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SOYBEAN COSTS

And PRODUCTION
PRACTICES

By R. C. Ross

UNIVERSITY OF ILLINOIS
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Soybean Costs and Production Practices

By R. C. Ross, Associate Chief in Farm Management¹

MORE THAN 21 million bushels of soybeans were produced in Illinois in 1935, an amount approximately twenty times the average yearly volume during 1920 to 1928. Thus rapidly have soybeans grown in popularity among Illinois farmers during the past decade.² Whether this change in Illinois cropping systems will be permanent will depend chiefly upon the ability of this relatively new crop to compete with the older crops in the purposes it serves and in profitableness.

In expanding so greatly their acreages devoted to soybeans, farmers have become increasingly interested in growing and harvesting practices that will give them the greatest profit. That improvement has been made in this respect in recent years is indicated by the fact that the increase in production in 1930-1932 over 1920-1928 was relatively larger than the increase in acreage.

The income from soybeans, as from all crops marketed chiefly as grain, can be calculated or estimated by simple multiplication—yields times the market price or prices received. The cost of production, however, is not so easily estimated. The present study was therefore undertaken in order to ascertain what the detailed costs are that enter into the production of this crop on Illinois farms; the effects which different practices used in growing and harvesting have upon yields and costs; and the probable place of soybeans in corn-belt farming.

“Practices” as used in this publication mean specifically those operations directly connected with the preparation of the seedbed, seeding, cultivation, and harvesting. Practices dealing primarily with soil management and fertilizing, which would of course affect yields and hence costs, are dealt with only incidentally.

¹The author acknowledges the assistance of F. L. Underwood and W. W. Wilcox, formerly Assistants in Farm Management, in gathering data for the study in 1928 and 1929.

²In the three years 1930 to 1932 the average total acreage of soybeans was more than twice as large as in 1920-1928 and the average total production was more than three times as large. In 1934 and again in 1935 soybean acreage was still further increased because of drouth, chinch bugs and Agricultural Adjustment Administration programs.

SOURCES OF DATA

Location of Farms.—Altho soybeans are grown to some extent in most sections of Illinois, the area of heaviest production lies within a strip approximately one hundred miles wide extending east and west across the central part of the state. Within this area two studies have been made, one a detailed cost-of-production study and one an enterprise cost study. Both studies are reported in this bulletin.

Detailed Cost-of-Production Studies.—Annual data on costs, incomes, and labor and power requirements in soybean production have been gathered in Champaign and Piatt counties since 1921 by the Department of Agricultural Economics. But the number of farms and the acreage of soybeans included have been too limited to permit a study of the differences in costs resulting from differences in practices followed. Data from this detailed cost study do, however, show the changes in costs and incomes which have resulted from changes in economic conditions during the seven-year period from 1928 thru 1934. The farms supplying these records grew a total of 5,603 acres of soybeans, of which 3,691 acres were harvested for grain with combines, 858 acres were harvested with binders and threshers, and 1,054 acres were put up for hay.

Enterprise Cost Study.—In order to secure records from a sufficient number of farms to study the practices used in soybean production and the effects of these practices on costs, an enterprise cost study was made in 1928 and 1929 in two groups of counties in central Illinois (Fig. 1). Records were obtained from 226 farms having a total of 10,636 acres of soybeans.

The counties in which this study was made were divided into two groups because of differences in soil types, fertility, and land values. Vermilion, Edgar, Champaign, Douglas, Moultrie, Coles, Piatt, Macon, Christian, and Sangamon counties, lying north of the Shelbyville moraine and characterized by dark-colored silt loam and clay loam soils, are designated as the "central Illinois area." Records were secured in this area from 87 farms in 1928 and 95 farms in 1929. The central Illinois area thus includes the two counties—Champaign and Piatt—in which the detailed cost records were obtained.

The second area, in which records were secured on 26 farms in 1928 and 18 in 1929, lies farther south, and as nearly all the farms studied were in Montgomery county, the area is designated as the "Montgomery county area." The soils on these farms belong, for the most part, to the brownish gray and grayish brown soil groups.

Inasmuch as the results for the two years in each area were very

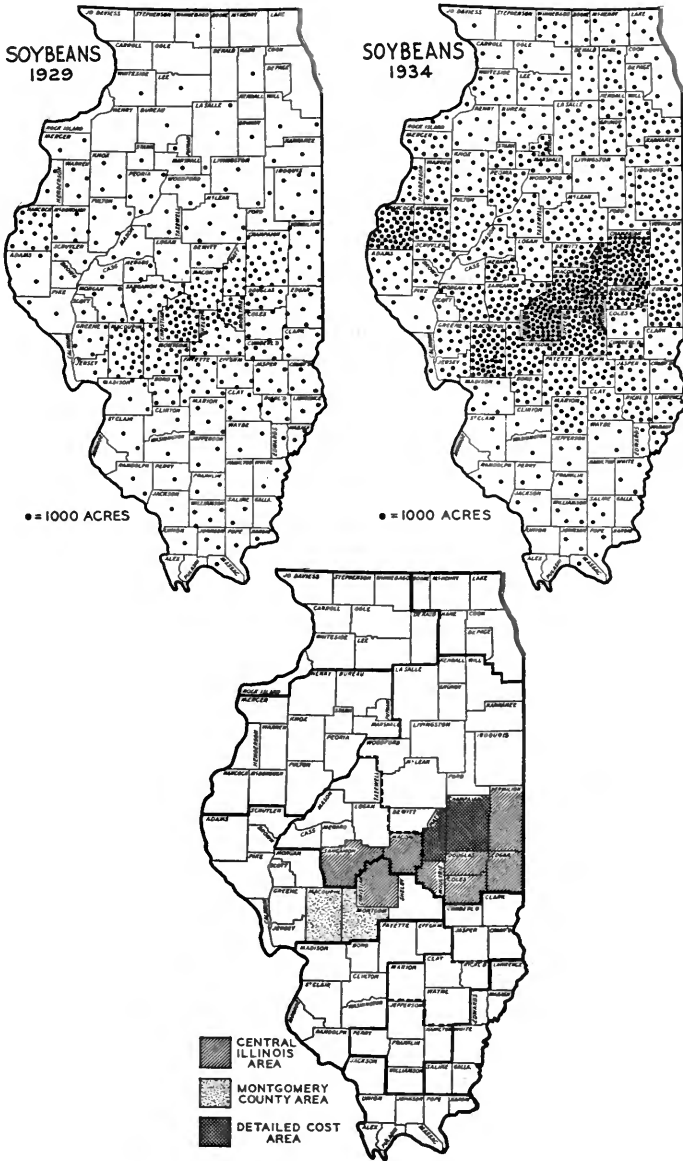


FIG. 1.—ILLINOIS ACREAGES OF SOYBEANS IN 1929 AND 1934, AND AREAS IN WHICH PRODUCTION COSTS AND PRACTICES WERE STUDIED

The counties in which the studies were made were approximately the same as those in which soybean production was heaviest.

similar in costs incurred and yields obtained, the combined results of the two-year study, separated according to the method of harvesting, are presented for each area.

Since these enterprise cost studies were concluded, the practices used in soybean production have changed but little except in the wider use of combines in harvesting and of trucks in hauling the threshed beans. The cost of production, however, has changed markedly because of price changes. In the present study the data from the more extensive enterprise cost study are therefore used for the analysis of practices, and the data from the detailed cost-of-production study are used to show recent changes in costs and the costs which were prevalent at the time of writing.

Grouping of Costs.—Two classes of costs are involved in producing soybeans: (1) *operating costs*, arising from the costs of seed and the use of labor, power, and machinery in growing and harvesting; and (2) *land charges*, consisting of taxes and interest on the investment in land.

Land charges (interest plus taxes) are equivalent to a rental figure, altho they are calculated on a different basis. Interest is figured at 5 percent of the inventory value of the land. Taxes are listed for each farm at the amount actually paid an acre. The land charges are therefore a fixed amount regardless of the crop grown on the farm that year.

Operating costs may be subdivided into costs occurring before harvest and costs involved in harvesting. The costs incurred before harvest differ widely from farm to farm, depending on the amount of work performed in preparing the seedbed, in planting, and in cultivating. The before-harvest costs also vary from year to year, because of differences in (1) the amount of work made necessary by seasonal variations and (2) prices of seed and rates charged for labor and power. Since in any area the practices used before harvest have little relation to the methods used in harvesting, the costs before harvest are similar in a given year regardless of the method of harvesting.

Harvesting costs likewise vary from year to year and from farm to farm because of changes in rates; but they vary even more as a result of the methods of harvesting, for different methods require widely different amounts of labor, power, and equipment.

During the seven-year period 1928-1934 definite changes occurred in the cost of producing soybeans whether the beans were harvested with binders and threshers, with combines, or were put up for hay (Table 1). In the early part of the period, from 1928 to 1930, production costs were quite stable; they declined rapidly during 1931-

1933; and in 1934 they apparently entered upon another period of stability at a lower price-level than in 1928-1930. Costs of producing soybeans in 1934 are probably fairly typical of what may be expected until rates for labor, power, and seed undergo considerable change.

PRODUCTION COSTS IN 1934

Total acre-costs of producing beans in 1934 were \$17.95 for beans harvested by binder and thresher, \$14.89 for beans which were combined, and \$16.36 for beans harvested for hay. These and the other figures on 1934 costs cited in the following discussion are either found in or based on those given in Table 1.

Land Charges About Half of Total

Variations in land values and in tax rates among the individual farms resulted in differences in land charges for the three groups of farms classified on the basis of harvest methods, tho it is not assumed that the method of harvesting had any connection with land charges. Taxes and interest together, on the land, were \$7.72, \$7.91, and \$7.74 an acre respectively for farms harvesting beans by binder and thresher, by combine, or for hay, thus constituting about half the total cost of production.

Operating Costs About Half of Total

Operating costs on these farms comprized approximately half the total cost of producing soybeans—57 percent where binder and thresher were used, 47 percent where combines were used, and 53 percent where beans were cut for hay.

Before-Harvest Costs.—Items of cost incurred before harvest, in growing soybeans in 1934, were similar in kind and in amounts for the three methods of harvesting (Table 1). Total before-harvest costs per acre were \$5.03 for beans combined, \$5.51 for beans harvested for hay, and \$6.24 for beans harvested with binder and thresher. Seed was the largest single item of cost, followed in order by power (horse and tractor), overhead, and man labor. Machinery and fertilizer costs were relatively small.

Variations in the items of cost were the result (1) of differences in amounts of work done on the individual farms, and (2) of differences in charges for overhead, since the value assigned to this item was based on the total amount of labor used in growing and harvesting the crop. Overhead costs were lowest when beans were combined, and were highest when the crop was harvested for hay.

TABLE 1.—COSTS, INCOME, PROFITS, AND LABOR WHEN HARVESTING SOYBEANS BY DIFFERENT METHODS; CHAMPAIGN AND PIATT COUNTIES, ILLINOIS, 1928-1929, 1931-1933, AND 1934
(From detailed cost records. Data are on acre basis except as otherwise indicated)

	Binder and thresher			Combine*			Hay		
	1928-1930	1931-1933	1934	1929-1930	1931-1933	1934	1928-1930	1931-1933	1934
Before-harvest costs									
Man labor.....	\$1.31	\$.80	\$.75	\$1.29	\$.68	\$.52	\$1.48	\$.79	\$.51
Horse labor.....	1.86	1.09	.79	2.39	.53	.53	2.60	1.07	.55
Tractor use.....	.95	.72	.67	1.01	.96	.70	1.08	.64	.62
Truck use.....	.....	.....	.....	.....	.....	.01	.....	.....	.....
Machinery.....	.58	.34	.33	.65	.43	.39	.64	.42	.38
Seed.....	3.19	1.31	2.22	3.12	1.30	2.11	3.17	1.33	1.86
Fertilizer.....	.47	.53	.33	.35	.39	.23	.50	.48	.29
Overhead.....	2.08	1.18	1.15	1.68	.86	.54	2.40	1.52	1.30
Total.....	\$10.44	\$5.97	\$6.24	\$10.49	\$5.15	\$5.03	\$11.87	\$6.25	\$5.51
Harvesting costs									
Man labor.....	\$1.65	\$1.19	\$1.00	\$.50	\$.28	\$.28	\$3.38	\$2.06	\$1.68
Horse labor.....	1.17	.78	.72	.26	.12	.16	1.78	.93	1.00
Tractor use.....	.....	.32	.41	.51	.22	.14	.02	.04	.01
Truck use.....	.....	.....	.03	.....	.....	.04	.....	.....	.....
Machinery.....	.35	.25	.08	2.62	1.22	1.33	1.19	.91	.42
Twine.....	.32	.18	.22	.....	.....	.....	.....	.....	.....
Threshing and fuel.....	2.37	.99	1.03	.....	.....	.....	.....	.....	.....
Total.....	\$6.03	\$3.71	\$3.99	\$3.89	\$1.84	\$1.95	\$6.37	\$3.94	\$3.11

TABLE 1.—(Concluded)

	Binder and thresher				Combine ^a			Hay			
	1933		1934	1929-1930		1931-1933		1934	1928-1930	1931-1933	1934
	1928-1930										
Operating costs, total.....	\$16.47	\$9.68	\$10.23	\$14.38	\$6.99	\$6.98	\$18.24	\$10.19	\$8.62		
Taxes.....	1.96	1.66	.97	1.61	1.56	1.13	1.89	1.71	1.15		
Interest on land.....	9.13	7.36	6.75	9.29	7.81	6.78	8.78	7.74	6.59		
Total costs.....	\$27.56	\$18.70	\$17.95	\$25.28	\$16.36	\$14.89	\$28.91	\$19.64	\$16.36		
Income											
Beans.....	\$27.16	\$9.47	\$19.53	\$27.86	\$11.15	\$19.42	\$28.33	\$13.25	\$22.61		
Straw.....	2.06	.75	.96	.....	.....	.01	.32	.03	.....	
Pasture.....	.44	.06	.03	.80	.10	.....	.....	.....	.....
Total.....	\$29.66	\$10.28	\$20.52	\$28.66	\$11.25	\$19.43	\$28.65	\$13.28	\$22.61		
Net profit per acre.....	\$2.10	\$-8.42	\$2.57	\$3.38	\$-5.11	\$4.54	\$-2.26	\$-6.36	\$6.25		
Net cost a bushel or ton.....	1.12	.78	.64	1.08	.63	.77	1.48	9.37	10.14		
Farm price a bushel or ton.....	11.20	10.38	10.74	11.71	11.43	11.74	13.33	16.06	14.06		
Man labor, hours.....	11.12	10.80	10.19	6.88	7.29	4.63	19.41	16.06	12.73		
Horse labor, hours.....	23.60	23.78	18.24	15.81	7.73	7.18	27.90	23.84	16.60		
Tractor use, hours.....	1.46	1.40	2.19	1.81	2.24	1.50	1.40	1.23	1.16		
Truck miles.....	.....	.....	.23	.....	.....	.51	.....	.....	.....
Value of land.....	\$182.60	\$147.20	\$135.60	\$185.80	\$156.20	\$135.60	\$175.60	\$154.80	\$131.80		
Yield, bushels or tons.....	22.4	22.9	26.4	22.7	26.3	26.2	2.06	2.13	1.61		
Number of acres.....	410	352	96	362	1 706	1 623	216	442	396		
Number of farm records.....	18	14	7	10	37	32	37	36	37		

^aIn 1928 only one farm harvested soybeans with a combine.

