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SOYBEANS UNDER IRRIGATION IN COLORADO

By D. W. ROBERTSON, ALVIN KEZER and G. W. DEMING

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CONCLUSIONS

From tests conducted at Fort Collins, Colorado, it was found that good yields of soybeans could be obtained under irrigation. The following varieties gave the highest yields:

YELLOW-SEEDED VARIETIES.—Minsoy, Wea, Saskatoon.

DARK-SEEDED VARIETIES.—Soysota and Black Eyebrow.

The highest-yielding variety was Soysota, a brown-seeded bean.

The best date to plant soybeans proved to be late April or early May. When beans are planted after the middle of May, the yield falls off rapidly.

Twenty-inch rows gave the highest yield of grain per acre. A beet planter and cultivator were used successfully in the planting and cultivation of the narrow rows.

Soybeans can be harvested early. While the yield was somewhat lower when the beans were harvested when the plants had lost half their leaves and about 20 percent of the pods were brown, the quality of beans was good. If beans are harvested after they become dead ripe, the yield may be reduced by shattering.

The best yields were obtained with two or more irrigations.

The furrow method of irrigation is recommended when the beans are planted in rows.

Frequent cultivations are necessary to control weeds and keep the soil in good tilth.

No advantage in yield was found in a 3-year test from planting soybeans and corn together.

About 1 and three-quarters tons of hay were obtained from beans planted in 36-inch rows. Slightly higher yields were obtained when the beans were broadcast, but the crop had a high percentage of weeds in the hay.

Oats and peas mixed gave a higher yield of hay and matured about a month earlier than the soybeans.

SOYBEANS UNDER IRRIGATION IN COLORADO

A PRELIMINARY REPORT

By D. W. ROBERTSON, ALVIN KEZER and G. W. DEMING

At the Colorado Experiment Station farm at Fort Collins, a number of different varieties of soybeans have been tested for several years. Several different methods of planting, irrigating and dates of harvesting have been studied. Forage yields of several varieties have also been made and compared with other annual hays. The results of these experiments will be given and discussed in this bulletin.

Historical

According to Piper and Morse,[1] "The soybean is native to Eastern Asia, the wild form of the plant formerly called *Glycine ussuriensis,* being known to occur in China, Manchuria and Korea." The culture of the soybean is recorded in ancient Chinese literature and, undoubtedly, dates from a period long before the time of written documents.

In Colorado, soybeans were not extensively grown until about 1923 and for several years after that date. Due to the fact that other crops furnished protein feeds, their use on irrigated land has not increased. On the dry land, while some varieties are adapted, their general use cannot be recommended until the jack-rabbit damage, particularly to small isolated patches, is reduced.

Climatic Requirements

The average elevation of Colorado is high, which gives it a relatively cool and short season. The large, so-called hay types of soybeans are not adapted. In climatic situations similar to Fort Collins, the medium-maturing varieties are best adapted. Good yields are obtained from several of the midseason sorts. The very early varieties will grow in these climatic situations. But, they do not make full use of the season. They mature before the season is fully completed. In climatic regions much cooler than that of Fort Collins the earliest maturing varieties are possibilities.

Soybeans Under Irrigation

The rainfall during the growing season is not normally sufficient to produce a crop with maximum yield. Supplementary applications of water thru irrigation are necessary.

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[1]Piper, C. V. and Morse, W. J. The Soybean. McGraw-Hill Book Co. 1923.

PREPARATION OF SEEDBED

Soybeans may either be grown for hay or for grain. When grown for grain under Colorado conditions, better results will be obtained when they are grown in rows. A hay crop may be sown broadcast. In preparing the seedbed, similar methods should be used. The seedbed in either case should be well worked and firm.

METHOD OF SEEDING

When sown in rows, good yields under Colorado conditions have been obtained with 20-inch rows, spacing the beans about 3 or 4 inches apart in the rows. A beet planter and cultivating machine can be used with the narrow rows. A corn planter with bean plates or an ordinary grain drill with several spouts closed can be used for planting 30 or 36-inch rows. Lower yields, however, were obtained with the wider rows. A grain drill can be used for broadcasting the beans for hay.

RATE OF SEEDING

The rate of seeding varies with the variety (size of seed) and the method of sowing. When sown in rows, from 20 to 40 pounds of beans are necessary per acre. When broadcast for hay, about 100 to 130 pounds of beans should be used.

DATE OF SEEDING

Under the conditions found at the station, the earlier seeding, April 20 to May 1, gave the best yields. Beans should not be planted until danger of killing frosts is over, and not after the middle of May. After this date the yield of beans decreased very materially.

