AN ECONOMIC STUDY
OF
THE METHODS OF HARVESTING
SOYBEANS FOR SEED

A THESIS

Presented

to

The Department of Agronomy

of

The Virginia Polytechnic Inatitute

For

The degree

of

MASTER OF SCIENCE

By

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154286

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Introduction

The soybean or soja bean is rapidly becoming one of the most important legumes of today, especially in Virginia. During the past 15 years the soybean has come into favor in this state, the total acreage grown in Virginia having increased from practically nothing in 1909 to 63000 acres in 1924 according to the Virginia Crop Reporting Service. This great increase is easily explained by the numerous advantages of the crop. As a hay crop it is superseding the cowpea for it usually gives better returns of an excellent hay which is high in feeding value and easier to cure than cowpea hay. For green manure the soybean is one of the best of the legumes. It makes excellent grazing especially for hogs, when seeded alone or together with corn. The seed which contain a high percentage of protein make a high grade meal for feeding purposes, also containing considerable oil, the extraction of which is a growing industry.

In addition to the above advantages the soybean is a most excellent crop for seed production. Since the production of soybean seed in this state has grown from 415 bushels in 1909 to 182000 bushels in 1924, it is evident that the soybean is a paying seed crop. The production of soybean seed is comparatively simple and inexpensive, the saving of the seed being the only serious difficulty.

Reasons for Making a Study of Soybean Harvesting.

The increase in popularity of the soybean for seed production has advanced much more rapidly than the development of methods and

equipment for saving the seed. The amount of seed wasted by some methods of harvesting, the cost of others less wasteful, and the inconvenience incurred by some of these methods are enough to warrant the preceding statement. Of course, the farmer realized this first and he immediately called for information from the Experiment Station but his question could not be answered satisfactorily since no information was available.

Recognizing the need for this information it was considered advisable that a study of soybean harvesting, methods and equipment be made. Hence, this investigation.

Object of This Investigation

The object of this investigation was to study soybean harvesting equipment and methods with special reference to:

1. Waste of seed in harvesting
2. ~~Seed cleaning~~ Cleanliness of seed
3. Damage to seed saved
4. Rate of harvesting
5. Cost of harvesting
6. Factors affecting successful harvesting.

Present Methods of Harvesting Soybeans for Seed.

Generally speaking, there are two methods of saving soybean seed, namely: the "cut and thresh" method and the row-harvester method.

The "Cut and Thresh" Method.- This method of harvesting soybeans for seed is similar to the method of harvesting small grain, such as wheat, with the exception that soybeans are often cut with a mower rather than with a grain binder although the latter is used in some sections. The corn binder is used by some farmers but only for cutting the tall growing varieties. The self rake reaper is used to some extent with excellent

results also.

When the plants have reached the desired stage of maturity, the crop is cut. This stage depends to some extent upon the machine used for cutting the crop.

The amount of volume that the soybean plant takes up depends on the number of leaves, which varies with the stage of maturity, for as the plant approaches maturity the leaves drop off. Since the capacity of a grain binder is limited, it is necessary that soybeans be at a stage of maturity at which two-thirds of the leaves have dropped before cutting with the grain binder. A mower, corn binder, or a self rake reaper will cut the crop at an earlier stage of maturity without the troubles encountered with a grain binder. This is not a great advantage in favor of the mower, self rake reaper or corn binder, however, for the yield of seed is greater and the quality better when the crop is mature.

Since the beans are quite easy to shatter at such an advanced stage of maturity, when the vines are dry, it is the general practice to cut and shock in the early morning or late evenings, unless the weather is cloudy. For this reason the shocks are usually made small enough to insure drying of the vines without molding.

Fig. 1

Fig. 2

Two views of a corn binder cutting Mammoth Yellow soybeans in Princess Anne County, Virginia.

Figures 1 and 2 show two views of a corn binder that was used with success to cut a heavy crop of Mammoth Yellow soybeans.

After cutting, the crop is put in shocks to cure for a period ranging from ten days to two weeks, depending on the weather conditions. The method of shocking depends upon the way the crop is cut. If a binder (either a grain binder or a corn binder) is used for cutting, the bundles are put up in shocks similar to shocks of wheat without caps. In sections of the Middle West where moisture is not a factor the bundles are left as they fall from the binder until the beans are cured and ready to thresh. However, in Virginia the general practice is to put the bundles in shocks and occasionally straw or hay is used to cap them and to make beds to keep the beans in the butts of the bundles from being discolored or molded due to the moisture from the soil.

Fig. 3.- A crop of the Virginia variety in shocks after being cut with a grain binder. The frame 1 yard square, is leaning against the shock in the foreground. This picture was taken on Mr. C. H. Crafton's farm near Somerset, Virginia.

used in making counts

Figure 3 shows a crop of the Virginia variety in shocks, after being cut with a binder.

When the crop is cut with a mower the vines are raked into windrows with either a sulky or side-delivery rake. Shocking from the windrow as practiced in Virginia consists in building the shocks or cocks on poles or frames to allow the free passage of air through the vines which hastens curing and prevents damage from wet weather to a great extent. This method of shocking is considerably more laborious than that of simply setting up bundles.

The crop is threshed as soon as it is completely cured, which is as has been noted, about two weeks after cutting. The bean and pea huller which is recommended for threshing soybeans is an excellent machine for the job. However, a common grain thresher when properly adjusted gives very good results. Another machine used to some extent in threshing is the ordinary corn husker and shredder. Of course, the latter machine does not clean the seed to any marked degree, for the sieve which is intended to allow shattered kernels of corn to pass allows considerable trash to come through with the beans. This trash is removed quite readily with the aid of a fanning mill.

Fig. 4.- A G. I. Case grain thresher threshing soybeans on Mr. C. M. Crafton's farm near Somerset, Orange County, Va.

Fig. 5.- A G. L. Owens Bean and Pea Huller threshing Virginia soybeans in Caroline County, Virginia.

Of the machines mentioned the bean and pea huller is the outstanding thresher.

Figures 4 and 5 respectively, show views of a grain thresher and a pea huller threshing soybeans. The two types of threshers are quite similar in outward appearance.

The Row Harvester Method of Saving Soybean Seed.- This method of saving soybean seed consists simply in gathering the seed direct from the mature, standing vines with a special machine for the purpose. This machine is known as a bean harvester, picker or row harvester. Generally speaking this machine consists of a long box-like body mounted on two wheels and is drawn by two horses. A drum or beater, driven by a chain from the ground wheels, is placed in the front part of the machine. Under the beater is a "V" shaped slot, the narrow part being directly under the beater shaft while the spreading part is to the front. The rear of the machine is simply a box over which in some types, is a screening device. As the machine is drawn along the row, the vines are guided into the slot by its shape and as they reach the narrow end the beater shatters the beans from the vines. The beans together with a certain amount of trash are sent to the rear of the machine while the vines are pressed down below and left on the ground. In the machines equipped with a screening device the trash passes over the rear while the beans drop through the sieve into the box at the back of the machine. This equipment saves the labor of an extra man who is required to fork the trash from the beans in the rear of the types of machines which are without sieves.

Fig. 6. A Scott 1-Man harvester harvesting Virginia Soybeans on Dr. J. S. Andrews' farm in Orange County, Va.

Fig. 7. A Gordon 2-Man harvester harvesting Mammoth Yellow Soybeans in Princess Anne County, Virginia.

Figures 6 and 7 show respectively a Scott 1-Man and a Gordon 2-Man row harvester in operation.