^bIn the detailed cost records the charge for overhead is based on the amount of man labor used on the crop; hence the charge is heaviest for hay and least for combined beans.

Harvest Costs.—Harvest costs amounted to \$1.95 an acre for beans combined, \$3.11 an acre for beans harvested as hay, and \$3.99 an acre for beans harvested with binder and thresher. The wide differences in these costs were largely due to differences in amounts of labor and power required.

The charge recorded in Table-1 for tractors in combine harvesting is probably too small and that for machinery too large, for when harvesting was done with a custom machine these items could not well be separated, and the entire cost of combining, including cost of power and labor, was listed as machinery cost. The items of man labor, horse labor, and truck use in combine harvesting are largely costs for hauling the threshed beans. Combine harvesting requires only a small amount of labor but involves a fairly large investment in machinery.

Harvesting with binder and thresher likewise requires a relatively large investment in machinery and, compared with combine harvesting, much more power and labor because of the larger number of operations involved. The total cost of harvesting by binder and thresher, according to this study, was twice as great as the total cost of harvesting with a combine. This higher cost is offset in part by the value of the straw saved by this method, as the straw often has considerable feeding value. The proportion of the Illinois crop of soybeans harvested by binder and thresher is, however, declining. On the cost-accounting farms in Champaign and Piatt counties less than 6 percent of the beans harvested as grain in 1934 was harvested with binders.

Of the three methods of harvesting beans, harvesting for hay requires the largest amount of labor but only a relatively small amount of equipment. The total cost of harvesting by this method is affected both by the yield secured, since the labor requirements increase with higher yields, and by weather conditions. At the time when soybean hay is harvested, the days are shorter and the weather is usually cooler than during the harvest period for most other hay crops, and the time required for curing is therefore greater. Rainy periods, not uncommon at this season, not only delay curing and lower the quality of the hay but cause extra work such as turning over the hay or scattering it for drying, and thus increase labor costs.

Income and Profits

Soybean yields in 1934 in the areas studied averaged a little more than 26 bushels an acre, and the price at harvest was 74 cents a bushel. Average income, including value of straw, was \$20.52 an acre where binder and thresher were used, leaving a profit of \$2.57 an

acre. Beans harvested with a combine returned an income of \$19.43 and a profit of \$4.54 an acre. When cut for hay, the average yield was 1.61 tons an acre, which at an average price of \$14.06 a ton produced an income of \$22.61 an acre and a net profit of \$6.25 an acre.

CHANGES IN COSTS: 1928-1934

Costs of producing soybeans declined markedly during the seven-year period 1928-1934 (Table 2). Altho land charges—interest and taxes—were somewhat reduced, especially during the later part of the seven-year period, the decline in production costs was largely the

TABLE 2.—PERCENTAGE REDUCTION IN ACRE-COSTS OF PRODUCING SOYBEANS BETWEEN 1928-1930 AND 1934; CHAMPAIGN AND PLATT COUNTIES, ILLINOIS
(Costs in 1928-1930 = 100)

	Binder and thresher	Combine	Hay
	<i>percl.</i>	<i>percl.</i>	<i>percl.</i>
Costs before harvest.....	40	52	53
Harvesting costs.....	34	50	51
Land charges (taxes and interest).....	30	27	28
Total costs.....	35	41	43

result of reductions in prices of seed and in rates charged for labor and power. Labor, power, and machinery costs are to a considerable extent under the farmer's control, whereas land charges are not. Some reduction in amount of labor required per acre also occurred during this period, a reduction which indicates, probably, increased efficiency in the production of soybeans.

Operating Costs Sharply Cut

Before-harvest costs declined approximately one-half from 1928-1930 to 1931-1933. Costs in the latter period, except land charges, were similar to those in 1934 (Table 1).

Harvest costs also declined from 1928-1930 to 1931-1933—about one-third for beans harvested with binder and thresher or cut for hay and about one-half for combined beans. This greater reduction in cost of combine harvesting resulted primarily from (1) a marked decline in custom rates for combining, and (2) a better adjustment in the number of grain haulers. When combines first came into use farmers frequently provided more grain haulers than were needed and consequently labor costs were higher than necessary; but with more experience growers have corrected this fault.

The costs for harvesting beans as grain changed very little from 1931-1933 to 1934. A lighter yield of hay in 1934 caused some reduction in harvest cost.

Land Charges Lowered

Costs for taxes and interest on land declined somewhat less than did operating costs incurred in growing and harvesting the crop. Taxes were reduced about 10 percent from 1928-1930 to 1931-1933, and about 31 percent from 1931-1933 to 1934. Interest charges on land, computed at 5 percent of the appraised value, likewise declined, as a result of declining land values during the period of the study. Interest charges averaged \$9.07 an acre in 1928-1930, \$7.30 in 1931-1933, and \$6.71 in 1934.

Income and Profits Varied Widely

The reduction in costs noted above might have been expected to increase the profits from the soybean enterprise during this seven-year period, but sharp changes in market prices and minor variations in yield were responsible for wide variations in income and profits (Table 1).

During the years 1928-1930 prices of beans were favorable, and growers who marketed their beans as grain gained a profit from them. Harvested by binder and thresher they yielded a profit of \$2.10 an acre, and harvested by combine, \$3.38 an acre. In the same period, however, growers who cut beans for hay had an average loss of 26 cents an acre.

In the period 1931-1933 prices of beans and bean hay were low, and losses resulted regardless of the method of harvesting. Growers harvesting by binder and thresher lost an average of \$8.42 an acre, those harvesting by combine, \$5.11 an acre, and those harvesting beans as hay lost an average of \$6.36 an acre.

In 1934, as already indicated, these growers again realized a profit: \$2.57 when harvesting by binder and thresher, \$4.54 by combine, and \$6.25 when harvesting the beans as hay.

COSTS IN ENTERPRISE STUDY: 1928-1929

The costs and returns determined by the enterprise study made in 1928 and 1929 in the central Illinois and Montgomery county areas are summarized in Table 3.

These figures must not be taken as representative of costs incurred in soybean production at the present time (1936), because the prices

TABLE 3.—COSTS AND RETURNS IN GROWING AND HARVESTING SOYBEANS IN TWO AREAS IN ILLINOIS, 1928-1929

(Data are on an acre basis except as otherwise indicated)

	Central Illinois			Montgomery county		
	Binder and thresher	Combine	Hay	Binder and thresher	Combine	Hay
Before-harvest costs						
Man labor.....	\$ 1.40	\$ 1.11	\$ 1.22	\$ 1.59	\$ 1.10	\$ 1.31
Horse labor.....	1.64	1.06	1.26	2.04	.66	1.29
Tractor use.....	1.28	1.53	1.45	.85	1.96	1.42
Machinery.....	.70	.70	.70	.70	.70	.70
Seed.....	2.70	2.66	2.68	2.04	2.54	2.26
Inoculation.....	.06	.04	.05	.07	.02	.04
Overhead.....	1.55	1.43	1.47	1.46	1.39	1.42
Total.....	\$ 9.33	\$ 8.53	\$ 8.83 ^a	\$ 8.75	\$ 8.37	\$ 8.44 ^a
Harvesting costs						
Man labor.....	\$ 1.55	\$	\$ 2.90	\$ 1.67	\$	\$ 2.18
Horse labor.....	.98	....	1.44	.88	....	.96
Tractor use.....	.17	....	.03	.02	....	.05
Machinery.....	.30	....	.30	.30	....	.30
Twine.....	.30	....	....	.11	....	....
Threshing and fuel.....	2.38	4.44 ^b	....	2.15	5.03 ^b	....
Meals.....	.18	.04	....	.32	.06	....
Hauling.....	.47	.59	....	.27	.54	....
Baling and miscellaneous.....	....	....	1.62	....	....	.10
Total.....	\$ 6.33	\$ 5.07	\$ 6.29	\$ 5.72	\$ 5.63	\$ 3.59
Operating costs, total.....	\$15.66	\$13.60	\$15.12	\$14.47	\$14.00	\$12.03
Taxes.....	1.82	1.91	1.95	.75	1.24	.82
Interest on land.....	8.57	8.95	8.61	3.92	5.59	4.11
Total costs.....	\$26.05	\$24.46	\$25.68	\$19.14	\$20.83	\$16.96
Income						
Beans.....	\$32.17	\$34.02	\$	\$19.01	\$30.38	\$
Straw.....	2.89	....	....	3.12	....	....
Hay.....	....	....	26.43	....	....	14.34
Total.....	\$35.06	\$34.02	\$26.43	\$22.13	\$30.38	\$14.34
Net profit an acre.....	\$ 9.01	\$ 9.56	\$.75	\$ 2.99	\$ 9.55	\$ -2.62
Net cost a bushel or ton.....	\$ 1.06	\$ 1.05	\$11.89	\$ 1.34	\$ 1.05	\$11.90
Yield per acre, bushels or tons.....	22.0	23.5	2.16	12.0	19.9	1.43
Number of farm records.....	77	99	121	26	11	37
Number of fields.....	106	174	....	37	30	....
Acres included in costs before harvest.....	2 743 ^c	5 620 ^d	8 730 ^a	629 ^e	840 ^f	1 906 ^a
Acres included in harvesting costs.....	2 381	5 326	837	451	816	475
Value of land.....	\$171.40	\$179.00	\$172.20	\$ 78.40	\$111.80	\$ 82.20

^aThese figures represent true averages for all fields.^bBased on prevailing custom rates.^cIncludes 291 acres cut for hay and 71 acres not harvested.^dIncludes 256 acres cut for hay and 31 acres not harvested.^eIncludes 167 acres cut for hay and 11 acres not harvested.^fIncludes 24 acres cut for hay.

of the items entering into production were on a considerably higher level in 1928-1929. The data are of value, however, in supporting or showing the representative character of the figures obtained in the detailed cost study (Table 1), which were secured from a smaller number of farms and a more limited acreage.

The somewhat lower acre-costs shown by the enterprise records for the central Illinois area in 1928-1929 compared with those shown for

Champaign and Piatt counties in 1928-1930 by the detailed cost records may be explained in part by the wider range of farming conditions in the larger area included in the enterprise study and in part by differences in the methods used in obtaining the records. Also in the larger area seed and overhead costs were somewhat lower than in the smaller area, and interest charges on land investments averaged somewhat less because of lower land values.

Incomes in the two areas showed a rather wide variation because of the inclusion, in the detailed cost study, of records for 1930, a year in which bean prices were much lower than in 1928 and 1929. Yields and net costs per bushel were closely comparable in the two areas, altho the higher acre-cost for hay in Champaign and Piatt counties gave a higher net cost per ton.

Differences in the methods used in obtaining data in the two studies were as follows: in the enterprise cost study no charge was entered for fertilizers (for only a few fields had received soil treatments of fertilizer or manure); charges for hauling the threshed beans were calculated as a separate item; and charges for combining were based on custom rates rather than on actual costs.¹

PRACTICES INFLUENCING SOYBEAN COSTS

Not only is the acre-cost of producing soybeans affected by the growing and harvesting methods used, but of course yield of beans or hay is also affected and consequently the unit cost per bushel of beans or per ton of hay. The planting of a higher yielding variety, which may involve no change in type of work performed in growing and harvesting the crop, may increase acre-costs for seed and for harvesting a higher yield but may lower unit costs. Hence in the following discussion emphasis is given to *yields*, which the reader may translate into costs.

¹In estimating costs in the enterprise study, the various items were calculated at rates prevailing at the time the study was made, according to records kept by central Illinois farmers in cooperation with the Department of Agricultural Economics of the University of Illinois. *Man labor* was figured at 30 cents an hour, *horse labor* at 14 cents an hour per horse; *two-plow tractors* at 75 cents an hour, not including the labor of the operator, and *three-plow tractors* at \$1.25 an hour. *Machinery use*, not including tractor use, was calculated at flat rates of 70 cents an acre for operations before harvest, 30 cents an acre for harvesting with a binder or cutting for hay, and at custom rates for combining. *Seed costs* were entered at the purchase price if bought, or at a fair appraised value if home grown; and inoculation costs, where inoculation was made, were charged at the cost of labor and materials. *Overhead costs* were calculated at 20 percent of the other current before-harvest costs.