IRRIGATION

Best yields were obtained from irrigating two or three times. Care should be taken not to over-irrigate. Soybeans are very sensitive to over-irrigation. The furrow method is the best to use. Small and frequent irrigations, when necessary, are recommended, rather than heavy irrigations at longer intervals.

INOCULATION OF SEED

Soybeans, like other legumes, such as clover, alfalfa, etc., should be inoculated with legume bacteria before planting. This is especially necessary if they have not been grown in the field before. Bacterial cultures may be obtained from commercial seed companies at a small cost. In treating soybeans, care should be taken not to soak the beans. Sprinkling a water mixture of the bacteria on the beans is advised. If treated this way, they can be immediately planted without drying.

STAGE TO HARVEST SOYBEANS

Under Colorado conditions, the highest yields were obtained when the majority of the leaves had turned yellow and had dropped. The pods at this stage had nearly all turned brown. No appreciable loss in fat or protein content was noticed if the beans were harvested slightly earlier. Beans harvested after maturity often shatter badly and therefore decrease the yield.

HARVESTING METHODS

When soybeans are harvested for grain under Colorado conditions, the mower or binder can be used. If cut with a mower with side-delivery attachment,[1] the beans can be cocked from the bunches and later hauled in bulk to the thrasher. Rather high small cocks should be used. Soybeans may be cut with a binder, if the crop is

Figure 1.—Soybean variety test plats. Fort Collins, Colorado, 1924.

not too short. Care should be taken, where the binder is used, to keep the twine tension loose so that bundles will not mould under the band. When the beans are lodged, they can be harvested with a binder using lodged-grain guards. Long shocks should be used in curing soybeans, rather than round shocks.

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[1]Morse, W. J. Harvesting Soy-Bean Seed. U. S. D. A. Farmers' Bul. 886.

[2]Reynoldson, L. A., Humphries, W. R. and Martin, J. H. Harvesting Small Grain, Soybeans, and Clover in the Corn Belt with Combines and Binders. U. S. D. A. Technical Bulletin 244.

Table I.—Annual and average yields of soybean varieties grown at Fort Collins, Colorado, for varying periods from 1923 to 1926.

Variety	F. C. No.	Yield in Bushels Per Acre				Average	Yield in Percentage of Minsoy
		1923	1924	1925	1926		
YELLOW-SEEDED VARIETIES							
Wea	1017	26.5±1.7	23.2±2.6	23.2±2.8	28.2±2.3	25.3±1.14	111.5
Minsoy	1036		25.4±2.8	17.8±2.1	26.2±2.1	23.1±1.30	101.8
Minsoy		20.7±1.3	20.8±2.3	27.2±3.2	21.8±1.8	22.7±1.14	100.0
Saskatoon	1018	28.6±1.8	18.1±2.0	19.0±2.3	22.8±1.8	22.1±1.00	97.4
Manchu	1016	27.2±1.7	17.9±2.0	18.0±2.1		21.0±1.22	92.5
Pinpu	1031		16.3±1.8	26.4±3.1	15.0±1.2	19.2±1.08	84.6
Elton Sel.				16.2±1.9	22.6±1.8	19.4±1.24	85.5
A. K.	1025	21.3±1.4	15.1±1.7	25.9±3.8	14.4±1.2	19.2±0.97	84.6
Ito San	1022	22.7±1.4	17.2±1.9	18.6±2.7	16.7±1.4	18.8±0.95	82.8
Mandarin	1020	23.1±1.5	19.5±2.2	13.7±1.6	19.0±1.5	18.8±0.85	82.8
Elton	1019	18.3±1.2	17.2±1.9	19.4±2.3	20.1±1.6	18.8±0.85	82.8
Habaro	1030		16.6±1.8	22.9±2.7	16.6±1.3	18.7±1.05	82.4
Early Yellow	1033		9.9±1.1	24.8±3.0		17.4±1.42	76.7
Dunfield			3.0±0.3	21.2±2.5	9.8±0.8	11.3±0.64	49.8
Midwest		10.6±0.7	5.7±0.6	16.7±2.4		11.0±0.72	48.5
Aksarben			5.6±0.6	16.2±1.9		10.9±0.89	48.0
DARK-SEEDED VARIETIES							
Soysota	1032		19.5±2.2	39.7±4.7	26.5±2.2	28.6±1.61	126.0
Soysota		25.1±1.6	30.1±3.3	22.5±2.7	29.7±2.4	26.9±1.21	118.5
Black Eyebrow	1021	19.5±1.2	20.4±2.3	24.5±2.9	20.6±1.7	21.3±0.96	93.8
Early Brown	1024	21.6±1.4	20.7±2.3	24.7±3.6	13.6±1.1	20.2±1.02	89.0
Chestnut		22.6±1.4	12.6±1.4	19.8±2.4	15.1±1.2	17.5±0.79	77.1
Wisconsin Black	1023	19.4±1.2	13.4±1.5	10.9±1.3	13.5±1.1	14.3±0.64	63.0