The stage of maturity for this method of harvesting is considerably further advanced than that for the "cut and thresh" method. The row harvester can efficiently shatter the beans from the vines only when the plants are throughly mature and dry. For this reason

the crop is ready to harvest when all the leaves have dropped and the pods are easily shattered. Since the vines must be thoroughly dry as well as fully mature the row harvester is used only during the middle of the day.

Fig. 8. Showing a field of the Virginia variety soybeans before harvesting. In the distance the harvested part of the field is visible.

Fig. 9 The field shown in Fig. 8 after harvesting with a row harvester. The contrast in the condition of the vines before and after harvesting is striking.

Figures 8 and 9 show views of a field of the Virginia variety before and after harvesting with a Scott 1-Man harvester. Figure 8 shows the heaviness of the vines before harvesting in the foreground, while in the distance at the right the harvested part of the field is visible. In Figure 9 is shown a view of the vines after the row harvester had gathered the beans. This contrast in the condition of the vines before and after harvesting with a row harvester shown by the Figures 8 and 9, gives an idea of how this type of harvester tears up the vines in order to shatter the beans. Also it is evident that the plants must be thoroughly mature and dry for the row harvestwr to operate to best advantage.

Equipment Used and Studied

The machinery observed in this study was that found in the field under actual working conditions. Machinery or equipment found that was not in a reasonable state of repair or working under reasonable conditions was not taken into consideration.

Equipment Used in the "Cut and Thresh" Method for Cutting Soybeans.- In this method the machines observed that were used for cutting the crop were as follows: A McCormick six foot grain binder, a Massey-Harris corn binder, and several common makes of mowing machines. Sulky rakes were used to rake the vines into windrows when a mower was used for cutting. All of these machines are so common that it is not worth while to describe them. However, the type of packing mechanism employed in the Massey-Harris corn binder should be mentioned. Instead of packer arms projections pivoted on chains pack the bundles. These arms or projections on the chains press the vines till the pivot is released which allow the arms to lie flat on the chain. When a sufficient quantity of vines have collected the pressure caused by the arms on the chain is

enough to tip the tying mechanism. In this way the bundles are formed with a minimum of shaking and therefore with a small loss of seed.

Machines Used to Thresh Soybeans in the "Cut and Thresh" Method.- There were two types of threshing machines in operation that were studied. The first was a 24-inch cylinder grain thresher made by the J. I. Case Threshing Machine Company, the other being a bean and pea huller made by the J. L. Owens Company.

Since the grain thresher was not designed for threshing soybeans a few changes had to be made to make it perform properly. The cylinder speed of this machine, which is about 1000 R.P.M. for small grains, is too great for soybeans, for such a speed causes the beans to be split and broken up almost as if in a mill. A satisfactory cylinder speed of about 450 R.P.M. was obtained by replacing the 9 inch driven pulley on the cylinder shaft with one 20 inches in diameter. The speed of the rest of the machine was kept up to normal by replacing the 6 inch driving pulley on the cylinder shaft with one 13 inches in diameter. Half the teeth in the concaves were removed, the remainder being staggered. Then of course, bean riddles were put in the shakers. Later it was found necessary to increase the speed of the blower fan to prevent choking of the stacker. A 6 inch pulley in place of the 12 inch pulley on the fan shaft gave the desired results. This grain thresher did satisfactory work when these changes were made.

Since the "pea huller," as the bean and pea huller is most commonly called, is designed for threshing soybeans and cowpeas, no changes had to be made in this machine. This threshing machine is decidedly different from a grain separator although in outward appearance the two machines are quite similar. The "pea huller" has two cylinders which run at a speed of about 410 R.P.M., an

arrangement insuring almost prefect threshing with very little damage to the beans. The cleaning capacity of this machine is about three times that of a grain thresher of the same cylinder width. The vines are kept loosely separated all the time in the cleaning apparatus by various types of kickers. This is necessary to facilitate rapid cleaning of the seed for the cut-up vines, broken pods and leaves make a great amount of trash of a nature such that it is difficult to separate the seed from it. These features make the "pea huller" an excellent machine for threshing soybeans.

Types of Machines Used in the Row Harvester Method.- In this method of harvesting a Gordon Bean Harvester and a Scott One-Man Harvester were used. Both of these machines are one-row harvesters and require the rows to be about three and one-half feet apart for their operation. The principle of each of these machines has been described under "Present Methods" hence it is needless to repeat the description except to distinguish between the two machines.

The Gordon machine has no cleaning device, while the Scott harvester has this equipment. Otherwise the two machines are practically alike. The beater in both machines revolves 16 times for each revolution of the ground wheels or for a traveling speed of 2 miles per hour the beater has a speed of 180 R. P. M.

The Gordon machine, since it has no cleaning equipment, requires 2 men to operate it. One man drives the team while the other stands in the rear part of the machine and forks out the trash from the beans. In the Scott harvester this cleaning is done mechanically and hence only one man is required to operate it. Therefore, the Gordon machine is called a 2-man harvester while

the Scott is called a 1-man harvester.

Methods of Procedure Used in This Study.

Method of Determining Waste of Seed in the "Cut and Thresh" Method.- In order to determine the percentage of seed wasted by this method of saving soybean seed it was necessary to find the wastes incurred by the different steps in the method. The first loss of beans occurs during cutting and shocking the crop. Waste also occurs during the curing period and again when the crop is threshed. The loss of beans in the straw will be considered separate from the loss in threshing.

Waste Incurred While Cutting and Shocking.- The percentage of seed wasted in cutting and shocking the soybean crop was determined by comparing the number of beans found on the standing vines in a given area before cutting with the number found on the stubble and the ground in the same area after cutting and raking. A frame, one yard square, was used to mark out the area taken. An average of several of these plots in different parts of a field was taken in order to approach the actual percentage of beans lost. This method was used to determine the percentage of waste incurred in cutting and shocking when either a binder or a mower was used for cutting the crop.

Waste During the Curing Period.- When the shocks were taken up to be threshed, the area under and immediately about the base of the shock was found to be literally covered with beans. The area was measured for several shocks and was found to be practically the same in extent since the shocks were about uniform in size. The beans in one square foot of the area, where a shock had stood, were gathered up and weighed and this weight multiplied by the number of square feet in the area under a shock gave the loss in weight

per shock. Repeating this procedure gave data which should be close to the actual loss per shock from which the loss per acre was computed by multiplying by the number of shocks per acre.

Waste of Seed in Threshing.- This waste was determined by finding the total amount of beans shattered into the wagon beds, as well as the waste about the machine.

The wagon beds were made tight or covered with sheets to prevent the escape of beans shattered while loading or unloading. The amount saved in this way was taken for a whole crop in order to establish the percentage of waste that would occur in hauling to the thresher if sheets or tight bottomed wagons were not used. Sheets were spread on the ground under and about the thresher and the amount of seed saved in this way was of course, taken in toto for a crop.

The exact loss in the straw was impossible to obtain but it was attempted by catching the straw at the stacker from a small amount of vines fed into the machine and comparing the weight of the beans found therein with the weight of these saved at the grain spout. It was impossible to catch all the straw for the force of the blower fan was so great.

Method of Determining the Various Percentages of Loss.- When these losses in the "cut and thresh" method were obtained they were brought to a proper relation by calculating a theoretical total yield from which the percentage of loss in each case could be obtained. Such a theoretical yield was found as follows: the amount lost during the curing period plus the amount lost in hauling to the thresher plus the amount lost about the thresher plus the amount saved equals a 100 percent theoretical yield minus the percentage lost in cutting and shocking. It is admitted that this is not absolutely accurate for there were a few minor losses such as the few

beans that fell from the outside edges of the wagons in hauling and the loss in the straw but the data obtained may be considered to be as reasonably close to the correct figure as could be expected.