Altho soil and climatic differences are responsible for some of the variations in practice among Illinois farmers in the production of soybeans, farmers with the same soil and climatic conditions are by no means agreed as to the best methods of growing this crop. This lack of agreement arises, at least in part, from the newness of the crop and the rapid expansion that has taken place in acreage before various practices have been thoroly tested.

Some farmers prepare the seedbed early but do not plant until later, so that as many weeds as possible may germinate and be destroyed before seeding and a smaller amount of cultivation may be needed later. Others plant the crop as soon as possible and depend on cultivation for weed control. Nor do all farmers use the same implements for cultivation. Many use rotary hoes; others use harrows, bean cultivators, corn cultivators, or weeders. The kind of cultivating implement to be used depends to some extent upon the method of planting. Cultivators can be used only on beans seeded in rows. Beans drilled solid may be cultivated by any of the other implements when the beans are small, but the rotary hoe is best adapted after the beans are well started.

Many other variations in practices occur—as in the amount and kind of work given to the preparation of the seedbed, the relative use of horses and tractors for power, and the methods used in harvesting the crop.

Fertilizing and soil-management practices also vary and also affect the yields and the costs of producing soybeans, but these practices are not analyzed in this bulletin.

In general the method to be used in harvesting has little influence on the practices followed in preparing the seedbed, in planting, and in cultivating the growing crop. In fact, most farmers in central Illinois grow soybeans primarily for the grain, and obtain what hay they need by cutting the borders from the grain fields.

BEFORE-HARVEST PRACTICES

Average costs of preparing the ground, seeding, and cultivating soybeans in 1928 and 1929 were \$8.83 an acre in the central Illinois area and \$8.44 in the Montgomery county area (Table 3). Of these costs, 44.4 percent in the central Illinois area was for labor and power and 30.5 percent for seed. The proportions were similar in the other area.

Variations in before-harvest costs, both from farm to farm and between the two areas, were caused chiefly by differences in costs of

labor, power, and seed. Other before-harvest costs—machinery costs, figured at a flat rate per acre in both areas, and overhead costs, figured at a fixed proportion of other costs incurred before harvest—were similar in the two areas.

The fairly wide spread in before-harvest costs, ranging within the central Illinois area from \$6 to more than \$12 an acre, resulted in part from variations in rates charged for labor, power, and seed, but chiefly from differences in the amounts of these items used. Obviously so wide a variation in acre-costs would directly affect unit costs unless the practices responsible for the higher acre-costs caused sufficient increase in yields to reduce unit costs. Many of the practices do directly affect the yield, and in the following portions of this publication their influence on costs is therefore discussed primarily from the standpoint of their effect on yield.

Because of changes in price-level subsequent to the time the enterprise cost study was made in 1928-1929, variations in amounts of labor, power, and seed shown therein are more significant from present viewpoints than are variations in rates paid for those items.

Relation of Amounts of Labor and Power to Yields

In considering the effect of before-harvest practices on before-harvest costs, the practical question for farmers is whether it pays to put more than a minimum of work on the soybean crop—a question which can be answered only by comparing the value of the increase in yield with the additional cost incurred.

In general, the farmers who put into the growing of beans a medium amount of labor had the highest yields; those who expended the least labor had the lowest yields; and those who put in the most labor, both in ground preparation and cultivation, secured about average yields (Fig. 2). The greater labor requirements on some fields may have been due to poor physical condition of the soil.

Man labor used in ground preparation, seeding, and cultivation in the central Illinois area varied from 1.5 to 10 hours an acre and averaged 3.98 hours (Table 4). The amount of horse labor used increased simultaneously with that of man labor, but tractor use was relatively constant, a relationship which reflects the common practice of farmers to use tractors for the heavy operations of plowing and disking and to use horses for the lighter work such as raking stalks, harrowing, planting, rolling, and cultivating. Farmers who grew beans with the least amount of man labor largely omitted such operations as raking stalks, rolling, and cultivating. Also, they used larger power

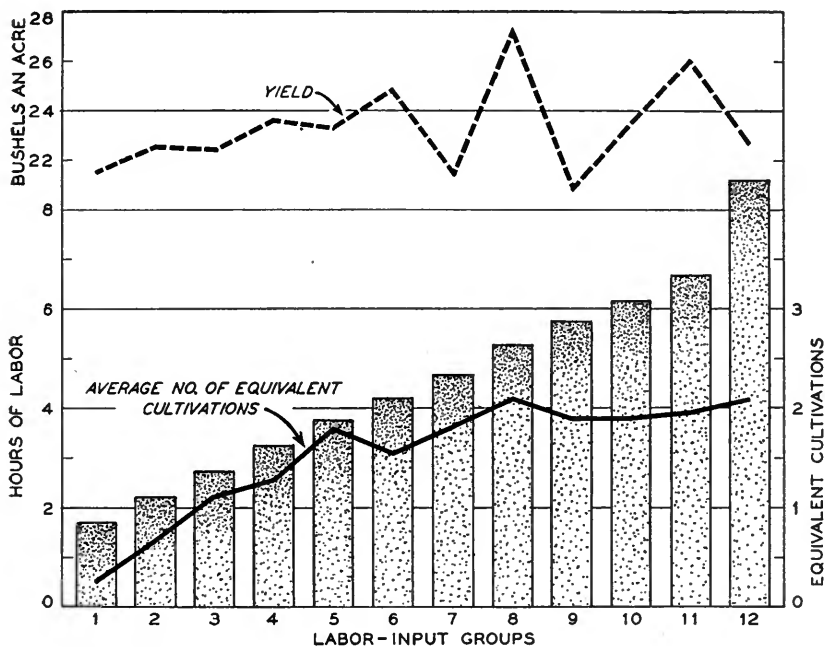


FIG. 2.—HOURS OF MAN LABOR AND AMOUNT OF CULTIVATION IN RELATION TO SOYBEAN YIELDS

Up to a given point—about 5 hours of man labor—yields increased with increasing labor input and cultivation. Further increases in labor were used in ground preparation, not in additional cultivations, and apparently had no further effect in increasing yields. The acreages in the last four groups of fields were, however, too limited to warrant definite conclusions on this point.

units in preparing the seedbed (the heaviest use of three-plow tractors was associated with least amounts of man labor), and they did the harrowing and the disking as one operation. The heaviest use of two-plow tractors was associated with amounts of man labor ranging from 3 to 6 hours an acre. Farmers who used the largest amounts of man labor used horses for power to a greater extent than tractors, some of them using horses only.

On the central Illinois farms for which data are given in Table 4 bean yields (as grain) increased rather consistently thru the first eight labor-input groups, or until the amount of man labor reached about 5.0 to 5.49 hours an acre (Fig. 2). On farms in the remaining groups the yields were erratic, but, as the acreages involved were comparatively small, the results were not conclusive. On the farms in the first eight labor-input groups, which included 87 percent of the total acre-

TABLE 4.—RELATION BETWEEN AMOUNTS OF LABOR AND POWER USED PER ACRE IN BEFORE-HARVEST OPERATIONS AND NUMBER OF CULTIVATIONS AND YIELDS OBTAINED; CENTRAL ILLINOIS, 1928 AND 1929

Labor-input group	1	2	3	4	5	6	7	8	9	10	11	12	True average of all groups
Hours of man labor per acre	1.50-1.99	2.00-2.49	2.50-2.99	3.00-3.49	3.50-3.99	4.00-4.49	4.50-4.99	5.00-5.49	5.50-5.99	6.00-6.49	6.50-6.99	7.00 and over	
Man labor, hours	1.72	2.21	2.72	3.25	3.74	4.20	4.68	5.28	5.76	6.15	6.67	8.60	3.98
Horse labor, hours	1.56	2.78	3.84	4.91	7.76	9.13	13.42	14.48	18.12	19.37	20.20	26.29	8.99
Tractor use, hours													
2-plow	.46	.39	.81	.93	.96	1.08	.50	1.25	1.27	.82	.65	.75	.86
3-plow	.83	.99	.82	.87	.65	.59	.71	.22	.10	.11	.19	.26	.64
Total	1.29	1.39	1.63	1.80	1.61	1.67	1.21	1.47	1.37	.93	.84	1.01	1.50
Amount of cultivation, percentage of total area													
Not cultivated	76	41	22	10	4	13	4	5	15	6	.....	7	.....
1 cultivation	22	49	45	58	25	42	33	29	33	30	19	22	.....
2 cultivations	2	10	33	27	64	28	50	30	15	38	68	42	.....
3 cultivations	.....	.....	.....	3	4	12	9	28	27	22	13	14	.....
4 cultivations	.....	.....	.....	2	.....	3	.....	5	7	4	.....	15	.....
5 cultivations	.....	.....	.....	.....	3	2	4	2	3	.....	.....	.....	.....
6 cultivations	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....
Average cultivations	.....	.69	1.11	1.28	1.80	1.54	1.81	2.10	1.89	1.90	1.95	2.08	.....
Yield of beans, bushels	21.5	22.5	22.4	23.6	23.3	24.8	21.4	27.2	20.8	23.5	26.0	22.6	23.0
Yield of hay, tons	1.47	1.94	2.20	2.34	2.08	2.17	1.62	2.29	1.89	2.94	2.4	2.07	2.15
Acres grown													
Harvested as beans	435	454	1 293	1 188	1 213	1 057	470	654	223	102	307	308	(7 704 T)
Harvested as hay	5	112	114	78	139	82	70	107	16	56	19	39	(837 T)
Not harvested	10	43	9	6	2	1	13	30	47	8	5	15	(189 T)
Total	450	609	1 416	1 272	1 354	1 140	553	791	286	166	331	362	(8 730 T)
Number of fields	13	20	44	45	46	38	18	32	14	12	13	16	(311 T)
Average acres per field	34.6	30.4	32.2	28.3	29.4	30.0	30.7	24.7	20.4	13.8	25.5	22.6	28.1
Rate of seeding per acre, bushels	1.44	1.59	1.56	1.51	1.43	1.54	1.55	1.42	1.45	1.53	1.20	1.21	1.48

Note—In right-hand column, "T" indicates "total."

age involved in the study, the addition of each hour of man labor an acre beyond a minimum of one hour increased the yield of beans, on an average, .94 bushel an acre (Fig. 3). That this increase was not caused by differences in amount of seed sown is indicated by the lack of relationship between yields and rate of seeding.

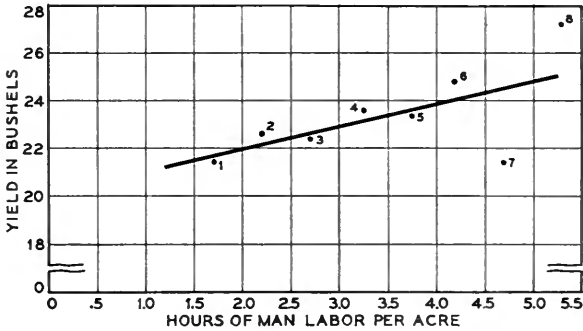


FIG. 3.—RELATION BETWEEN HOURS OF MAN LABOR AND SOYBEAN YIELDS, AS EXPRESSED IN A FITTED TREND LINE

Here hours of labor are shown correlated with yields. The trend line was fitted by the least-squares method from the equation $y = 21.125 + .492x$, x equaling the number of hours.

Yields of bean hay were apparently influenced but little by the amount of labor used before harvest. This lack of definite relation between amount of labor and yield of hay should not be regarded as conclusive, however, because (1) the acreage of beans harvested as hay was too small to be thoroly representative, and (2) many of the beans which were cut for hay were cut from the borders of fields harvested for grain and consequently the yield of hay did not give a true indication of the yield of the entire fields.

Altho no uniform relationship was evident between sizes of fields and labor-power requirements an acre, the larger fields were in general associated with the smaller requirements and the smaller fields with the higher requirements. The larger fields provided an opportunity for more efficient operation.

Relation of Cultivation to Yields

Of the total increase in labor from group to group in Table 4 approximately half was given to cultivation and half was divided among the other operations in growing the crop.

The amount of cultivation needed by a particular field of beans

depends largely upon the work done before planting and the climatic conditions during the growing season. While the amount of cultivation varied widely on the different fields within each of the eight labor groups (Table 4), yields increased progressively in the different groups as the amount of cultivation increased up to and including an average of two cultivations. In the remaining groups the average amount of cultivation was nearly constant, but the yields were erratic, indicating that other influences than cultivation were affecting yields.

No conclusions can be drawn as to whether an average of more than two cultivations would have further increased the yields. The number of cultivations which a farmer gives a field of soybeans is usually determined, of course, by the condition of the field and the competition offered by other farm work needing to be done.

