 | | | |
| Belt horsepower of engine | 33 | | 25 | | 25 | | | | |
| Gasoline, cost per gallon | $ 0.16 | | $ 0.16 | | $ 0.16 | | | | |
| **Item of cost (per day)** | | | **Cost per day** | | | | | **Total** | |
| Depreciation of machine | $0.80 | $3.55 | $1.60 | $0.90 | $0.53 | $1.33 | | $ 8.71 | |
| Interest on investment | .36 | 1.60 | .72 | .54 | .24 | .60 | | 4.06 | |
| Repairs and overhead | .60 | 3.73 | 1.20 | 1.26 | .40 | 1.00 | | 8.19 | |
| **Total machine cost** | **1.76** | **8.88** | **3.52** | **2.70** | **1.17** | **2.93** | | **$20.96** | **$20.96** |
| Fuel and oil cost | 3.37 | | 6.30 | | 2.53 | | | | 12.20 |
| Labor cost | 8.00 | | 24.00 | | 8.00 | 6.00 | 12.00 | | 58.00 |
| **Total operating costs per day** | **13.13** | **8.88** | **33.82** | **2.70** | **11.70** | **8.93** | **12.00** | | **$91.16** |
| Total operating cost per hr. (8 hr. day) | | | | | | | | | 11.40 |
| Cost per ton @ 83½ T/day | | | | | | | | | 1.10 |

**Table 2. Cost of Operation of Field Ensilage Cutter and Complete Crew, 1951**

| Values from which costs are calculated | Tractor | Harvester | 3 Tractors | 6 Wagons | Tractor | Blower | Silo | Total | |
|---|---|---|---|---|---|---|---|---|---|
| First cost | $2700 | $2250 | $4800 | $2400 | $1600 | $500 | | $14250.00 | |
| Years of life | 15 | 15 | 15 | 20 | 15 | 15 | | | |
| Days used per year | 150 | 15 | 150 | 100 | 150 | 15 | | | |
| Interest rate on ½ first cost, % | 6 | 6 | 6 | 6 | 6 | 6 | | | |
| Hours per day | 8 | 8 | 8 | 8 | 8 | 8 | | | |
| Belt horsepower | 36 | 35* | 27 | | 27 | | | | |
| Gasoline, cost per gallon | $0.18 | $0.18 | $0.18 | | $0.18 | | | | |
| **Item of cost (per day)** | | | **Cost per day** | | | | | **Total** | |
| Depreciation of machine | $1.20 | $10.00 | $2.13 | $2.00 | $0.71 | $2.22 | | $18.26 | |
| Interest on investment | .54 | 4.50 | .96 | 1.20 | .32 | 1.00 | | 8.52 | |
| Repairs and overhead | .90 | 17.50 | 1.60 | 2.80 | .53 | 1.67 | | 25.00 | |
| Total machine costs | 2.64 | 32.00 | 4.69 | 6.00 | 1.56 | 4.89 | | 51.78 | 51.78 |
| Fuel costs | 4.15 | 4.00 | 5.85 | | 3.11 | | | | 17.11 |
| Labor costs | 10.00 | | 20.00 | | 10.00 | 8.00 | 16.00 | | 64.00 |
| Total operating costs per day | 16.79 | 36.00 | 30.54 | 6.00 | 14.67 | 12.89 | 16.00 | | $132.89 |
| Total operating cost per hr. (8 hr. day) | | | | | | | | | 17.80 |
| Cost per ton @ 110 T/day | | | | | | | | | 1.29 |

*Motor-driven harvester

**Fig. 5. The blower for ensilage at the silo. Note the low feed hopper and the apron-drive mechanism**

a mechanical wagon unloader where the unloading would be done entirely by machinery. Hand feeding is still done, even when silage is brought in in dump trucks, for the silage will not flow freely when the dump box is raised. Some wagons are now manufactured that have aprons in the wagon bottom and beater mechanisms in the rear, all of which are power driven from the tractor which pulls the wagon. Such wagons, though expensive, would go far toward replacing one or two men at the silo.

## Summary

**1.** The field ensilage harvester is a machine which combines the corn gathering and cutting devices of the corn binder, with the chopping method of a silo filler. Usually the chopped forage is delivered to the trailed wagon with a fan.

**2.** The design features in the various brands of machines have not been entirely standardized as yet; some machines have gathering points on the right hand side, others on the left, with some using a cylinder type of cutter and others the flywheel type.

**3.** Field ensilage harvesters with their own mounted gasoline engine are preferred because: (1) they have adequate power, (2) they allow

change in ground travel rate without lowering the efficiency of the cutting and elevating processes, and (3) they allow for greater freedom in turning.

**4.** Those machines which are both pulled by the tractor and powered through the tractor PTO shaft should have an "over running" clutch to facilitate stopping and gear shifting.

**5.** Field ensilage harvesters should have a reversing gear on the feed roll mechanism and have a quick-change method for controlling the length of cut.

**6.** Calculation of cost of operation of a single machine or of the entire group of machines and laborers is best done on a daily or hourly basis as there are so many variable conditions, such as speed of travel, corn yield, length of haul, etc.

**7.** Daily costs of individual machines, or the entire group can be found in Table 1 on a 1947 price and wage basis, or in Table 2 for 1950-51 prices and wages.

**8.** Labor costs account for more than one half of the total costs.

**9.** An inexpensive mechanical unloader for the silage wagons at the silo would save labor and reduce costs $6.00 to $12.00 per day.