Method of Determining the Degree of Waste Incurred by the Row-Harvester Method of Saving Soybean seed.- In this method it was a simple matter to determine fairly closely the total percentage of waste in one operation. Except for the size of the plots the same method that was used to find the percentage of waste in cutting and shocking in the "cut and thresh" method was used to determine the total percentage of loss in the row harvester method of harvesting. Since the soybeans were in rows, plots extending 5 feet along the row and half the distance toward the 2 adjacent rows were taken rather than plots 1 yard square for making counts before and after harvesting.

Method of Determining the Degree of Cleanliness of the Seed Saved by Either Method.- The degree of cleanliness of the seed was taken by observation. All of the seed observed would have needed recleaning before placing on the seed market and for this reason only the seed that was trashy enough to need fanning before it could be recleaned or graded was considered below the desired degree of cleanliness.

Damage to Seed Saved by Either Method of Harvesting.- The damage to the seed saved was noted by observing samples and comparing the number damaged with the total number in the sample.

Rate and Cost of Harvesting.- The rates of the different methods of harvesting were taken from the time observed that the different operations took for their performance. These, together with the conventional labor charges and the yield per acre, were taken as the basis of determining the cost of harvesting per bushel of beans saved.

Results and Discussion of the Investigation.

Waste Incurred in Cutting and Shocking in the "Cut and Thresh" Method.- As has been observed, there are several ways in which seed may be lost in the "cut and thresh" method, first of which occurs when the crop is cut and shocked. Tables 1, 2 and 3 were prepared from the data obtained in the field investigation on the waste of seed during cutting and shocking.

From Table I the average percentage of loss is shown to be 8.98%. This figure is for a crop cut with a mower at the stage of maturity when about half the leaves were dropped. When the data in Table I was obtained the day was cloudy and cool, an ideal weather condition for cutting and shocking, and since the vines were standing up well it is evident that the conditions were ideal. This loss of 8.98% was caused mainly by the horses and mowers passing over the swath which had been cut the preceding round. From this it is safe to assume that a smaller loss than about 8 percent may not be expected.

Table 1.- Showing Waste of Seed in cutting and shocking when a mower was used to cut soybeans from counts made on plots 1 square yard in area.

Plot No.	Number of beans on vines before cutting	Number of beans in pods on ground after cutting.	Number of beans shattered on ground after cutting	Number of beans left on stubble	Total number of beans lost	Percent of loss: in pods by shattering	Percent of loss: on stubble	Total percent of loss
1	1232	15	72	12	99	1.22	5.84	0.98	8.04
2	1308	6	83	11	100	.46	6.34	.84	7.64
3	1292	11	104	8	125	.85	8.05	.62	9.52
4	1062	7	93	0	100	.66	8.75	.00	9.41
5	982	6	88	7	101	.61	8.96	.71	10.28
Aver-age	1175.2	9	88	9.6	105	.76	7.59	.63	8.98

Note: These data were obtained on Mr. Moore's farm in Caroline County, Virginia.

The data shown in Table 2 were obtained under rather adverse conditions. The vines were badly down which caused the mower to strip off many of the pods as well as to cut some of the plants as much as a foot from the roots. In addition to the leaning of the vines the crop was rained upon immediately after it was cut and since the vines could not be put up in shocks so wet they settled on the stubble to such an extent that raking was difficult and resulted in the shattering of more beans than otherwise would have been incurred. Hence the loss of 15.18 percent shown in table 2. represents a greater loss than may usually be expected.

Table 2.- Showing Waste of Seed in Cutting and Shocking When a Mower Was Used for Cutting Soy Beans When the Vines Were Badly Down from Counts Made on Plots 1 yard square.

Plot No.	Number of beans on vines before cutting	Number of beans in pods on ground after cutting.	Number of beans shattered on ground and after cutting	Total left on stubble	Total number of beans lost	Percent of loss in pods	Percent of loss by shattering	Percent of loss on stubble	Total percent of loss
1	1300	178	23	60	261	13.69	1.78	4.62	20.07
2	1250	71	7	55	133	5.68	.56	4.40	10.64
3	700	94	12	36	142	13.43	1.71	5.14	20.28
4	1400	59	75	66	200	4.21	5.36	4.71	14.08
5	1350	81	33	61	175	6.00	2.44	4.52	12.96
Aver age	1280	96	30	56	182	8.60	2.37	4.68	15.61

Note: These data were secured on Mr. C. H. Crafton's farm at Somerset, Virginia.

Since the horses and machine never travel over the plants after the first round, when a binder is used for cutting the crop, the waste of beans would be expected to be lower than when a mower is used. The data in Table 3 do not show this, however, for the average percentage of loss shown for the binder is 12.79 percent which is a greater loss than is shown for the mower in Table 1. The conditions under which the data were obtained for Table 3 are responsible for this greater waste. The plants in the crop cut with the binder were very low and the pods were as low as 2 inches from the ground. This condition made it impossible for the binder to cut the plants below the pods and accounts for the large number of beans left on the stubble as well as the number of pods knocked off, for only a few of these pods were knocked off by the packing and tying mechanism. The stage of maturity at which this crop was cut with the binder was slightly further advanced than the stage at which the other two crops were cut with mowers. All three of these

crops were of the same variety of soybeans namely, the Virginia variety.

Table 3.- Showing Waste of Seed in Cutting and Shocking When a binder Was Used to Cut Soybeans from Counts made on Plots 1 yard square.

Plot	Number of beans				Total number of beans lost	Percent of loss			Total percent of loss
	on vines before cutting	in pods on ground after cutting	shattered on ground after cutting	left on stubble		in pods	by shattering	on stubble	
1	1143	42	24	40	106	3.69	2.09	3.49	9.27
2	763	63	3	37	103	8.25	.39	4.85	13.42
3	717	101	5	27	133	14.08	.69	3.77	18.54
4	836	71	4	2	77	1.32	.47	.24	2.03
5	572	80	3	131	214	13.98	.53	22.90	37.41
6	822	73	1	28	102	8.89	.12	3.41	12.42
7	461	37	0	35	72	8.02	.00	7.60	15.62
8	650	45	1	2	48	6.92	.15	.31	7.38
9	906	25	1	11	37	2.75	.11	1.21	4.07
10	1132	34	3	51	88	3.00	.26	4.50	7.76
Aver-age	8002	57.1	4.5	36.4	98.0	7.09	.46	5.22	12.79

Note: These data were secured on the farm of Mr. C. M. Crafton, Somerset, Virginia.

Comparing the mower and the binder, from the standpoint of waste in cutting and considering observations, together with the data obtained, it is believed that the binder may be expected to be the less wasteful of the two types of machines.

As to shocking it is evident that bundles may be put in shocks with less than the waste of seed incurred by raking into windrows and cocking the loose vines.

From the discussion this far it would seem that the binder is the more satisfactory machine for cutting soybeans. This conclusion, however, is a rather hasty one for the binder can be used only when the stand of plants is comparatively thin. A heavy crop of soybeans especially of the Virginia variety type, cannot be cut satisfactorily with a binder for the machine will not handle the amount of bulk that heavy crops make. Also the vines have a tendency to catch in the reel making it worse than useless.

The objection sometimes raised that the beans mold when the vines are tied in bundles is not a serious one, because the nature of the soybean plant is such that it is hard to compact, a rather open bundle is assured which does not hinder curing. In case of a wet season the bundle has a decided advantage over the loose vines since it is much easier to open up a shock of bundles to dry and set up again than it is to dry out the cocks of loose vines.