Relation of Power Efficiency to Labor Load

The size and kind of power unit used and the efficiency with which it is operated largely determine the amount of labor used in field operations. In Table 5 are shown the power units used and the time required for the various before-harvest operations on the central

TABLE 5.—ACREAGES COVERED AND RATES OF ACCOMPLISHMENT IN VARIOUS BEFORE-HARVEST OPERATIONS IN GROWING SOYBEANS; CENTRAL ILLINOIS, 1928 AND 1929

	Total acres	Man hours per acre	Horse or tractor hours per acre	Average number horses in teams	Acres per 10-hour day
<i>Horse operations</i>			(horse)		
Disking stalks	1 226	.47	1.98	4.2	21.7
Raking stalks	1 092	.46	1.12	2.4	21.9
Plowing	1 716	2.19	10.26	4.7	4.6
Disking	3 470	.69	3.16	4.6	14.5
Harrowing	6 988	.29	1.15	4.0	34.5
Planting	6 847	.58	2.07	3.6	17.9
Rolling	919	.55	2.00	3.6	18.3
Cultivating, harrow	2 536	.29	1.12	3.9	34.5
Cultivating, rotary hoe	6 985	.44	1.28	2.9	22.5
Cultivating, cultivator	1 158	1.06	2.34	2.2	9.5
Cultivating, weeder	618	.46	.94	2.0	21.6
<i>Two-plow tractors</i>			(tractor)		
Disking stalks	1 098	.34	.34	...	29.2
Plowing	2 526	1.14	1.14	...	8.7
Disking	4 583	.42	.42	...	23.6
Planting	284	.57 ^a	.50	...	19.9
Cultivating, harrow	358	.23	.23	...	42.7
Cultivating, rotary hoe	413	.33	.33	...	30.1
<i>Three-plow tractors</i>			(tractor)		
Disking stalks	516	.31	.31	...	31.7
Plowing	2 772	.88	.88	...	11.3
Disking	5 620	.32	.32	...	31.6
Planting	315	.42 ^a	.36	...	27.6
Cultivating, harrow	158	.23	.23	...	43.7
Cultivating, rotary hoe	168	.31	.31	...	33.2

^aTwo men used part of time.

Illinois farms included in the enterprise study. The acreages stated for each operation and each kind of power are the number of acres worked multiplied by the number of times they were worked. The draft requirements for the different operations and the power units used in performing them (Table 6) indicate the way in which these farmers adjusted the kinds of power to the kind of work to be done.

TABLE 6.—PROPORTIONS OF SOYBEAN-GROWING OPERATIONS* DONE BY VARIOUS POWER UNITS; CENTRAL ILLINOIS, 1928 AND 1929

Operation	Total acres	Acres with horses	Acres with 2-plow tractor	Acres with 3-plow tractor
		<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
Disking stalks.....	2 840	43.2	38.6	18.2
Plowing.....	7 014	24.5	36.0	39.5
Disking.....	13 673	25.4	33.5	41.1
Planting.....	7 446	92.0	3.8	4.2
Cultivating, harrow.....	3 052	83.1	11.7	5.2
Cultivating, rotary hoe.....	7 566	92.4	5.4	2.2
All cultivation.....	12 394	91.2	6.2	2.6

*Operations not shown here were performed entirely by horse power.

While a few of the farmers used only horses for power, most of them had also either a two-plow or a three-plow tractor. But since very few of them owned two sizes of tractors, the choice usually lay between horses and the tractor at hand.

The machinery used was the kind usually available on corn-belt farms, and included very little special machinery for soybeans.

All of the work in raking stalks, rolling, and cultivating with weeder and cultivator was done with horses, as was 83 percent of the harrowing both before and after planting and 92 percent of the cultivation with the rotary hoe (Tables 5 and 6). On 43 percent of the acreage horses were used to disk down stalks but on only 25 percent for disking after plowing. This latter proportion is too high when account is taken of the several operations—double-disking, or double-disking and harrowing—usually done as one operation when tractors are used.

On the basis of the above rates of performance, plowing was done with horses at the rate of one acre per horse per 10-hour day. In this operation a two-plow tractor was equal to 8.7 horses and a three-plow tractor to 11.3 horses. Harrowing, on the other hand, was done at the average rate of 8.6 acres per day per horse; and a two-plow tractor was equivalent to 5.0 horses and a three-plow tractor to 5.1 horses. Similarly with the rotary hoe, each horse averaged 7.8 acres, and

two- and three-plow tractors were equivalent to 3.8 and 4.25 horses respectively.

From these ratios it is evident that much may be gained by fitting the power unit to the requirements of the operation. If fields are sufficiently large, the machinery unit of harrows or rotary hoes may be expanded enough to use the power of the tractor to advantage. On the other hand, when other work is not pressing, plowing with horses may be more economical even tho less efficient use is made of man labor, for horses must be maintained even tho idle.

Relation of Width of Planting to Yields

On the central Illinois farms included in this study, no greater yields were obtained from planting soybeans in rows than from drilling them solid—that is, in rows 7 inches apart—by a grain drill. Eighty-five percent of the bean acreage on which records were taken was drilled solid, and the remaining acreage was drilled in rows ranging from 14 to 42 inches apart. From acreages planted at these various distances between rows, the following yields were obtained:

	<i>Acres</i>	<i>Bushels per acre</i>
Drilled solid.....	6,412	23.2
Rows, 14 inches.....	160	24.1
Rows, 20 24 inches.....	993	22.3
Rows, 36-42 inches.....	199	17.8
Total and average.....	7,707	23.0

These data indicate that rows 36 to 42 inches apart may be too far apart for best yields; but this indication should not be considered as conclusive, for the acreage so planted was too limited to give results that can be considered truly representative.

Altho planting soybeans in rows appeared to give no advantage from the standpoint of yields, it does make cleaner cultivation possible, and the better weed control that results may offset the slight reduction in yield. Care should be taken, however, not to ridge the rows in cultivating, for ridges make harvesting difficult.

Influence of Time of Planting on Yields

Soybeans planted early are generally believed to yield better than those planted late. On the farms covered by this study the best yields in 1928 were obtained from plantings made early in May. In 1929, however, yields from later plantings up to about May 25 showed increases over yields of earlier plantings; but yields from plantings made after June 5 declined rather steadily compared with yields from earlier plantings (Table 7).

TABLE 7.—GRAIN YIELDS OF SOYBEANS PLANTED AT DIFFERENT DATES; CENTRAL ILLINOIS, 1928 AND 1929

Date of planting	1928			1929		
	Acres	Percent of total	Yield	Acres	Percent of total	Yield
			<i>bu.</i>			<i>bu.</i>
May 6-10.....	116	4.4	29.6	...	...	....
11-15.....	172	6.5	22.4	148	4.6	21.4
16-20.....	20	.8	28.0	40	1.3	21.5
21-25.....	1 455	54.9	21.9	242	7.5	24.1
26-30.....	587	22.1	21.0	162	5.1	25.7
31-June 4.....	225	8.5	17.5	764	23.7	25.2
June 5-9.....	...	...	...	622	19.4	24.5
10-14.....	75	2.8	20.8	428	13.3	23.8
15-19.....	...	...	...	234	7.3	21.3
20-24.....	...	...	...	374	11.7	20.2
25-29.....	...	...	...	197	6.1	17.3
Total.....	2 650	100.0	22.9	3 211	100.0	23.3

The time actually chosen for planting beans on a given farm depends largely upon the season, and the relative importance of the crop on that farm. Early planting gives less opportunity to kill weeds before planting time than late plantings, and in many years conflicts with corn planting.

Commonly Grown Varieties Gave Like Yields¹

Since varieties of soybeans differ in capacity to yield, in time of maturity, and in value as seed, the choice of variety plays an important part in the returns from the crop. Practically no data are available from this study, however, on this point, for only two varieties—Illini and Manchu—were grown extensively enough to offer any comparisons, and these two gave practically the same yields.

At the time this study was begun in 1928, Manchu was the most popular variety of soybean grown in Illinois, and only limited quantities of seed of the relatively new Illini variety were available. Accordingly Manchu beans comprized about 70 percent of the total acreage. By 1929, however, Illini beans for seed were available in much larger amounts, tho at a premium in price over other varieties, and were grown on a slightly larger acreage than Manchu, the two varieties together making up more than 86 percent of the acreage on which the records were obtained (Table 8). During the two years neither of these two varieties, both of which are high yielding, showed a marked superiority in yield over the other.

¹For a description of varieties and comparative yields both of grain and hay on the experiment field at Urbana, see Bulletin 310 of this Station, "Soybean Production in Illinois."

TABLE 8.—GRAIN YIELDS FROM DIFFERENT VARIETIES OF SOYBEANS; CENTRAL ILLINOIS, 1928, 1929, AND 1935

Variety	1928			1929			1935		
	Acres	Percent of total	Average yield	Acres	Percent of total	Average yield	Acres	Percent of total	Average yield
			<i>bu.</i>			<i>bu.</i>			<i>bu.</i>
Illini.....	209	5.6	27.3	1 811	45.6	23.8	13 598	67.5	25.5
Manchu.....	2 615	70.0	23.8	1 628	40.9	24.2	2 513	12.5	25.9
A. K.....	431	11.5	23.2	124	3.1	21.1	...	...	...
Mansoy.....	136	3.6	18.5	...	...	...	...	...	...
Ebony.....	68	1.8	15.1	139	3.5	13.1	...	...	...
Dunfield.....	...	...	...	...	...	...	2 819	14.0	28.4
Others and mixed...	281	7.5	15.9	273	6.9	17.7	1 200	6.0	22.8
Total or average	3 740	100.0	22.9	3 975	100.0	23.3	20 130	100.0	25.8

Extensive data in 1935 from the same area studied in 1928-1929 indicated a marked predominance of Illini beans, the area planted to this variety amounting to 67.5 percent of the total acreage, whereas Manchu and Dunfield varieties accounted for 12.5 and 14 percent respectively.¹ Acre-yields of Illini and Manchu were again practically the same, and thus the growth in popularity of Illini beans is attributable, in part at least, to characteristics other than yield.

Inoculation Costs

The average cost for inoculation was 5 cents an acre in the central Illinois area and 4 cents in the Montgomery county area. Of the 8,730 acres of beans grown in the central Illinois area, 31 percent was not inoculated, 45 percent was treated with dirt from soybean fields, and 24 percent with commercial cultures. Inoculation with dirt involved a labor expenditure of one-tenth hour per acre seeded, with no cost for materials; and inoculation with commercial cultures cost 19 cents an acre, most of which was for materials.

No comparison of yields from inoculated and uninoculated fields was made, for the soils of many fields not inoculated during these two years contained bacteria as a result of inoculations of previous soybean crops.

¹Data on 1935 yields were obtained in connection with a study of combine harvesting. Yields from the larger area covered in the study of combine harvesting averaged 1.5 bushels an acre less than those obtained on cost-accounting farms in Champaign and Piatt counties (see text, page 377).

Seed Costs

In most years the cost of seed is the largest single item in before-harvest costs in soybean production. Seed prices in the central Illinois area in 1928 ranged from \$1.05 to \$2.75 a bushel and averaged \$1.62; in 1929 they ranged from \$1.15 to \$3.00 a bushel and averaged \$2.06. The higher cost in 1929 was due in part to the heavy demand for Illini beans, which were generally available for the first time. Seed costs as recorded here were also affected by the general level of soybean prices, by the time and place of purchase and the quality of seed bought, and by differences in valuations when cooperators used seed of their own production.

Seed prices in the Montgomery county area, averaging \$1.92 a bushel in 1928 and \$2.10 a bushel in 1929, were somewhat higher than in the central Illinois area, largely because of the more extensive use in the Montgomery county area of hay varieties of beans, the seed for which was more expensive than that of other varieties.

Rates of Seeding

Rates of seeding as well as price affected the acre-costs of seed. In 1928 the rate of seeding averaged 1.53 bushels an acre in the central Illinois area and 1.07 bushels an acre in the Montgomery area; and in 1929 the average was 1.41 and 1.17 bushels an acre in the two areas respectively.

Between 1929 and 1932 farmers increased the rate of seeding somewhat. Seed prices, however, were lower, with the result that acre-costs for seed were reduced. With higher seed prices in 1933 and 1934 some reduction occurred in the rate of seeding. These changes are shown by data from farms keeping complete cost records in Champaign and Piatt counties:

<i>Year</i>	<i>Acres¹</i>	<i>Seed, bushels per acre</i>	<i>Price per bushel</i>	<i>Acre-cost</i>
1930.....	544	1.71	\$1.70	\$2.90
1931.....	772	1.76	.76	1.34
1932.....	573	1.88	.40	.75
1933.....	1,247	1.82	.98	1.78
1934.....	2,177	1.64	1.23	2.02

(¹Includes some acreage seeded but not harvested.)

HARVEST PRACTICES

Practices used in harvesting the soybean crops on the farms included in the enterprise cost study varied more than before-harvest practices. According to whether the beans were harvested with binder

and thresher or combine, or were harvested for hay, variations occurred in amounts of labor and power used, in investments in machinery and therefore in machinery costs or charges, in time of harvesting, in losses of beans, and in value of and disposition of straw. Acre-costs for harvesting did not, however, vary widely when costs for combining are computed at the custom rates that prevailed at the time, and if low costs of harvesting beans cut for hay in the Montgomery area are excepted (Table 9). The wide difference between costs of harvesting for hay in the two areas was due chiefly to the more extensive baling of hay in the central Illinois area.

TABLE 9.—ACRE-COSTS OF HARVESTING SOYBEANS BY DIFFERENT METHODS IN TWO AREAS IN ILLINOIS, 1928-1929

Items	Central Illinois			Montgomery county		
	Binder and thresher	Combine	Hay	Binder and thresher	Combine	Hay
Man labor.....	\$1.55	\$.....	\$2.90	\$1.67	\$.....	\$2.18
Horse labor.....	.98	....	1.44	.88	....	.96
Tractor use.....	.17	....	.03	.02	....	.05
Machinery.....	.30	....	.30	.30	....	.30
Twine.....	.30	....	....	.11	....	....
Threshing and fuel.....	2.38	4.44*	....	2.15	5.03*	....
Meals.....	.18	.04	....	.32	.06	....
Hauling.....	.47	.59	....	.27	.54	....
Baling and miscellaneous.....	....	....	1.62	....	....	.10
Total.....	\$6.33	\$5.07	\$6.29	\$5.72	\$5.63	\$3.59
Acres harvested.....	2 381	5 326	837	451	816	475

*Based on prevailing custom rates.