Table II.--Date ripe and days to mature of the soybean varieties grown at Fort Collins, Colorado, for varying periods from 1923 to 1926.

Variety	F. C. No.	Days to Mature					Date Ripe			
		1923	1924	1925	1926	Average	1923	1924	1925	1926
YELLOW-SEEDED VARIETIES										
Wea	1017	122	145	113	130	128	Sept. 27	Oct. 5	Sept. 25	Sept. 25
Minsoy	1036		127	88	117	111		Sept. 17	Sept. 1	Sept. 11
Minsoy	Check	106	128	94	117	111	Sept. 11	Sept. 19	Sept. 6	Sept. 10
Saskatoon	1018	121	145	110	Frozen	125	Sept. 26	Oct. 5	Sept. 22	Frozen
Manchu	1016	120	144	112	Frozen	125	Sept. 26	Oct. 3	Sept. 23	Frozen
Pinpu	1031		133	103	124	120		Sept. 25	Sept. 16	Sept. 15
Elton Sel.				92	115	104			Sept. 4	Sept. 9
A. K.	1025	130	145	120	Frozen	132	Oct. 5	Oct. 4	Sept. 30	Frozen
Habaro	1030		136	103	129	123		Sept. 27	Sept. 17	Sept. 20
Ito San	1022	113	139	111	128	123	Sept. 18	Sept. 29	Sept. 23	Sept. 23
Mandarin	1020	107	124	95	122	112	Sept. 12	Sept. 15	Sept. 8	Sept. 16
Elton	1019	113	134	101	124	118	Sept. 19	Sept. 25	Sept. 12	Sept. 18
Early Yellow	1033		Frozen	132		132		Frozen	Oct. 12	
Dunfield			Frozen	127		127		Frozen	Sept. 10	
Aksarben			Frozen	137		137		Frozen	Sept. 18	
Midwest		135	Frozen	129		132	Oct. 10	Frozen	Oct. 10	
DARK-SEEDED VARIETIES										
Soysota	1032		135	105	129	123		Sept. 28	Sept. 21	Sept. 21
Soysota		114	137	108	127	121	Sept. 19	Sept. 25	Sept. 17	Sept. 23
Black Eyebrow	1021	113	132	106	129	120	Sept. 18	Sept. 24	Sept. 17	Sept. 23
Early Brown	1024	116	139	111	129	124	Sept. 24	Sept. 29	Sept. 23	Sept. 23
Chestnut		111	128	96	121	114	Sept. 16	Sept. 19	Sept. 9	Sept. 15
Wisconsin Black	1023	102	110	87	101	100	Sept. 1	Sept. 1	Sept. 1	Aug. 27
Mikado	1043		Frozen							
Menko	1044		Frozen							
Yakotenn	1045		Frozen							

Soybeans can be easily thrashed, when properly cured, with the usual type of bean thrasher. In recent years, some success has been obtained in the use of the combine in harvesting soybeans.[2]

If cut for hay, the crop should be cut before the leaves begin to turn yellow and drop off. The crop should be cut with a mower and raked into windrows soon after cutting and allowed to cure in the windrow before cocking. Care should be taken not to handle the hay when too dry, as a high percentage of the leaves may be lost thru shattering.

EXPERIMENTAL RESULTS AT FORT COLLINS

VARIETY TESTS, 1923 TO 1926.—The varieties were grown in rows 30 inches apart. The seeds were spaced about 3 inches apart in the rows with a small, hand drill. All plats were irrigated twice, the furrow method of irrigation being used. The beans were planted about May 25. At harvest time, 1 foot from each end of the center row was discarded and the remainder of the row harvested for grain yield. Three plats of each variety were grown. These were systematically distributed over the field. The yields are calculated in bushels per acre (60 pounds) and the probable error is determined by the deviation-from-the-mean method. Table I gives the yearly and average yields of the various varieties grown in the test. Due to a discrimination against colored beans, the table has been arranged so that the yellow or green-colored beans are in one group and the brown, black and semi-black beans in another group. Minsoy has been used as a measure of comparison and the last column gives the yields in percentage of the Minsoy variety for the same years. Only two varieties outyielded Minsoy. These were Wea and Soysota. Three other varieties yielded more than 90 percent of the Minsoy check. These were Saskatoon, Manchu and Black Eyebrow. All of the other varieties yielded less than 90 percent of the check. Of the yellow-seeded varieties, Wea, Minsoy and Saskatoon were the highest yielders. Two strains of a brown-seeded variety, Soysota, however, outyielded all other varieties.