The self-rake reaper is used in some sections and is said to do excellent work. This machine does not bind the vines into bundles but it does sweep them from the path the horses and machine take the succeeding round, thereby eliminating the greater part of the waste incurred by the mower. As none of these machines were found during this investigation no data were found to compare with the figures for the mower and grain binder.

The corn binder also is used with success for cutting the larger growing varieties of soybeans such as the Mammoth Yellow. It was impossible to observe one of these machines working during the part of the day when the owner operated it, that is, while the dew was on. However, from observations of the work the corn binder had done, it would compare favorably with the grain binder. Of course, the crop must be in rows if a corn binder is to be used

for cutting but this is not a great advantage in favor of the grain binder for many farmers prefer to cultivate the crop when it is grown for seed.

Loss During Curing Period in the "Cut and Thresh" Method.- When the soybean pod loses its sap and becomes dry there is a tendency for it to burst open and eject the beans. This occurs while the vines are curing and the amount of seed lost in this way is considerable as may be seen in detail in Table 4. The data show an average loss of 53.7 pounds per acre for a crop of the Virginia variety yielding 15 bushels per acre after a curing period of 14 days. Of course, this waste will vary in amount with the length of the curing period, with the yield and with the variety. Farmers consider the Laredo variety to be one of the worst in this respect while the Virginia and Mammoth varieties are considered to shatter less during the curing period.

It is probable that the season may affect the rate of shattering characteristic to soybeans but nothing definite on this point can be brought out in the data obtained and the observations made in this investigation. Suffice it to say that growers in different parts of the state during the season of 1924 noticed that their crops, although cut at a later stage of maturity than usual in many cases, did not shatter as badly as usual while cutting or during the curing period.

The data in Table 4 were obtained from a crop cut with a mower. Corresponding figures were impossible to obtain for a crop cut with a binder, owing to circumstances, but from the characteristic tendency of the bundle to retain the shattered beans, it is safe to assume that the loss during the curing period is not over half that for the loose vines in cocks - Hence in the following discussions the loss

during the curing period for a crop cut with a binder will be taken as half that for a crop cut with a mower for the sake of comparison.

Table 4.- Showing Loss of Soybeans in Pounds per Acre for a Crop yielding 15 bushels per Acre During a 14-day curing period. From Counts made on an Area of 1 Square Foot Under Shocks, there being 25 Shocks per Acre.

Shock No.	Radius of area covered by shock	Area shock covered sq.ft.	Weight of beans: Per sqft. Grm.	Per shock Grm.	Per Acre Grm.	Per Acre lb.
1	3.00 ft.	28.27	30.34	857.71	21443	47.17
2	3.16	31.42	36.27	1139.60	28490	62.24
3	3.08	29.87	40.35	1205.25	30131	66.29
4	2.83	25.22	26.21	661.02	16525	36.36
5	3.00	28.27	41.43	1171.23	29281	64.42
6	3.00	28.27	32.61	921.88	23047	50.70
7	3.25	33.18	27.42	909.80	22745	50.04
8	3.00	28.27	31.22	882.59	22065	48.54
9	3.08	29.87	34.46	1029.32	25733	56.61
10	3.00	28.27	35.25	995.95	24899	54.78
Aver-age	3.04	29.02	33.55	973.62	24341	53.55

Note: These data were secured in Caroline County, Virginia.

Waste in Hauling to and About Thresher.- The amount of seed wasted in the threshing operation depends largely on the degree of care ~~expenditure~~ exercised in handling the crop. The data in Table 5 were obtained from four crops of the Virginia variety soybeans and show this loss to be comparatively small.

Since it was the thresherman's practice to furnish the sheets to be spread beneath the thresher, the amount that was saved in the sheets on the wagons is the amount of seed that would have been lost

had the owner not provided sheets for the wagons. Hence this loss will be considered to be only that which was found in the sheets on the wagons. It is true that there is a small additional loss which is not included, that is, the loss of beans from the edges of the wagon in transit. The greater loss, however, is incurred by the handling and trampling of the vines during loading and unloading and since the small waste from the edges of the wagons was impossible to obtain this latter loss will not be considered, as well as the amount found in the sheets under the thresher in the discussions that follow.

Table 5.- Showing Loss of Beans in Hauling to and about the Threshing Machine.

Crop No.	Amount of Seed saved (bushels)	Amount of seed found in sheets on wagons (bushels)	Amount of seed found in sheets spread under and about thresher (bushels)
1	60	1	1.5
2	92	2	6
3	90	(No sheets on wagon)	4
Average	80.7	1.5	3.8

Note: The data shown in this table were secured from 3 crops of the Virginia variety in Caroline County, Virginia.

Beans Lost in Straw in the "Cut and Thresh" Method.- The amount of beans blown over with the straw depends largely upon the condition of the vines and pods provided the threshing machine is running properly. The data in Table 6 were obtained while using a grain thresher and the results from this data would seem to be unfavorable to this type of threshing machine. However, this crop of soybeans was decidedly damp when it was threshed. Hence the results shown in Table 5 really show what a poor practice it is to try to

thresh damp soybeans rather than cast disfavor on the grain thresher. When the vines are thoroughly dry and completely cured, the grain thresher will thresh soybeans without blowing over with the straw more than a negligible amount of good beans.

Similar data to that shown in Table 5 were impossible to obtain for a "pea huller". However, observation of the straw about the base of the stack revealed only shrivelled or otherwise inferior beans.

In the comparisons of these two types of threshers the blowing over of beans with the straw will not be considered, for it is within the control of the thresherman in either case to reduce this waste of beans to a negligible amount by properly adjusting his machine when other conditions are favorable.

Table 6.- Showing Loss of Beans in the Straw When the Vines Were Threshed While Damp.

Test No.	Amount of beans saved at grain spout (pounds)	Amount of beans found in straw (pounds)	Total amount of beans on vines (pounds)	Percent of beans lost in straw
1	17.0	5.0	22.0	22.73
2	16.0	4.0	20.0	20.00
3	18.0	5.5	23.5	22.44
4	20.5	4.5	25.0	18.00
Average	18.4	4.75	22.6	21.02

Note: The data shown in this table were secured on Mr. C. H. Crafton's farm at Somerset, Virginia, while threshing his crop of the Virginia variety. The same amount of vines were run through the thresher for each test.

Seed Cleaning in "Cut and Thresh" Method.- The cleanliness of the seed saved by the "cut and thresh" method was found to depend largely on the threshermen. Of course, the efficiency of the threshing machine is an important factor but this is usually taken care of in the construction of the machine. A good thresherman with a "pea huller" under favorable conditions can thresh soybeans almost perfectly clean. Since the cleaning capacity of a grain thresher is rather small for soybeans it is harder to make it do as clean work without slowing up the rate of threshing to a great extent. However, the grain thresher will do good work. Although the seed saved by both of these types of threshing machines under average conditions would need to be recleaned and graded before placing on the pure seed market, as this market is handled in Virginia., Preliminary fanning of the seed is not usually necessary. Hence additional cost for fanning will not be included in the following discussions.

Damage to Seed in Threshing.- The damage to the seed in threshing depends to a great extent upon the thresherman as well as the machine. The "pea huller", if operating correctly, will thresh soybeans with practically no damage to the seed. It is true that an occasional cracked bean may be found in the seed but such is unavoidable. Practically the same may be said for a grain thresher if operating under the same conditions, for the damage to the seed, although greater than that incurred by a "pea huller," is still negligible.

The content of the foregoing is founded upon actual observations. The greatest damage noted, when the grain thresher was operating correctly, was about .02 percent of the seed saved. A half bushel of seed was spread thinly on a tight floor and one dozen cracked beans were found which gives use to the above figure.