Costs of Harvesting by Different Methods

In the sharp decline of harvest costs during the general price decline of 1930-1933, costs of combining and of harvesting for hay were reduced about one-half, and the cost of harvesting with thresher and binder about one-third (Table 2, page 351). Since the actual costs of combining (as computed in Table 1, page 348) were substantially lower than costs figured at the custom rates (Table 3, page 353, and Table 9), an even greater reduction in costs of combining occurred than is indicated in Table 2. Harvest costs for 1934 were \$3.99 an acre for binder and thresher, \$1.95 for combine, and \$3.11 when the beans were cut for hay (Table 1). Since the differences in costs between the two periods were largely a matter of differences in prevailing rates, they affect but slightly the following analysis of the different harvest practices that influence harvest costs.

Labor and Power Requirements of Different Methods

Both in the central Illinois area and in the Montgomery county area the combine method of harvesting soybeans required less than one-third as much man labor per acre and less than one-sixth as much horse labor as the binder-thresher method (Table 10). Hours of tractor use with the two methods were similar when the use of steam engines in threshing was included. In both areas more extensive use was made of trucks for hauling the grain when the beans were combined than when they were threshed.

TABLE 10.—LABOR AND POWER USED PER ACRE IN HARVESTING SOYBEANS BY BINDER AND THRESHER AND BY COMBINE IN TWO AREAS IN ILLINOIS, 1928 AND 1929

Operations	Man labor	Horse labor	Tractor	Truck
Central Illinois area				
<i>Binder and thresher</i> (2,381 acres, yield 22.0 bu.)				
Cutting, shocking, hauling bundles.....	5.16	7.02	.11	....
Operating tractor and separator ^a.....	.52	....	.46	....
Hauling threshed beans.....	.79	1.46	....	.06
Total.....	6.47	8.48	.57	.06
<i>Combine</i> (5,326 acres, yield 23.5 bu.)				
Operating tractor and combine.....	1.08	....	.58	....
Hauling threshed beans.....	.90	1.38	....	.26
Miscellaneous ^b.....	.08	.01	....	....
Total.....	2.06	1.39	.58	.26
Montgomery county area				
<i>Binder and thresher</i> (451 acres, yield 12.0 bu.)				
Cutting, shocking, hauling bundles.....	5.55	6.34	.02	....
Operating tractor and separator ^a.....	.69	....	.53	....
Hauling threshed beans.....	.48	.79	....	.09
Total.....	6.72	7.13	.55	.09
<i>Combine</i> (816 acres, yield 19.9 bu.)				
Operating tractor and combine.....	1.06	....	.45	....
Hauling threshed beans.....	.72	1.02	....	.20
Miscellaneous ^b.....	.16	.08	....	....
Total.....	1.94	1.10	.45	.20

^aIncludes steam engine where used.

^bIncludes extra help in combining and cutting borders which were later run thru the combine.

The higher man-labor and horse-labor requirements of the binder-thresher method were due to the larger number of operations performed. Such operations as shocking and hauling bundles are entirely eliminated in combining, and the two operations of cutting and threshing are performed together. And so, instead of the five distinct operations—cutting and binding, shocking, loading and hauling the bundles, threshing, and hauling the grain—involved in the binder-thresher

method, only two are involved in combining, namely, cutting-threshing (combining) and hauling the grain.

Tractors are little used for pulling binders in cutting beans, for at the time this work is usually done other farm work is not pressing and the period of hot weather, which makes horse work with binders in midsummer so difficult, has passed.

The amounts of labor and power used per acre in hauling threshed beans were somewhat greater on the farms using combine harvesting. The chief reason for this difference was that, as a rule, more acres of soybeans were planted on the farms using combines than on other farms and consequently a larger portion of grain was hauled directly to market and a smaller portion was stored on the farm. The length of haul from field to market was of course much longer than from field to farm granary. Yields also affect hauling requirements. In the Montgomery county area, where yields were much lower than in the central Illinois area, hauling requirements were proportionately lower. For the most part, the beans combined in that area were on the more level and more productive land, while those cut with the binder were on the poorer soils and more broken fields.

In both areas there was a small amount of miscellaneous work in opening up fields and providing extra help in combining. Where beans were badly tangled, an extra man was sometimes needed with the combine to prevent bunching on the platform and uneven feeding.

In both methods of harvesting, labor and power requirements are influenced by yield and by cutting conditions. Under favorable cutting conditions the time required for binding is quite uniform, but variations in yield and in volume of straw affect the time required in shocking, hauling bundles, threshing, and hauling beans. Under unfavorable conditions all operations may vary widely in their labor and power requirements. Aside from the hauling of threshed beans, labor requirements in combining are affected much more by general harvesting conditions than by yields. The average time-rate at which beans were combined during the two years studied was 1.73 acres per hour.

Use of Machinery in Different Methods

Binders have long been standard equipment on corn-belt farms. Threshing machines have commonly been owned by company "rings" or groups of farmers, or by custom operators, rather than by individual farmers. On only 12 of the 226 farms studied were beans threshed with a machine owned on the farm; hence the average farmer's investment in threshing equipment was not large, and the harvesting of soybeans with binder and thresher did not, as a rule,

increase the investment already made in small-grain harvesting equipment.

Individual ownership of combines, which do the work of both binders and threshers, has been more common. Sometimes combines are owned jointly by several farmers in a neighborhood. In the two areas studied combines were owned on 44 of the 226 farms. Altho combines will harvest crops other than beans, the addition of a combine to the farm equipment does not always replace entirely the use of a binder and thresher. The purchase of a combine usually increases the investment in machinery, and consequently in the machinery costs in harvesting, altho the larger investment is offset partly, at least, by less use of man labor and horse labor and of such equipment as wagons, and by receipts from custom work done for hire.

The threshing costs of farmers who hire threshing equipment or combines consist of direct cash outlays on the basis of prevailing custom rates.

Custom Rates: Bases and Changes

Custom rates, where combines were operated for hire, were assessed on the farms studied in 1928-1929 on the basis of a flat rate per acre or per bushel or a flat rate per acre plus a given charge per bushel. An acre-rate was most frequently used, a method which obviously favors the combine owner when crops are light and crop owners when crops are heavy. When a bushel-rate is used, however, the advantages lie the other way around. A combination of the two bases appears to be the fairest method if the rates are equitable, altho this method has not been popular probably because it is less simple than the other methods.

Over a period of years custom rates tend to equal the costs involved. For a short period after the introduction of a new machine, rates are often high enough to return a considerable profit to the operators if the price of the product is sufficiently high to support the charge. But when the price of the product is extremely low, custom rates may for a short period be forced to a level too low to provide a fair compensation for noncash items of depreciation, interest, and operator's wages after cash operating costs are paid. Farmers who own combines usually own them primarily to do the combining on their own farms, altho very few such farmers have enough harvesting to use their machines to full capacity. These farmers find that custom work off their own farms helps to distribute the fixed overhead expense of depreciation and interest and to offset cash operating expense. Even in times of low grain prices, custom rates should be

maintained sufficiently high to pay the machine owner for the costs involved.

In the period 1928-1929 when the present field study was made, custom rates were high. Not a great many combines were available in the area, operators had not yet fully determined their actual operating costs, and the prices of soybeans and other small grains were well sustained at a fairly high level. From 1928-1929 to 1932¹ custom rates both for combining and for threshing dropped approximately 50 percent (Table 11). That the reason for this drop in custom rates was the extremely low level of farm incomes in 1932 and the willingness of the owners of the machines to operate them for but little more than the actual cash outlay required to keep them running, is indicated by the fact that of the items of cost in operating harvesting machines in 1932 only labor rates were materially reduced from 1928-1929 levels.

By 1935, however, some increase over 1932 custom rates for combining occurred.² Altho there was no greater uniformity in rates charged by different operators in 1935 than in 1932, and some operators were still combining at the same rates as in 1932, the prevailing rates were nevertheless about 25 percent higher. As the 1935 harvest season advanced and conditions of operation became more unfavorable, some operators increased their custom rates; and in some cases growers who were anxious to get their crops harvested at once offered higher prices to combine operators to come in and do the work.

Changes in bases for custom rates as well as in amounts occurred between 1928-1929 and 1935. The proportion of operators using the acre-rate charge increased steadily, the proportion using a combination of acre rate and bushel rate declined somewhat, and the bushel-rate charge alone nearly disappeared.

Custom rates for harvesting in the area studied varied in reality more than the records in Table 11 reveal, for there was in practice in the earlier years no uniform method of handling fuel costs. Sometimes these costs were paid by the machine owner, sometimes by the crop owner (in addition to the regular rates), and sometimes partly by one and partly by the other. In 1935 fuel costs were borne in nearly all cases by the combine operators. Variations in rates other than those arising from methods of handling fuel costs were caused by such varying factors as size of job, condition of beans, ground and weather

¹Data for 1932 were secured by a survey in the same area and including a considerable number of the same farms.

²Data for 1935 were secured in connection with a study in the same area of the cost of operating combines. No data were obtained on threshing rates.

TABLE 11.—CUSTOM RATES FOR COMBINING AND FOR THRESHING BEANS; CENTRAL ILLINOIS, 1928-1929, 1932, AND 1935

Method of harvesting	Types of rates						
	Bushel basis		Acre basis		Acre and bushel basis		
	Rate	Number of cases	Rate	Number of cases	Rate		Number of cases
					Acre	Bushel	
1928-1929							
Combining.....	\$.18	1	\$3.00	2	\$1.00	\$.25	1
	.20	3	3.25	1	1.25	.20	4
	.25	7	3.50	7	1.50	.12	2
	.30	1	4.00	14	1.50	.15	2
	...	..	4.25	1	2.00	.08	2
	...	..	4.50	9	2.00	.10	5
	...	..	5.00	1	....	....	..
* Total.....	...	12	....	35	....	....	16
Threshing.....	\$.05	1	....	..	....	....	..
	.07	2	....	..	....	....	..
	.08	6	....	..	....	....	..
	.09	1	....	..	....	....	..
	.10	36	....	..	....	....	..
	.11	5	....	..	....	....	..
	.12	5	....	..	....	....	..
	.15	13	....	..	....	....	..
	.17	2	....	..	....	....	..
	.18	2	....	..	....	....	..
	.20	11	....	..	....	....	..
	.25	4	....	..	....	....	..
Total.....	...	88	....	..	....	....	..
1932							
Combining.....	\$.08	1	\$1.00	1	\$1.00	\$.05	7
	.10	3	1.50	1	1.00	.06	3
	...	..	2.00	26	1.00	.10	1
	...	..	2.25	7	1.25	.04	1
	...	..	2.50	7	....	....	..
Total.....	...	4	....	42	....	....	12
Threshing.....	\$.04	5	....	..	....	....	..
	.05	16	....	..	....	....	..
	.06	3	....	..	....	....	..
	.07	2	....	..	....	....	..
	.10	4	....	..	....	....	..
	.15	1	....	..	....	....	..
Total.....	...	31	....	..	....	....	..
1935							
Combining.....	\$.10	1	\$1.50	1	\$1.00	\$.04	1
	...	..	2.00	5	1.00	.05	4
	...	..	2.25	3	1.00	.06	2
	...	..	2.40	1	1.25	.05	1
	...	..	2.50	46	1.25	.06	3
	...	..	3.00	1	1.50	.05	1
Total.....	...	1	....	57	....	....	12

conditions, amount of beans grown in community, prevailing custom rates, and force of competition. Because of such variations, custom rates for harvesting will probably never become entirely standardized.

Time of Harvesting

Because of the likelihood of unsettled weather at the time soybeans are harvested, speculation has arisen about which method of harvesting for grain involves the less hazard. Binder cutting begins somewhat earlier than combining, but the greater labor requirements

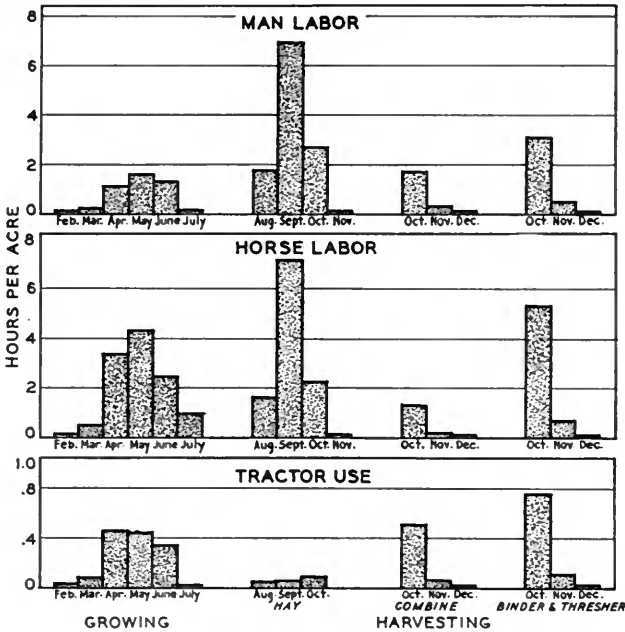


FIG. 4.—SEASONAL USE OF MAN LABOR, HORSE LABOR, AND TRACTOR USE IN PRODUCING THE SOYBEAN CROP

Heaviest work on the soybean crop in the before-harvest period comes in April, May, and June, at the same time as the heavy work for corn. And the time of harvesting soybeans for grain coincides with that of corn. There is no competition between these crops at harvest time, however, when soybeans are harvested for hay.

per acre in harvesting with a binder (Table 10, page 367) may create some hazard if the acreage to be harvested is large, since the threshing of the beans competes directly with corn husking (Fig. 4).

On the farms in Champaign and Piatt counties on which detailed cost-of-production records were kept from 1929 to 1933 a large

portion of the beans was harvested by the two methods during October and a small portion carried beyond the end of November. Practically every year, however, a few fields of soybeans are to be observed standing far into the winter, with consequent loss from shattering and deterioration in quality; and instances of complete loss of the crop are by no means uncommon. In 1935, for example, a considerable acreage of beans remained uncut thruout the winter as a result of wet weather in November and heavy snowfall during the winter months. Such delays in harvesting usually result from dependence upon a hired machine whose operator has contracted more custom work than he can do under average or adverse conditions. The increase in number of combines in recent years has reduced such losses, but the increase in number of combines was offset in 1935 by the great expansion in acreage planted to beans.