Similar observations on seed taken from a "pea huller" showed an even lower percentage of damaged beans.

Rate of Harvesting by the "Cut and Thresh" Method.- Since it was not practical to fix a definite rate of cutting, shocking, and threshing in one figure for this method of harvesting soybeans, the rate of harvesting will be considered under two general heads: First; rate of cutting and shocking, and second; rate of threshing. The following rates are estimates based upon actual timing of the work checked with the information offered by the farmers.

The rate of cutting and shocking noted by the above method of observation was approximately 1½ acres per hour. This rate is the same when either a binder or a mower is used for cutting, provided both machines cut a six-foot swath. It may be well to add at this point that six men are required to cut and shock a crop at this rate when a mower is used for cutting. One of these six men rides the mower, another the rake, a third distributes and sets up the poles or frames for the shocks, and the other three men make the shocks. When a binder is used for cutting only three men are required for the operation. Two men are required to drive and operate the binder while the third sets up the shocks.

The rate of threshing, as noted in the same way as were the rates of cutting and shocking, was found to be about 20 bushels per hour for the grain thresher operating under average conditions while, under similar conditions, the rate for the "pea huller" was 40 bushels per hour. This difference in the rates of threshing for these two machines is explained by the fact that the "pea huller" has the larger cleaning capacity. The cylinder width in each of these machines was 24 inches but it has been noted that the "pea huller" had two cylinders while the grain thresher had only one. Hence

it is needless to take up more space explaining why a "pea huller" threshed soybeans twice as rapidly as a grain thresher.

Harvesting Cost for the "Cut and Thresh" Method.- Preliminary to preparing figures on the cost of this method of harvesting soybeans it was necessary to establish several conditions. Since the data obtained heretofore were obtained for crops yielding an average of 15 bushels per acre this yield was taken as the basis for determining the cost per bushel of harvesting. The man labor cost of 25 cents per hour was taken from the current wage rate. Since there were no available data on the cost of horse labor for Virginia, the set rate of twenty cents per hour was taken. It is true that this figure is only an estimate but it is considered to be nearer correct for Virginia conditions today than the data given by Warren for New York for 1913 or Cooper of Ohio for Illinois, New York and Ohio.

The equipment cost was taken on a depreciation versus amount of service basis. For instance, a binder costing $250. with a life of ten years would cost the owner $25. per year for depreciation. Fifty acres of cutting per year was taken as an average amount of service for Virginia and hence a charge of 50 cents per acre was used in calculating the cost to cut with a binder. The cost per acre or per hour used for the other machinery was obtained similarly with the exception of the threshing outfit. The threshermen's fee of 35 cents per bushel, the most common charge, included all expenses, operation and incidental, for the threshermen's outfit.

The following costs shown in Table 7 were obtained by considering a yield of 15 bushels per acre based on the foregoing as to labor and machinery costs together with the rates of doing the work as observed heretofore.

From the results shown in Table 7 the most expensive method is that of cutting the crop with a binder and threshing with a grain thresher, the cost per bushel being 62.50 cents. When a mower is used for cutting the total cost per bushel for saving the seed is a little lower, ie 61.78 cents. Since a binder is a more expensive machine than a mower, the cost of operation during its life is greater and for this reason the binder is shown in Table 7 to be the more expensive machine for cutting by .8 cent, which is the difference noted above in favor of the mower and grain thresher. This difference is too small to be an important factor when the difference in labor required in favor of the binder is considered, the binder's requiring three men for cutting and shocking versus the mower's requiring six men for the same operation. Together with this advantage, the convenience that the binder affords makes it the more desirable machine to use for cutting when the condition of the crop permits its use. When the crop is very heavy or badly down of course, the mower must be used.

Comparing the costs shown in Table 7 with reference to the threshing machine used, a greater difference than that between the mower and binder is noted. This difference of almost 6 cents (5.37 cents) is in favor of the "pea huller" and is explained by the fact that the rate of threshing for the "pea huller" is double that for the grain thresher.

Since the advantage of economy and rapidity of good threshing easily over come the suggestion that the labor of one [redacted] more man is required, it is evident that the "pea huller" is decidedly the more desirable machine to use for threshing. However, it is not intended to discredit the grain thresher for it will do satisfactory work and might be used, under some conditions, more conveniently, especially, for threshing the smaller crops.

Table 7.- Showing the Total Harvesting Costs per bushel of Saving Soybean Seed by the Different Methods Under the "Cut and Thresh" Method.

Methods of Saving Seed.		Total cost per bushel
Machine used for cutting	Type of thresher used for threshing.	
Mower	"Pea huller"	$0.5641
Binder	" "	.5721
Mower	Grain thresher	.6178
Binder	" "	.6256

Factors Affecting the Success of the "Cut and Thresh" Method.- The degree of success with which the "cut and thresh" method of harvesting the soybean crop is accomplished in general, depends upon the farmer's care and management together with the thresherman's ability and the efficiency of his threshing outfit.

It has been noted that the greatest waste incurred by this method of harvesting occurs during the cutting and shocking of the crop. The waste incurred by the binder may be expected to be lower than that incurred by a mower, however, the degree of care with which the vines or bundles are handled in shocking determines to a greater degree the extent of waste incurred.

The loss during the curing period should be considerably lower when a binder is used for cutting than when a mower is used, due to the characteristic of the vines in bundles and in the loose condition. The success of the threshing operation depends about equally upon the thresherman and the farmer, provided the threshing outfit is a good one. The thresherman cannot adjust his machine to make it do its best work unless the machine is fed properly. To avoid choking of the machine as well as to facilitate clean threshing with a minimum of waste and damage to the seed, soybeans must be fed evenly and comparatively slowly into the cylinder

of the threshing machine. Failure to feed the machine at a reasonable rate ~~and in such~~ or a manner will result in poor threshing and dissatisfaction to all concerned. This factor is very important.

Good management on the part of the farmer is essential in order that the foregoing may apply. The crop should be cut when about two-thirds of the leaves have dropped. If the crop is cut at a later stage of maturity it will be almost impossible to avoid excessive shattering while shocking. To cut the crop at an earlier stage of maturity in order to avoid the usual waste is not recommended for, although seed saved from plants cut while the beans were only half grown, have tested over 90 percent germination according to Mr. C.M. Grafton at Somerset, Virginia, the size and yield of the seed is much greater when the plants are nearer maturity. Mr. C. J. Willard, of the Ohio State University, in 1919 found that soybeans would germinate if harvested very early but his data show the yield to be very low.

Since the waste during the curing period is considerable it is also good management on the part of the farmer to have the crop threshed as soon as the vines are thoroughly mature.

Summary of the "Cut and Thresh" Method.- A summary of the wastes in the different steps of this method in percentage is shown in Table 8. Since the binder has been shown to be probably less wasteful than the data in Table 3 indicated, the figures for this loss are taken to be the same for both a binder and a mower. The waste during the curing period for the crops cut with a mower is taken as it was obtained while half this percentage is taken for this loss for the binder, since it has been shown that this relation between the losses during the curing period for soybeans cut with the two machines should be nearly correct.

The percentage of loss incurred by hauling to the thresher includes only the amount of beans saved in the sheets on the wagons.

From the results shown in Table 8 it is clear that the greatest loss occurs in cutting and shocking the crop. The next greatest loss occurs during the curing period while the waste in threshing is the least. The relation between these losses is fairly close for the two methods of cutting the crop, the difference being only 2.6 percent in favor of the binder. The efficiency of the two types of threshing machines is considered to be equal since no actual difference was observed.

Table 8.- Showing Summary of Losses that Occurred in the Different Steps in the "Cut and Thresh" Method when a Mower and a Binder was used for cutting; the loss in threshing being considered the same for either a "Pea Huller" or a Grain Thresher.

Machine used for cutting	Percent of beans lost			Total percent of loss
	in cutting and shocking	during curing period	in hauling to and about thresher	
Mower	8.98	5.19	1.92	16.09
Binder	8.98	2.59	1.92	13.49

The cleanliness of the seed saved as well as the percentage of damage incurred by either type of threshing machine depends upon the thresherman's ability together with the manner in which the thresher is fed.

The rate of cutting and shocking is practically the same for a mower or a binder, being about 1½ acres per hour. The binder requires only 3 men for this operation while the mower requires 6.

The rates of threshing for a grain thresher and a "pea huller" are respectively 20 and 40 bushels per hour. The cost of harvesting by this method depends more upon the type of thresher than the machine used for cutting. The "pea huller" is cheaper by about 6 cents per

bushel than the grain thresher for threshing the crop. For cutting the crop, the mower is about 1 cent per bushel cheaper than the binder. The latter method of cutting, however, requires less labor and is more convenient when it is possible to use the binder.

The factors affecting the success of the "cut and thresh" method of harvesting soybeans for seed are:

1. The cutting of the crop at the correct stage of maturity.

2. The careful handling of the vines in shocking and in hauling to the thresher.

3. The threshing of the crop when the vines are completely cured and thoroughly dry.

4. The thresherman's ability to make his machine do its best work.

5. The proper feeding of the thresher.

Provided the threshing outfit is efficient, the above factors are practically all within the control of the farmer, weather conditions permitting.

Seed Wasted in the Row-Harvester Method of Harvesting Soybeans.- Since gathering the seed with a row harvester involves only one field operation, it was comparatively easy to find the percentage of waste incurred. The method of counting the beans on the standing vines in a given area before and comparing with the number found in the same area after harvesting, has been described. Tables 9, 10 and 11 show the data found in this way for the Gordon and Scott machines respectively.

The average percentage of loss found for the Gordon row-harvester which is a 2-man machine, is shown by the data in Table 9 to be 37.76 percent. This percentage of waste is very high and is explained partly by the fact that the trash is separated from the beans by a man with a fork. As the beans and trash tend to accumulate in the rear of the machine rather rapidly, it is no easy task to

forked
keep the trash ~~pranged~~ out and the man doing the forking is very apt to throw out beans with the trash by trying to gain speed.

Aside from the forking factor the waste incurred by the Gordon harvester may be divided into two parts. The first of these is the percentage left on the vines and the second is the percentage shattered on the ground. This latter waste includes the amount that the man in the rear of the machine, may fork out with the trash. Disregarding the loss for which the man may be responsible, the beans left on the vines and shattered on the ground are wastes incurred by the machine togethwr with the natural condition of the vines. The beater in the machine is there to shatter out the beans and send them to the rear of the machine but it also knocks a considerable amount of beans in front of the machine. Pockets placed on each side and to the front of the beater catch and save many of the stray beans, nevertheless a considerable amount is lost. Probably half the percentage of beans shattered on the ground get there in this manner while the other half ~~are~~ 15 thrown out by the man who forks out the trash.

The percentage of beans left on the vines is explained by the fact that the pods on the soybean plant do not mature evenly. Very often there may be several quite green pods on a vine while the rest of the pods may be fully mature. Aside from this peculiarity of the individual plant, it is a rare case to find a field of soybeans in which every plant is at the same stage of matarity. Since the beater can shatter the beans from the vines only when the pods are quite mature it is evident that beans will b e left on the less mature vines in the field as well as on parts of the individual plants.

Table 9.- Showing Loss of Seed When Mammoth Yellow Soybeans Were Harvested with a Gordon 2-Man Harvester.

Plot No.	Number of beans on vines Before Harvesting.	Number of beans on vines after harvesting.	Shattered on ground after harvesting	Total no. of beans lost	Percent of beans lost by being left on vines	Percent of beans lost by being shattered on ground	Total percent of beans lost
1	650	65	171	236	10.00	26.31	36.31
2	800	34	255	289	4.25	31.87	36.12
3	950	47	341	388	4.95	35.89	40.84
Average	800	48.7	222.3	304.3	6.40	31.36	37.76

Note: The data in this table were secured from counts made on plots extending 5 feet along the harvested row and half the distance toward the two adjacent rows in a field in Princess Anne County, Virginia.

According to the results shown in Table 10 for the Scott row harvester, which is a 1-man machine, the percentage of waste it incurs is less than that by the Gordon machine. This difference of about 12 percent in favor of the Scott machine is probably the waste due to the forking out of the trash in the Gordon machine for the Scott harvester is equipped with a cleaning device. It is generally conceded that a mechanical device will perform such work more efficiently than a man will do it. Since the cleaning arrangement is the only point in which these two machines differ to any degree it seems evident that the difference in the percentages of waste caused by these machines is due to this cleaning arrangement.

From Table 10 the average of the losses shown by the data for the Scott row harvester is 22.31 percent. This waste may be explained for this machine in the same way as was the loss caused by the Gordon harvester with the exception that little waste by the mechanical seed cleaner was observed.

In Table 11 the data show an average loss of 25.78 percent. The difference between this figure and the average of 22.91 percent shown in Table 10 may be due to the fact that there is not enough data to consider either figure as conclusive. However, these results are shown separately because the data shown in table 10 were obtained from the harvest of a crop of Virginia soybeans, while Table 11 contains data found in the same way for a crop of the Mammoth Yellow variety. Hence, it may be that the results in spite of their limitations, indicate that the smaller seeded varieties such as the Virginia variety are harvested by the row harvestor with less waste than the Mammoth Yellow. Also if this be true, the much greater waste for the Gordon machine, as has been noted, is explained in part, since the data shown for this machine were found while harvesting a crop of the Mammoth Yellow variety.

Table 10.- Showing loss of soybean seed when a Scott 1-Man Harvester was used to harvest the Virginia variety. These data were obtained from counts made on plots 5 feet long and extending outward from the row harvested half the distance to the two adjacent rows.

Plot No.	Number of beans on vines		Shattered on ground after harvesting.	Total no. of beans lost	Percent of beans lost by being		Total percent of beans lost.
	Before harvesting	After harvesting.			left on vines	shattered on ground	
1	1608	373	240	613	23.19	14.92	38.12
2	1580	277	54	331	17.53	3.42	20.95
3	1550	281	76	357	18.13	4.90	23.03
4	1985	243	36	279	12.24	1.31	14.05
5	2164	347	52	399	16.05	2.40	18.43
Average	1777.4	304.2	91.6	395.8	17.42	5.39	22.91

Note: The data in this table were secured on the farm of Dr. J. S. Andrews at Orange, Virginia.

Table 11.- Showing loss of soybean seed when a Scott 1-Man Harvester was used to harvest the Mammoth Yellow Variety. These data were obtained from counts made on plots extending 5 foot along the harvested row and half the distance toward the two adjacent rows.

Plot No.	Number of beans on vines Before harvesting	Number of beans on vines After harvesting	Shattered on ground after harvesting	Total No. of beans lost	Percent of beans lost by being left on vines	Percent of beans lost by being shattered on ground	Total percent of beans lost.
1	1130	224	85	309	19.82	7.52	27.34
2	1260	240	67	307	19.04	5.31	24.35
3	1284	203	78	281	15.81	6.07	21.88
4	1012	262	104	366	25.89	9.28	35.17
5	1032	173	36	209	16.76	3.49	25.25
Average	1143.6	220.6	74	294.4	19.26	6.33	25.80

Note: These data were secured on Mr. W. T. Parker's farm in Surry County, Virginia.