Such losses from late harvesting serve by reducing the yield to increase directly the unit cost of producing the soybeans, and by a deterioration in quality of the product to decrease the income and the margin of profit, if any, on the crop.

Losses in Harvesting¹

Losses of soybeans during the harvest season are usually greater, proportionally, than losses of other crops. Such losses are smaller, as a rule, when beans are combined than when they are bound and threshed. With either method of harvesting, losses occur from cutting the beans too high, from shattering of pods in the field, and from grain being blown out with the straw because of faulty machine adjustment in threshing.

Total losses during the harvesting of soybeans varied from 15 to 41 percent in tests with various methods of harvesting, not including combining, made in 1925 by the Department of Agricultural Engineering at the University of Illinois. The various methods of harvesting tested were: beating, mowing and threshing, reaping (self-rake reaper) and threshing, and binding and threshing. Combines were at that time new machines in Illinois and were being modified frequently for greater adaptability to soybean harvesting. In the years from 1927 to 1930 numerous tests made on combines operated by farmers under normal field conditions showed average total losses ranging from 11.4 percent in 1927 to 6.9 percent in 1930. In 1929 a series of tests on losses in both methods of harvesting showed average losses of 9.0 percent in combining and 19.3 percent in binding and threshing.

¹This section on soybean losses was prepared by A. L. Young, Assistant Chief in Agricultural Engineering.

Proper adjustment of machines and care in pitching in the field will frequently reduce losses. In either method of harvesting (binder-thresher or combine), 80 percent or more of the total loss usually consists of pods that are missed by the cutter bar. When threshing is done from the shock, workmen often leave many beans where the shocks are gathered up, a loss that could be greatly reduced by raking the shock rows or having pitchers do cleaner work with their forks. The number of soybeans escaping with straw and chaff may become excessive in combining if the machine is operated carelessly or too rapidly. This loss is normally quite low with stationary threshers.

Another common loss, often excessive with both combine and stationary thresher, is damage from the splitting and cracking of the beans. The chief causes of splitting and cracking are: (1) high cylinder speeds; (2) too many concave teeth; and (3) concave and cylinder teeth bent or improperly spaced. Normally the cylinder speed in threshing beans need not be more than half that recommended for wheat. The operator should use as few concave teeth as possible and yet not leave an excessive number of beans in the pod. Special thin concave teeth are sometimes used to reduce splitting and cracking but the use of fewer teeth, with the concaves lowered, gives about the same result, tho more pods may pass thru without being threshed.

Good cleaning often requires the use of special sieves and screens. Openings in screens must be larger than for other grain if weed seeds and pieces of broken beans are to be properly removed. Unless screens are of the nonlogging type they must be watched carefully. Normally a strong blast of air can be used to facilitate good cleaning. If, however, too many hulled beans are forced into the tailings and return to the cylinder, they are then more apt to be cracked than when going thru the first time.

Value of Straw Differed With Method of Harvesting

Any value gained from the straw of the soybean crop would of course serve to increase the total income from, or the general profitableness of, the crop. Beans that are cut with binders are usually cut while a considerable number of leaves are still on the stems, and consequently the straw makes a good roughage feed. By the time the beans are dry enough to combine, however, the leaves have fallen and the straw consists of stems and pods, which have little feed value. Straw from the combine is commonly spread by the machine and later is plowed under for soil maintenance.

Method of Disposing of Beans¹

Beans for seed usually bring considerably higher prices than those sold for commercial use. The disposition of the beans therefore affects the income from the crop. The rapidly expanding acreage under the unusually high prices prevailing in the years studied (1928-1929) and the heavy demand for seed of the Illini variety, which was then coming into general use, doubtless affected the proportion of beans held for seed purposes (Table 12).

TABLE 12.—DISPOSITION OF SOYBEANS TO DECEMBER 31, IN TWO AREAS OF ILLINOIS, 1928, 1929, 1930^a

Method of disposition	Central Illinois			Montgomery county		
	1928	1929	1930	1928	1929	1930
<i>Mill beans</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>	<i>perct.</i>
Sold.....	72	44	72	43	42	33
On hand ^b	5	5	3	4	2	6
Total.....	77	49	75	47	44	39
<i>Seed beans</i>						
Sold.....	7	14	2	1	15	2
On hand ^c	16	37	23	52	41	59
Total.....	23	51	25	53	56	61
Number of farms giving data.....	87	95	75	26	18	15

^aData for 1930 from a survey of farms included in study in 1928 and 1929.

^bIncludes beans held for feed.

^cIncludes beans held for seed on farm where grown or for sale as seed.

Since the records in this study were closed at the end of each calendar year, or somewhat in advance of the time the seed market became active, no information was available as to whether the beans held for seed were actually so used. That growers in the central Illinois area in 1929 overestimated the demand for seed in expecting to use half their crop for this purpose is indicated by the fact that they kept a much smaller part of their crop for seed in 1930, or an amount about equal to that so reserved in 1928.

The prices received for beans sold for seed and the values placed on seed to be sold indicate the profits derived from seed sales. Some of the cooperators each year valued seed on hand at the price of mill beans, which averaged about \$1.20 a bushel in 1928 and \$1.45 in 1929, but usually seed values were estimated at about 50 cents a bushel above current milling prices.

During the period of rapid acreage expansion, which has continued

¹The discussion here is limited to practices on the farms studied. A more complete treatment of marketing is given in Bulletin 376 of this Station, "Supply and Marketing of Soybeans and Soybean Products."

to the present, seed demands have provided a remunerative market for many growers whose product has been suitable for seed purposes. The development of new, high-yielding varieties, like the Illini, serves to maintain a satisfactory seed market until such varieties become generally available. The profit to be derived from soybeans when sold at seed prices has doubtless stimulated the acreage expansion.

In the Montgomery county area a smaller portion of the crop was harvested for seed or milling purposes than in the central Illinois area, and yields were lower; hence a larger portion of the threshed beans was normally required for seed. The demand for seed of hay varieties provided a good market.

During the past few years when lower price-levels have prevailed, the margin of prices of beans for seed over prices for mill purposes has narrowed, and it is unlikely that seed beans will again have, in general, as much price advantage as they held in 1928-1929. Shortages of seed supplies in relation to demand, however, may give rise to extremely favorable seed prices for limited periods, as in the summer of 1934, when greatly increased planting of beans because of drouth and the AAA crop-reduction programs caused a seed shortage and resulted in seed prices ranging from \$1.50 to \$2.00 a bushel when prices for mill beans were about 80 cents in August.¹

INCOME AND PROFIT FROM THE CROP

The income from soybeans is largely a matter of yields produced and market prices. Profits depend, of course, upon the difference between production costs and income.

Soybean crops returned good incomes and substantial profits in 1928 and 1929 because of a combination of high yields and favorable prices (Table 3, page 353). Since that time changes in economic conditions have caused definite changes in production costs and prices, altho yields have been maintained. Year-by-year records of soybeans harvested with combines in Champaign and Piatt counties illustrate these changes (Table 13). From 1932 to 1934 total costs per acre were nearly uniform at about three-fifths of the 1930 figures. Early in the period gross income per acre declined even more, relatively, than costs, but almost regained its 1930 position by 1934. Net losses instead of profits occurred during the first four years of this period, but by 1934 net profits of \$4.54 an acre were obtained as a result of increased income and radically lower costs.

¹During the planting season there are, as a matter of fact, no mill prices for beans. Farmers who have beans are not interested in mill prices so long as there is a seed market.

Harvest-time prices of soybeans also declined early in the five-year period—from \$1.45 a bushel in 1929 to \$1.00 in 1930 and 30 cents in 1931—and then advanced gradually to 40 cents in 1932, 60 cents in 1933, and 74 cents in 1934. In 1934 the price exceeded for the first time since 1929 the net cost per bushel of growing and harvesting the crop.

The price of soybeans, as of other grains, is frequently lowest at harvest time. Consequently, since many farmers store their beans at harvest time, the price finally obtained may have been considerably more than that at which the incomes listed in Table 13 were figured.

TABLE 13.—INCOME AND PROFIT FROM SOYBEANS HARVESTED WITH COMBINES; CHAMPAIGN AND PIATT COUNTY FARMS, 1930 TO 1934
(Data are from detailed cost-of-production records)

Year	Number of farms	Acres	Total cost per acre	Total income per acre*	Bushels per acre	Net profit per acre	Price at harvest	Net cost per bushel
1930.....	7	248	\$24.39	\$21.08	20.5	\$ -3.31	\$1.00	\$1.16
1931.....	9	462	19.19	7.37	24.8	-11.82	.30	.77
1932.....	9	393	14.85	12.51	31.2	- 2.34	.40	.48
1933.....	19	842	15.05	13.87	23.0	- 1.18	.60	.65
1934.....	32	1 623	14.89	19.43	26.2	4.54	.74	.57

*Includes values of straw and pasture.

Any gains obtained by the farmers from holding the beans would of course reduce the losses or increase the profits shown in the records.

In 1928 and 1929 the average yield of 23 bushels an acre was a record, but the yields listed in Table 13 indicate that 23 bushels an acre are not a higher average than may normally be expected. Records from 30 cost-accounting farms in 1935 show an average yield of 27.3 bushels an acre on 2,049 acres.

The influence of costs, yields, and prices on net profits are well illustrated in a comparison of 1930 and 1934 costs, incomes, and profits. As a result of high costs in 1930 the soybean enterprise resulted in a loss, whereas in 1934 low acre-costs and high acre-yields enabled these farmers to make a profit even tho the total income from this crop was less than in 1930.

HARVESTING SOYBEANS FOR HAY

Soybeans harvested for hay are used almost entirely for feed on the farms where grown. In the central Illinois area most growers harvest only small acreages of soybeans for hay, cutting these, as a rule, from borders or light-yielding areas in grain fields. In the Mont-

TABLE 14.—PROPORTION OF SOYBEAN ACREAGE CUT FOR HAY ON GROUPS OF FARMS IN TWO AREAS OF ILLINOIS, 1928 TO 1930

Year	Central Illinois		Montgomery county	
	Number of farms	Soybean acreage cut for hay	Number of farms	Soybean acreage cut for hay
1928.....	87	<i>perct.</i> 12	26	<i>perct.</i> 34
1929.....	95	7	18	18
1930.....	75	11	13	34

gomery county area, however, hay is relatively more important and hay varieties are frequently planted (Table 14).

Furthermore the harvesting of soybean hay usually involves little cash outlay, if any, unless the hay is baled, and for this reason, probably, little attention has been given to costs. Harvesting costs for soybean hay, as well as total costs, are summarized in Table 15.

Altho the methods used in harvesting soybean hay are in general the same as methods used with other hays, the practice of curing bean hay in shocks to a greater extent than is common with other hays results in the use of a comparatively large amount of man and horse labor, for loaders cannot be used with hay in shocks and the work

TABLE 15.—SUMMARY OF HARVESTING COSTS AND TOTAL COSTS PER ACRE IN PRODUCING SOYBEAN HAY

	Central Illinois ^a	Montgomery county ^a	Champaign and Piatt counties ^b	
	1928-1929	1928-1929	1928-1930	1931-1933
Harvesting costs				
Man labor.....	\$2.90	\$2.18	\$3.38	\$2.06
Horse labor.....	1.44	.96	1.78	.93
Tractor use.....	.03	.05	.02	.04
Machinery.....	.30	.30	1.19 ^c	.91 ^c
Baling and miscellaneous.....	1.62	.10	.....	.....
Total.....	\$6.29	\$3.59	\$6.37	\$3.94
Before-harvest costs.....	\$8.83	\$8.44	\$11.87	\$6.25
Operating costs.....	\$15.12	\$12.03	\$18.24	\$10.19
Taxes.....	1.95	.82	1.89	1.71
Interest on land.....	8.61	4.11	8.78	7.74
Total.....	\$25.68	\$16.96	\$28.91	\$19.64
Yield, tons.....	2.16	1.43	2.06	2.13
Net cost a ton.....	\$11.89	\$11.90	\$14.89	\$9.37
Number of acres.....	837	475	216	442

^aFrom Table 3.^bFrom Table 1.^cIncludes cost of baling.

must consequently be done by hand. Bean hay is cured in shocks in order to give stems and leaves a chance to dry evenly and also to give some protection against spoilage, for rains and prolonged damp weather are not uncommon during the harvest season. The heavy stems contain large amounts of moisture, and the leaves shatter easily when too dry; but when cured in shocks, the leaves remain fairly tough until the stems are well dried.

Soybean hay costs more per acre than biennial hays sown with nurse crops, because the costs for ground preparation, seeding, and cultivation must be charged directly to the hay crop and cannot be spread over two or more years or shared by a nurse crop. Because of these high costs, soybean hay, even with good yields, seldom returns an income large enough to show a direct profit, altho the net cost per ton is not excessive for good legume hay.

The drouth of 1934 emphasized the value of soybeans as an emergency hay crop. Altho a considerable part of this emergency acreage was planted too late to give maximum yields, it supplied much valuable feed. Likewise in 1935 farmers were forced to depend to a larger extent than usual upon annual hay crops because only a small proportion of new seedings of other hays withstood the drouth.