Cleanliness of the Seed Saved by the Row Harvester.- The degree of cleanliness of the seed saved by this method of harvesting with either of the machines mentioned, was observed to be practically the same. The product bagged from both machines consisted of about 2/3 seed and 1/3 trash. The efficiencies of the mechanical cleaner in the Scott harvester and of the man forking out the trash in the Gordon machine are about the same in regard to seed cleaning. The seed, therefore, required fanning before it could have been planted with any type of seeding machine or offered for sale.

Damage to Seed Saved by a Row Harvester.- Neither machine damaged enough of the beans to be worth considering. It is true that a small amount of seed is cracked but when only 5 damaged beans are found in a peck of seed this cause for worry may well be forgotten.

Rate of Harvesting with a Row Harvester.- The row harvester method of saving soybean seed seems rather slow since about ⅔ of an acre per hour is the rate of harvesting. The length of the harvesting day is rather short due to the fact that the machine cannot do effective work while the beans are damp with dew, as has been noted. Hence, from 6 to 7 hours is usually about the length of a days work with a row harvester and 4 or 5 acres is the maximum that one machine will harvest in a day. This slow rate of harvesting is the most serious objection to this method of saving soybean seed for the period during which the crop is at the optimum stage of maturity, at which stage it must be to insure satisfactory work with the row harvester, is rather short, lasting usually about one week. Hence, the size of the crop that one machine will handle is about 25 acres. Should a rain come during the harvest, a greater waste of seed may be expected, although the pods do not always split open badly after a rain.

Since the seed saved by this method of harvesting contains much trash it must be fanned. This may be done at odd times or during wet weather and therefore is no great inconvenience. Two men may be expected to fan about 20 bushels per hour with an ordinary fanning mill.

Cost of Saving Seed With a Row Harvester.- The cost of harvesting with a row harvester is small as may be seen in Table 12. The costs per bushel shown in this table were computed on a basis of a 15 bushel per acre yield including the cost of fanning. The use of the row harvester was valued at 50 cents per acre. The rate of harvesting and labor charges were taken as in the "cut and thresh" method.

Harvesting with a 2-man harvester is a little more expensive than with a 1-man machine, the respecitve costs per bushel being 14

and 12 cents. This difference is to be expected since the rate of harvesting is the same for both machines, while 2 men are required to operate the machine in one case and only one in the other.

Table 12.- Showing the total costs per bushel to save soybean seed including the cost of fanning on a basis of a yield of 15 bushels per acre.

Machine used	Cost per bushel		Total cost per bushel
	To harvest	To fan	
1-man harvester	$0.0911	$0.0275	$0.1186
2-man harvester	0.1133	.0275	.1408

Factors Affecting the Success of Row Harvesters.- The row harvester is a very satisfactory machine when used under favorable conditions, the main factors affecting the degree of success with which the machine is used being:

1. The distance between the rows
2. The stage of maturity of the crop.
3. The condition of the vines
4. The cleaning arrangement
5. The speed at which the machine travels.

Since soybeans tend to be more or less bushy plants especially when grown in rows the row harvester must be wide enough to catch all the vines. This condition necessitates the wheels of the machine being about 3½ feet apart. Hence the rows must be spaced at least this distance apart in order to avoid the wheels running over the vines in the rows on either side of the one being harvested.

To harvest soybeans successfully the pods must be easily shattered. A very good method of determining when this stage of maturity is reached, is to strike the vines a sharp blow with a stick and notice the shattering. If practically all of the beans are shattered from the pods by such a blow, the row harvester will do effective work. When this stage of maturity is reached all the leaves will have dropped and the pods will be quite dry.

Even though the stage of maturity be optimum, the row harvester cannot be expected to do its best work unless the vines are standing up fairly well. The construction of the machine enables it to pick up partly down vines very well but it will do better work if this condition is at a minimum.

The method of separating the trash from the seed used in the row harvester determines the degree of waste in harvesting. A mechanically operated screen may be expected to be less wasteful than the method of forking out the trash by hand.

Together with the above factors, the speed at which the machine travels while harvesting determines the degree of success with which the work is accomplished. A row harvester of the types observed must be driven at a speed of about 4 miles per hour in order that effective work may be done. Since this rate is a rather strenuous gait for a horse to maintain it is a good practice to change teams in the middle of the harvesting day for kindness sake alone.

From the foregoing it would seem that the proper conditions necessary, make this method of harvesting a "ticklish" proposition. However, in actual practice under ordinary conditions, the row harvester is used with success. The farmers that use the row harvester swear by it and say it is the only way to harvest soybeans for seed.

Summary of the Row Harvester Method of Saving Soybean Seed.-

The waste incurred by a 1-man row harvester may be expected to be about 25 percent under favorable conditions while the waste incurred by a 2-man machine may be expected to be about 12 percent greater. The seed saved by harvesting with either machine requires fanning. From 4 to 5 acres per day is about the rate of harvesting and 20 bushels per hour of fanning. The acreage of a crop to be harvested with one machine is limited to about 25 acres due to the shortness of the harvesting period.

The cost of harvesting is low, being about 12 cents per bushel including the cost of fanning.

In spite of the number of factors affecting the success of this method of harvesting soybeans for seed it is considered satisfactory by those using it.

The "Cut and Thresh" Compared with the Row-Harvester Method of Saving Soybean Seed.

Comparing the 2 methods of harvesting soybeans for seed with respect to waste, the "cut and thresh" method is more efficient to a marked degree. The comparison of the total percent of waste is shown in Table 13.

Table 13.- Showing the Comparison of the Average percentages of the total losses of seed incurred by the different methods of harvesting soybeans for seed.

Method of Harvesting	Machinery used for cutting or for harvesting.	Average percent of seed lost.
"Cut and Thresh"	Mower	16.09
" " "	Binder	13.50
Row-Harvester	Scott 1-man harvester	24.36
" "	Gordon 2-man harvester	37.76

Considering the comparison of these two methods with respect to waste alone the "cut and thresh" method appears to be the outstanding method but when the cost is considered, as is shown in Table 14, it is a much more expensive proposition than the row-harvester method.

Table 14.- Showing the comparison of the harvesting costs per bushel for the different methods of saving soybean seed exclusive of the value of the seed wasted.

Method of Harvesting	Machinery used in Harvesting	Total cost of saving seed per bushel.
"Cut and Thresh"	Binder and Grain Thresher	$0.6257
" " "	Mower " " "	.6173
" " "	Binder and "Pea Huller"	.5720
" " "	Mower " " "	.5641
Row Harvester	Gordon 2-man harvester	.1408
" "	Scott 1-man harvester	.1186

Note: The figures shown for the two types of row harvestors include the cost of fanning the seed.

From the foregoing the question of which method is the more economical in the long run arises. Comparing the two methods with respect to both waste and cost (Table 15) the relation between the two methods is shown to a more definite degree.

Preliminary to making a comparison of these two methods of saving soybean seed with respect to both waste and cost it was necessary to establish a basis upon which to make such a comparison. Since the data in this investigation were based on a yield of 15 bushels per acre, this yield was taken as a basis for table 15. Since the method of cutting the crop with a binder and threshing with a grain thresher is the most expensive way to save soybean seed with respect to labor cost and at the same time the most efficient with respect to waste of seed, this method was taken as a constant to which the other methods might be compared with reference to the cost per bushel of harvesting together with the value of the wasted seed. For

the sake of convenience as well as for the purpose of making a clearer comparison this method of cutting with a binder and threshing with a grain thresher was taken as being 100 percent efficient with respect to waste. Hence, in Table 15 the harvesting cost is shown for this method to be $2.50 for for harvesting 6 2/3 acres yielding 15 bushels per acre or for raising 100 bushels of seed and since no waste is considered this figure is taken as the total cost for this method. Since there is not more waste incurred by a "pea huller" than by a grain thresher, the method of cutting with a binder and threshing with a "pea huller" is also considered to be 100 percent efficient as to waste and the total cost is shown to be the cost of saving 100 bushels of seed, ie $57.21. However, when a mower is used for cutting the greater percentage of loss incurred in cutting and shocking would amount to 3 bushels more than the loss incurred when a binder is used. Hence, in the methods using a mower for cutting and either a grain thresher or a "pea huller" for threshing only 97 bushels would be saved while in the two methods using a binder 100 bushels would be saved. However, the cost of saving the 97 bushels would be practically the same as if 100 bushels were saved, for it was taken that the crop yield was 15 bushels per acre when a binder was used for cutting, and therefore, the same acreage (6 2/3 acres) would need to be harvested to save the 97 bushels with a mower and grain thresher or "pea huller." In this way the differences in cost between the mower-grain thresher and the costs of the other methods included under the "cut and thresh" method of harvesting as well as the row-harvestor method with respect to harvesting cost together with the value of the seed wasted, are as shown in Table 15. The price of seed was taken as $3.00 per bushel in preparing these data.

According to the results shown in Table 15 the use of a "pea huller" rather than a grain thresher for threshing saves $5.37 when a binder is used for cutting, considering a yield of 100 bushels with no extra waste. Had a mower been used for cutting such a crop and a grain thresher for threshing the waste of 3 bushels valued at $3.00 per bushel would make this method of saving soybean seed actually $8.20 more expensive than the method using a binder for cutting and a grain thresher for threshing. When a "pea huller" is used for threshing such a crop cut with a mower the saving this thresher permits over the grain thresher counteracts, to some extent, the expense due to the value of the seed wasted by the mower's use, the actual expense being just $2.83 more than the cost of the binder-grain thresher method. Likewise, the 2-man row harvester is shown to be $35.65 more expensive than the binder-grain thresher method. In the same way the 1-man row harvester is shown to be the cheapest method of all, it being $16.04 cheaper than the binder-grain thresher method, according to the basis taken for the comparison.

The actual difference in cost is, hence, shown to be really less important than the harvesting cost, as the farmer sees it. The relation of the several methods depends upon the price of the seed, for the value of the waste really determines the most economical method of saving the seed. For instance, if soybean seed was worth $5.00 per bushel the waste incurred by the 1-man row harvester would make it more expensive than the binder-grain thresher method.

There is another important factor that enters such a comparison as is shown in Table 15 that has not been discussed. The value of the straw is this consideration. The row-harvester leaves the straw in the field as well as the wasted seed, while the "cut and thresh" method saves the straw, although it is not inferred that the beans

wasted are in this straw, for it has been noted that very few beans get into the straw stack. However, the straw is good feed and is worth more to some farmers than a reasonable money value would indicate. On the other hand, some farmers have their farms so arranged with fences that it is convenient to turn stock, especially hogs, into the field after the soybean crop has been harvested with a row-harvester and in this way make use of the wasted beans as well as the straw. Hence, the importance of this factor depends upon the way in which the farmers can make use of the straw.

It is well to mention at this point that the maintainence of the soil productivity is affected to a marked degree by the method of harvesting the soybean crop. When the seed is saved by the "cut and thresh" method everything except the roots, the stubble and about 3/4 the leaves of the crop is removed from the land. On the other hand, the row-harvester leaves practically all of the plant except the seed. Hence, a crop following soybeans harvested with a row harvester will be considerably better than when the harvest is made with the "cut and thresh" method. In other words a crop of soybeans harvested by the "cut and thresh" method takes more plant food from the soil than the same crop would take, if harvested with a row harvester. From the standpoint of maintaining the productivity of the soil, the row harvester is the more desirable method.

The labor problem on the farm is one that must not be neglected for this is a problem too generally known today. The farmer gets around this difficulty in many cases by trading work with his neighbors. However, the labor required by the two methods of harvesting soybeans should not be omitted from the comparison.

It has been noted that the row harvester requires much less labor than the "cut and thresh" method to save soybean seed. Hence, it is evident that the row harvester is, at least, a much more convenient method of saving the seed.

With practically all of these advantages in favor of the row harvester it is wondered why the use of this method of harvesting soybeans for seed is not more universal. Genera ly, such a condition is explained by some good reason but this one is not. The farmers that use the "cut and thresh" method are skeptical about the row harvester while those using the row harvester swear by it. Such is the explanation of the popularity of the two methods of harvesting the crop for seed.

Table 15.- Showing the Differences in the total cost of harvesting Soybeans by the different methods including the value of the waste.

Method of Harvesting	Machinery used for cutting and threshing in the "cut and thresh" method and for harvesting in the row harvester method	Cost to harvest 6 2/3 acres which would yield 15 bu. per acre when harvested by the binder-grain thresher method	Saving of other methods over binder grain thresher method	Amount of seed lost by other methods over binder-grain thresher method	Value of waste over waste incurred by binder-grain thresher method at $3.00 per bushel	actual difference in cost of other methods considering binder-grain thresher method 100% efficient as to waste.	
						Amt. higher than binder-grain thresher method	Amt. lower than binder grain thresher method
Cut and Thresh	Binder and Grain Thresher	$62.58	$0.00	0	$0.00		$0.00
Cut and Thresh	Binder and "Pea Huller"	57.21	5.37	0	0.00		5.37
Cut and Thresh	Mower and Grain Thresher	67.28	.80	3	9.00	$8.20	
Cut and Thresh	Mower and "Pea Huller"	56.41	6.17	3	9.00	2.83	
Row-Harvester	2-man harvester	14.08	48.50	28.05	84.15	35.65	
Row-Harvester	1-man harvester	11.86	50.72	11.56	34.68		16.04

Note: Data prepared on a basis of 6 2/3 acres of soybeans that would yield 15 bushels per acre if harvested by the binder-grain thresher method, but would yield less if harvested by the other methods; hence the binder-grain thresher method is considered as 100% efficient with respect to waste.

General Summary

The greatest percentage of waste incurred by the "cut and thresh" method occurs during cutting and shocking. This loss should be less when a binder rather than a mower is used for cutting the crop.

The loss next in degree of importance occurs during the curing period. This loss also may be expected to be lower when a binder is used for cutting and greater when a mower is used.

When it is practica to use it the binder is the machine to be preferred for cutting the crop.

The "pea huller" is more desirable than the grain thresher for threshing except, possibly, for small crops.

The percentage of waste incurred by the row harvester is about double that wasted by the "cut and thresh" method. Seed saved with a row harvester must be fanned.

Considering the value of the various amounts of waste, the costs of the several methods of saving soybean seed dif er but little. When the straw is considered it depends upon the way in which the farmer can make the best use of it rather than is this a factor in favor of either method. The row harvester is more convenient when labor is considered.

No final conclusion can be taken definitely from this investigation in regard to which method of harvesting soybeans for seed is the better method. However, it is evident that the row-harvester method points to the logical method of saving soybean seed. Also it is evident that should a field harvester of a more efficient type than the modern row harvester be developed, the advantages in favor of this method of harvesting soybeans for seed would make it the outstanding method.

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