PLACE OF SOYBEANS ON CENTRAL ILLINOIS FARMS

On the farms included in the enterprise-cost studies in 1928 and 1929, soybeans occupied about one-sixth of the total acreage and one-fifth of the harvested-crop acreage. Since that time soybean production in Illinois has been greatly expanded both by a more general distribution of the crop over the state and a greater concentration in the areas of heaviest production (Fig. 1, page 345). The extent of this concentration is indicated by the records of crops grown in 1935 on 102 farms located in nine of the ten counties comprizing the central Illinois area.¹ On these farms soybeans occupied 36 percent of the total acreage and 42 percent of the acreage in harvested crops. Altho the acreage of soybeans on the farms included in the study both in 1928-1929 and in 1935 was larger than the average acreage of soybeans on all farms in the area (for only those farms growing soybeans were included in the study), the records nevertheless show how important a place the soybean crop holds on many farms.

Over a period of years the place of a crop in the cropping systems

¹Data for 1935 were secured in connection with a study of combine harvesting, a study which did not include farms in the Montgomery county area.

of an area is determined in part by the cost incurred in production and the income and profits obtained and in part by the relationship between that particular crop and the general organization and operation of the farms in the area. Data on costs, income, and profit from the soybean crop have been presented in the preceding sections of this bulletin. The more general relationships which affect the acreage of soybeans—relative profitableness as compared with other crops, place in the crop sequence, competition with other crops for labor and power, feed requirements for livestock, and adaptability for emergency uses¹—are discussed in this section.

Relative Profitableness of Soybeans

The farms of the central Illinois region included in these studies are nearly all located in the area of cash-grain farming, where corn has long been the major grain crop and oats or wheat, or both, are important small-grain crops. The recent rapid increase in soybean acreage in this area has come about largely as a result of the substitution of soybeans on part of the acreage formerly given to other grains. In 1928 and 1929 the average acreage of soybeans on the farms studied exceeded that of either oats or wheat and stood second to corn (Table 16). In 1935 soybeans occupied a larger acreage than corn, and thus ranked first of all crops in acreage. This larger acreage of soybeans than of corn on the 102 farms studied in 1935, and the slight advantage in profitableness which soybeans, when harvested with a combine, had over corn on the farms keeping detailed cost records in Champaign and Piatt counties for the five-year period 1930-1934, must be interpreted in the light of the unusual conditions which affected corn and soybean crops thruout this period and particularly in 1934 and 1935.

¹In 1928 and 1929 the farms in the Montgomery county area averaged in size about 60 acres smaller than those in the central Illinois area, grew about one-half as many acres of soybeans, and somewhat smaller acreages of small grains. Acreages of legumes other than soybeans were somewhat smaller and pasture acreages somewhat greater. The amount of livestock was about the same in the two areas, but the proportions of the various kinds of livestock differed considerably. The Montgomery county area had fewer numbers of work animals, more dairy cows, sheep and poultry, and fewer numbers of other cattle and of hogs.

These differences in crops and livestock corresponded to differences in soils and topography. The farms studied in the Montgomery county area were quite diversified, with grain, livestock, and livestock products for market, whereas the farms in the central Illinois area marketed grains chiefly. Because of these differences in conditions, a larger proportion of the soybean crop in the Montgomery county area was harvested for hay and less competition occurred with other crops in labor and power requirements. Emergency uses of soybeans in this area were similar to those in the central Illinois area.

TABLE 16.—AVERAGE ACREAGES OF CROPS PER FARM ON FARMS SUPPLYING DATA; CENTRAL ILLINOIS AREA, 1928, 1929, AND 1935

Land use	Average acres per farm			Percentage of farm area		
	1928	1929	1935			
	88 farms	94 farms	102 farms	1928	1929	1935
Corn.....	124.3	112.7	87.1	41.0	39.3	27.8
Oats.....	45.3	31.5	25.4	14.9	11.0	8.1
Wheat.....	10.6	27.7	29.8	3.5	9.6	9.5
Barley.....	10.0	4.9	.....	3.3	1.7	.....
Soybeans ^a	49.8	47.2	112.8	16.4	16.5	36.0
Alfalfa.....	3.0	2.0	5.5	1.0	.7	1.8
Red clover.....	5.6	10.2	5.4	1.8	3.5	1.7
Sweet clover.....	3.0	2.2	.6	1.0	.8	.2
Timothy.....	5.3	1.5	1.4	1.7	.5	.5
Miscellaneous crops.....	1.7	2.6	2.2	.5	2.6	.7
Total crop acreage.....	258.6	242.5	270.2	85.1	84.5	86.3
Pasture.....	37.3	37.0	34.5	12.3	12.8	11.0
Farmstead and waste.....	8.0	7.8	8.3	2.6	2.7	2.7
Total farm area.....	303.9	287.3	313.0	100.0	100.0	100.0

^aIn 1928 and 1929 only those farms growing soybeans, and in 1935 only those farms where combines were owned, were included in the study, and consequently the average acreage of soybeans on these farms was undoubtedly higher than the average acreage of soybeans on all farms in the area.

During the earlier years of the period 1930-1934, prices of all crops were abnormally low, and farmers were consequently more ready than they would have been under normal conditions to make shifts in crop acreages if such shifts appeared to promise an increase in income. And during the latter part of the period AAA programs, chinch bugs, and drouth combined to encourage the planting of larger acreages of soybeans. In 1934 and 1935 the limitations on acreages of corn and wheat under the AAA program released a considerable acreage to crops which were not so restricted. The severe chinch bug infestation of 1934 curtailed yields of corn and oats in that year, and the threat in the spring of 1935 of continued damage resulted in some shift in acreage from corn and oats to crops not susceptible to chinch bug damage. The severe drouth in 1934 likewise reduced the yields of corn and oats to a greater extent than of soybeans and damaged the seedings for 1935 meadows. These conditions influenced many farmers to make maximum reductions in corn acreage under their AAA contracts and to plant much of this acreage to soybeans, in order to obtain both the corn benefit payments and the soybean crop from such land.

Because of these abnormal conditions obtaining during the years covered by this study, neither the relative acreages of corn and soybeans nor their relative profitableness during the period of abnormal prices provides an adequate basis for ascertaining the relative positions

of the two crops during a period of normal relationships. Over a longer period the crop which proves to be the most profitable may be expected to occupy the larger acreage unless the advantage of profit is offset by other limitations.

Place of Soybeans in Crop Sequence

The extent to which soybeans may displace oats and wheat in the rotation is limited by the use of small-grain crops as nurse crops in which to seed grass and legumes for hay, pasture, or soil-building.

While most of the farms studied in the central Illinois area had about the proportions of crops indicated in Table 16, page 381, relatively few farmers had established a definite cropping plan. The sequence of the crops preceding soybeans therefore varied widely but did not greatly affect the yield of beans (Table 17).

When account is taken of the influences upon yields, discussed earlier (pages 356 to 365), the apparent effect of the preceding crop has little significance. On the rather small acreage where soybeans followed oats, the materially higher yields may indicate more available mineral elements in the soil. On the other hand, when soybeans followed soybeans or other legumes immediately, or when there was but one year of a grain crop intervening, no greater yields were obtained, a fact which indicates that a larger amount of nitrogen was of little, if any, benefit. The slightly larger yields that resulted when soybeans followed two years of corn probably indicate merely that the soils were more fertile, since it is on the best land that corn more frequently is grown two years in succession.

TABLE 17.—SOYBEAN YIELDS WHEN SOYBEANS FOLLOWED CERTAIN OTHER CROPS; CENTRAL ILLINOIS, 1928 AND 1929

Preceding crop	Acres		Average soybean yield
	Number	Percent of total	
<i>One preceding crop</i>			
Corn.....	5 018	65.0	<i>bu.</i> 23.1
Soybeans.....	647	8.4	22.8
Wheat.....	450	5.8	22.6
Oats.....	350	4.5	26.8
Miscellaneous ^a	1 250	16.3	21.6
Total or average.....	7 715	100.0	23.0
<i>Two preceding crops^b</i>			
Corn, corn.....	1 694	22.0	24.1
Corn, soybeans.....	1 140	14.7	23.1

^aIncludes, in addition to other crops, many fields which in previous year were divided with different crops on each part; hence relationship of yield to previous crop could not be determined.

^bFirst-named crop preceded soybeans; second was on land two years previous.

Competition With Other Crops for Labor and Power

In the production of soybeans competition for labor and power in growing the crop is more significant than in harvesting it. The operations necessary to prepare the seedbed and plant the seed do not differ greatly from those for corn. Beans are less generally cultivated than corn; and cultivation, when done, requires less time than for corn because of the wider machines commonly used on beans.

The labor and power distribution for the years 1929 to 1933 indicates that the operations involved in growing soybeans center largely in the months of April, May, and June, and thus compete directly with the heaviest demands for labor and power in growing corn (Fig. 4, page 372). This competition doubtless lowers soybean yields somewhat since first attention is likely to go to the corn crop. Altho competition with corn is strongest, a conflict also occurs with other crops whose labor and power demands fall in this peak of spring work.

The method of harvesting the soybean crop has marked effect on labor and power requirements, and hence on competition with other interests. In harvesting for hay, the heaviest labor and power demands are distributed from August into October, with the peak in September. In harvesting for grain, the heaviest demands come in October, with some carryover into November. The conflict during the harvest season is thus chiefly with ground preparation for and the seeding of winter wheat and to some extent with corn harvesting. When wheat follows soybeans, much less work is required to prepare the seedbed, and when the wheat is drilled directly in the soybean stubble, it is sometimes eliminated entirely. The conflict with corn harvesting is usually not serious, since these two operations are best performed under somewhat different atmospheric conditions—corn being harvested to best advantage during the morning hours and on damp days, whereas soybeans are best harvested in afternoons and on dry days. Obviously adjustment to atmospheric conditions is most practical on farms where harvesting equipment is owned, and it is better adapted to the combine method of harvesting beans than to the binder-thresher method.

In general, the requirements of power and labor in harvesting soybeans cause little serious conflict with other crop operations except in years, such as 1935, when unfavorable weather greatly delays harvesting. The conflict during the spring months has been met in part by a more general use of mechanical power, which increases the amount of work one man can do. When crops compete directly, their relative profitableness determines to some extent how the available time and equipment should be used. From this standpoint, soybeans,

a relatively new crop, had some disadvantage in earlier years, but as the crop and its markets have become better established, this handicap has tended to disappear.

Soybeans and Feed Requirements for Livestock

Because of the small average numbers of livestock on the farms in the central Illinois area (Table 18), the necessity of growing feed crops does not form an important limitation upon the acreage of soybeans. Few livestock are kept as compared with western and northern Illinois, and there is normally a surplus of feed grains and an adequate supply of forage feeds. In years when the supply of forage

TABLE 18.—AVERAGE NUMBERS OF LIVESTOCK ON FARMS SUPPLYING DATA; CENTRAL ILLINOIS, 1928-1929 AND 1935

	1928-1929 (178 farms)	1935 (102 farms)
Work stock.....	7.9	4.7
Other horses.....	.9	.9
Dairy cows.....	5.5	6.6
Other cattle.....	9.3	8.2
Sheep.....	7.4	6.5
Sows.....	8.0	3.7
Other hogs.....	51.9	25.1
Hens.....	103.0	82.3

feeds other than soybean hay is less than needed, a larger than usual acreage of the soybean crop is harvested for hay. In areas of heavier livestock production the total acreage of soybeans is more limited, and a much larger proportion is harvested for hay than for grain.

Soybeans as an Emergency Crop

The costs and practices in growing and harvesting soybeans and the yields and profits secured from them, as described in foregoing sections of this bulletin, represent particularly the conditions found in soybean production when the crop is grown as a part of the regular rotation. Soybeans, however, are being used to an increasing extent in various emergency situations in which the practices followed or the time of doing them may vary rather widely. These emergencies arise when wheat has been winterkilled, when legume hay crops have failed or have been winterkilled, when, owing to drouth, hay crops are short, and when late-planted corn or other crops susceptible to chinch bug damage must be replaced.

The most recent widespread winterkilling of wheat in Illinois occurred in 1927-28. In connection with this and other studies in progress at that time, records were obtained of acreages of winter

wheat abandoned and of crops which replaced the wheat (Table 19). In the central Illinois area 90.2 percent of the wheat seeded was abandoned. Corn replaced one-third of the abandoned wheat and soybeans replaced about one-fifth. When soybeans replace winterkilled wheat, little further ground preparation is necessary and the beans can be grown with less than the usual labor and power requirements.

The use of soybeans as an emergency hay crop varies with the

TABLE 19.—REPLACEMENT OF WINTERKILLED WHEAT IN TWO AREAS OF ILLINOIS IN CROP YEAR 1928

	Central Illinois	Montgomery county
Number of farms.....	120	23
Acres seeded to wheat (fall, 1927).....	8 683	1 078
Acres of wheat abandoned.....	7 834	922
Acreages replaced by—	<i>perct.</i>	<i>perct.</i>
Corn.....	33.4	32.2
Soybeans.....	20.0	19.2
Oats.....	18.5	42.1
Spring wheat.....	15.7	....
Barley.....	10.2	....
Miscellaneous.....	2.2	6.5

time and cause of the emergency. The simplest practice is to cut more of the regular soybean acreage for hay in years of hay shortage, a practice that affects only the harvesting requirements. The severe drouth of 1930, which reduced the yields of all hays and destroyed most new meadow seedings made that year, caused some increase in the acreage of soybeans cut for hay in 1930, but it caused a considerably larger increase in 1931.

The drouth of 1934 came much earlier than in 1930 and hence reduced more markedly the yield of hays harvested in June and July. Since this effect of the drouth was evident early in the season, it was doubtless responsible for the increased seeding of soybeans for hay. The total area planted to soybeans in Illinois in 1934 was 1,234,000 acres, an increase of 117 percent¹ over 1933, when it was 568,000 acres. Of this larger acreage, 57.5 percent was harvested for hay, compared with 49 percent in 1933. This wide shift in acreage harvested for hay indicates the adaptability of the soybean crop for such emergency uses.

A further increase in soybean acreage in Illinois occurred in 1935, the estimated total area being 1,866,000 acres, an increase of 51 percent over 1934 acreage.¹ The proportion of the 1935 crop harvested for hay was probably much less than in 1934 because of the favorable season for and the good yields of other hay crops.

¹U.S.D.A. General Crop Report, March 1, 1936.

A part of the general increase in soybean acreage, observation indicates, results from a tendency for many farmers in the central and northern parts of the state to grow small acreages for hay even tho they harvest no beans for market. This tendency is doubtless a result of the higher yields of hay obtained from soybeans than from most other hays and a recognition of the value of soybeans on farms not adapted to growing other legume hays without soil treatment.

While the marked increase in soybean acreage in Illinois in 1934 and 1935 was partly the result of emergency drouth situations and AAA crop-adjustment programs, a considerable share of the increase was caused by prices of soybeans in 1933 and 1934 being relatively higher than prices of other grains. Whether the 1935 acreage will be maintained, or whether it will be increased still more, will in the final analysis depend upon the relation between prices and costs of production and upon the place of the crop in the rotation. Judging from recent increases in acreage and yields, future prices for soybeans would appear to be influenced more by the development of ways to use the crop profitably than by the ability of farmers to grow it. The place the crop will take in rotations will depend upon its ability to compete with other crops in direct profit, to supply feed needs, to use labor and power and equipment advantageously, and to help in the maintenance of the soil.

SUMMARY

Some 250 farms located in the central part of Illinois where soybeans are grown most extensively furnished the basis for this study, which includes an analysis of the costs incurred in producing soybeans and the growing and harvesting practices followed, and the place of this crop in the farming systems of the area. The data were collected over a period of seven years—1928 to 1934.

Soybean Costs. Total acre-costs of producing soybeans on these farms in 1934, the last year of the study, were \$17.95 for beans harvested by binder and thresher; \$14.89 for beans that were combined; and \$16.36 for beans harvested for hay. Land charges (taxes and interest) accounted for about half of these totals, and operating costs for the other half.

During all the years included in the study, operating costs varied considerably from farm to farm. Before-harvest costs differed widely, chiefly because of differences in amounts of labor and power used, in

¹U.S.D.A. General Crop Report, March 1, 1936.

charges for overhead expense, and in seed costs, which varied with prices of seed and rates of seeding. Seed costs were the largest single item in before-harvest costs. Variations in harvest costs were due largely to differences in amounts of labor and power required for harvesting by binder and thresher, by combine, or for hay. Binder-thresher harvesting costs per acre were the highest and combining costs the lowest of the three methods.

During the seven years 1928 to 1934 the cost of producing soybeans declined markedly, largely because of reductions in prices of seed and in rates charged for labor and power. Custom rates for combining and for threshing soybeans declined sharply from 1928 to 1932 with declines in grain prices and increases in number of machines available. In 1935, however, combine rates were again higher, according to supplementary data gathered in that year.

On farms keeping detailed cost records, incomes and profits varied widely from year to year because of changes both in costs and in market prices for both beans and hay. The crop was generally profitable during the years 1928 to 1930; it was grown at a loss in 1931 to 1933 and was again profitable in 1934. From 1930 to 1934 it was slightly more profitable than corn, but price relationships during this period were abnormal and hence the relative positions of the two crops as to profitableness cannot be considered typical.

Variations in Growing and Harvesting Practices. Variations in the practices used in growing soybeans on the farms studied, even when soil and climatic conditions were similar, arose at least in part from the newness of the crop and the rapid expansion of it that has taken place during recent years. Differences in practices caused before-harvest costs to range from \$6 to \$12 an acre.

The amount of man labor used in ground preparation, seeding, and cultivation varied from 1.5 to 10 hours an acre. Horse labor increased simultaneously with man labor, but tractor use was relatively constant. Harvesting with a combine required less than one-third as much man labor per acre and less than one-sixth as much horse labor as harvesting with binder and thresher. Hours of tractor use under the two methods were similar. Farmers who had different kinds of power usually adapted the power unit to the kind of work to be done, thereby increasing the efficiency of their power and reducing operating costs.

Effect of Practices on Yields and Profits. Grain yields increased rather consistently with an increasing input of man labor until the input reached about 5 to 5½ hours an acre. Up to this point each additional hour of man labor resulted in about .94 bushel more beans.

Hay yields were apparently altered but little by the amount of labor put on the crop before harvest. On most farms only limited acreages were harvested for hay. The cash outlay for hay harvesting was small, but the labor input was comparatively large.

Approximately half the before-harvest labor above 2 hours an acre was absorbed in cultivation and, in general, yields increased as the amount of cultivation increased up to and including an average of two cultivations; but there was wide variation in the amount of cultivation even on fields given the same amount of before-harvest labor.

On 85 percent of the acreage planted to beans, the beans were drilled solid. No particular advantage in yield was gained by row planting, tho the acreages so grown may have been too limited to afford valid comparisons.

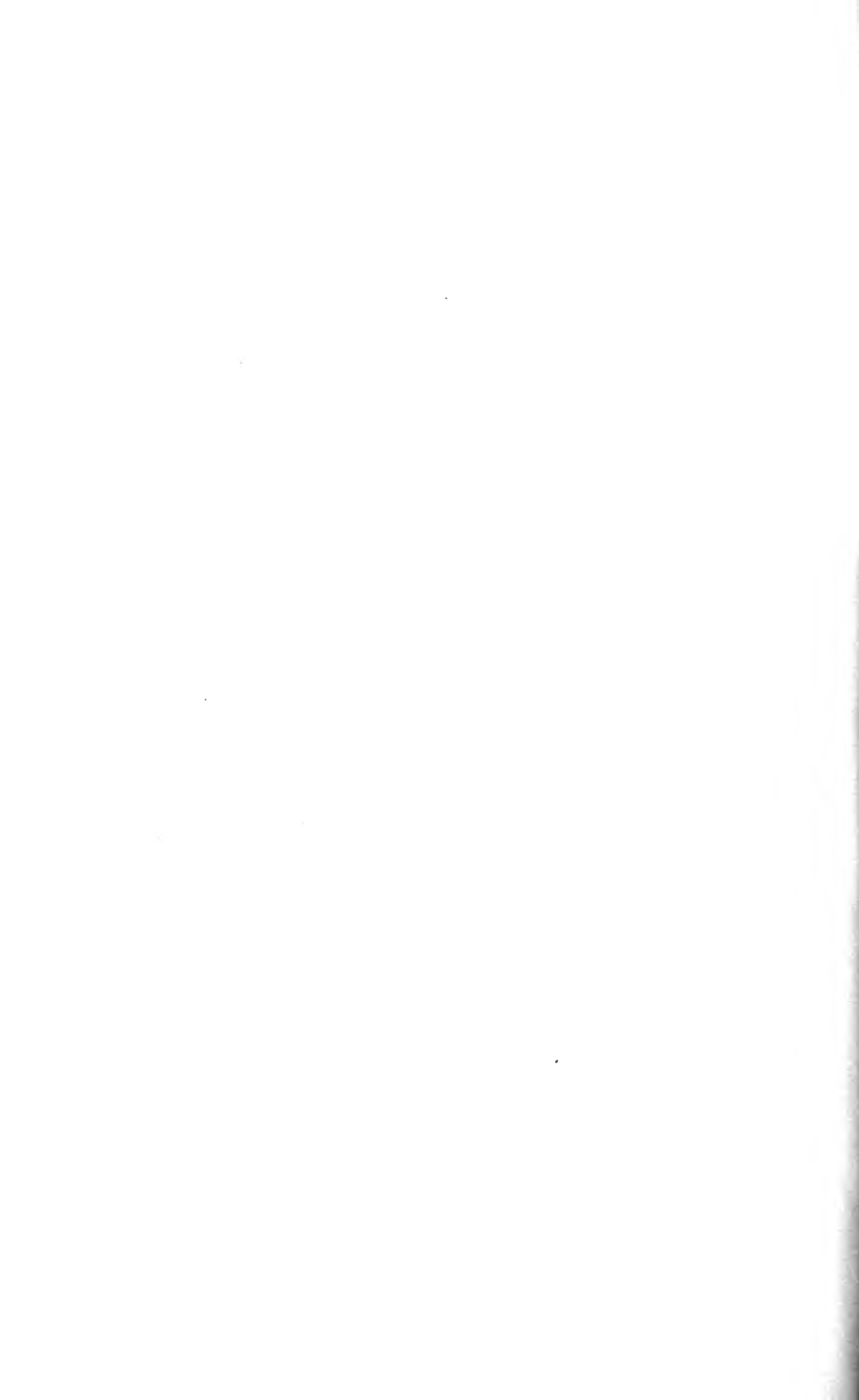
Losses of beans during harvest were much greater with binder and thresher than with a combine. Proper adjustment of machines, together with care in handling both the machines and the beans, reduces harvest losses materially.

Beans for seed commanded higher prices, as a rule, than beans for milling purposes. This price difference of course caused relatively large quantities of beans to be held for sale as seed. Any important advantage in price of seed beans usually occurs, however, only when a new variety is being introduced or when during brief periods supplies of seed are short in relation to demand.

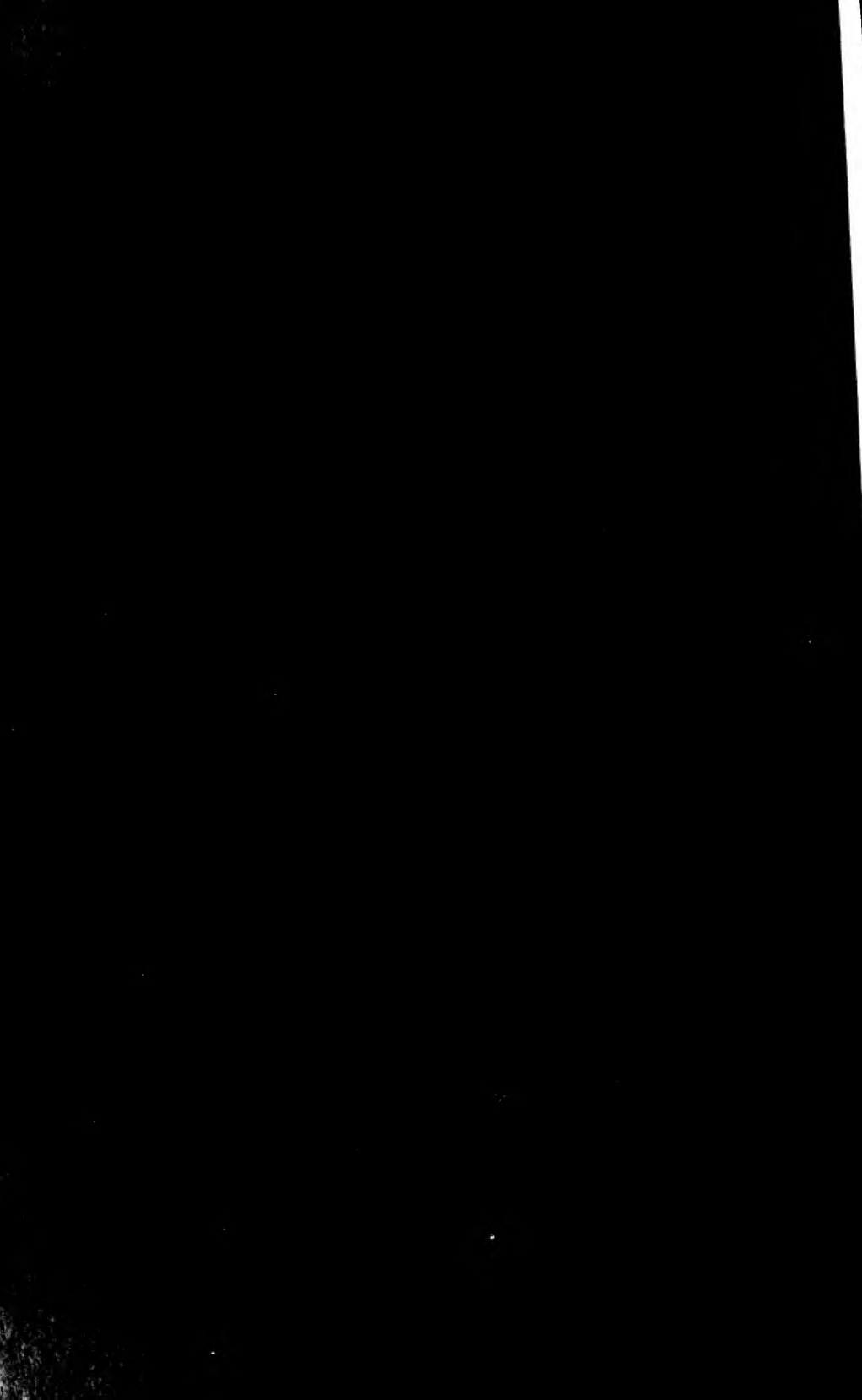
Place of Soybeans in Corn-Belt Farming. Soybean acreage on these farms increased from 16.5 percent of the farm area in 1928 and 1929 to 36 percent in 1935. In 1935 it exceeded even the acreage in corn. This high proportion of soybeans was due in part to the unusual conditions of drouth, to chinch bug threats, and to the AAA programs of that year.

Soybeans served well as an emergency crop to replace winterkilled wheat and to supply hay in years when other forage crops were short.

The replacement of one crop by another, or the general adoption of a new crop in the farming system of an area, usually takes place slowly, because new cultural practices must be learned and various adjustments on the individual farms must be made. The rapid increase in soybean acreage during the decade from 1925 to 1935 indicates that soybeans have passed thru this adjustment stage to a considerable extent. On the other hand, the wide variation from farm to farm in costs and in practices of growing and harvesting soybeans indicates that the process of adjustment is neither complete nor uniform.













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