The average number of days to mature and the ripening dates are given in Table II.

When we arrange the varieties in order of ripening, Table III, Minsoy ripens in about 111 days and is only outyielded by two varieties, Soysota and Wea. Soysota takes at least 8 days longer, on the average, to mature, and Wea takes 17 days longer. This latter factor will have to be considered before Soysota and Wea can be recommended. Wisconsin Black and Chestnut can be grown in shorter-season sections than those prevailing at Fort Collins. Manchu and Saskatoon were both frozen in 1926 before harvest. In fact, Manchu

Table III.—Average days to mature and number of days to mature for the 22 varieties or strains of soybeans grown at Fort Collins, Colorado, for varying periods from 1923-1926.

Variety	Average Number of Days to Mature	Yield in Percentage of Minsoy	Years Grown
Elton Sel.	104	85.5	2
Minsoy	111	101.8	3
Minsoy	111	100.0	4
Mandarin	112	82.8	4
Elton	118	82.8	4
Pinpu	120	84.6	3
Ito San	123	82.8	4
Habaro	123	82.4	3
Saskatoon	125 Frozen in 1926	97.4	4
Manchu	125 Frozen in 1926	92.4	4
Dunfield	127 Frozen in 1924	49.8	2
Wea	128	111.5	4
A. K.	132 Frozen in 1926	84.6	4
Early Yellow	132 Frozen in 1924	76.7	2
Midwest	132 Frozen in 1924	48.5	3
Aksarben	137 Frozen in 1924	48.0	2
COLORED SEED COATS			
Wisconsin Black	100	63.0	4
Chestnut	114	77.1	4
Black Eyebrow	120	93.8	4
Soysota	121	118.5	4
Soysota	123	126.0	3
Early Brown	124	89.0	4

was not harvested that year. Black Eyebrow, another promising variety, ripened only 10 days later, on the average, than Minsoy.

In summing up, the following varieties are the best for conditions similar to those found at Fort Collins:

YELLOW-SEEDED VARIETIES	DARK-SEEDED VARIETIES
Minsoy	Soysota
Wea	Black Eyebrow
Saskatoon	

DATE OF PLANTING SOYBEANS.—In 1924, 1925, 1926 and 1927, tests were made to determine the best date to plant beans under conditions similar to those found at the station. Plats were planted at 10-day intervals from April 20 to June 9. Five replications of each planting were used, small three-row nursery plats being used for the test. The plats were irrigated twice. No water was applied, however, before the beans had emerged. In 1925, due to the very dry season, the beans did not emerge in any of the plantings until after all the plantings had been made. No yields were taken that year.

Table IV gives the data obtained from the date-of-planting studies. The variety, Ito San, was used in all tests.

Table IV.—Annual and average yields of Ito San soybeans planted at different dates for the 3-year period, 1924, 1926 and 1927.

Date Planted	Yield in Bushels Per Acre			
	1924	1926	1927	Average
April 20	26.3±1.1	11.8±0.9	31.8±1.1	23.3±0.7
April 30	23.6±0.9	9.9±0.7	26.6±0.9	20.0±0.6
May 10	19.2±0.8	6.2±0.5	26.6±0.9	17.4±0.5
May 20	19.8±0.7	4.2±0.3	25.4±1.0	16.5±0.5
May 30	17.5±0.7	3.0±0.2	22.2±0.8	14.2±0.4
June 9	13.5±0.5	1.4±0.1	14.2±0.5	9.7±0.3

From the data in Table IV, it would seem that soybeans should be planted about the first of May. The highest yield of beans was obtained from the earlier planting, but unfavorable weather conditions and frost might damage beans planted at this date.

METHOD OF PLANTING SOYBEANS.—Several methods of planting were used in order to determine the best method under irrigated farming conditions. Use was made of several of the more common seeding implements found on most irrigated farms. The following methods were used:

The spouts of a grain drill were closed so that seed was dropped in rows 30 inches apart. A corn planter was used with bean plates and the rows were spaced 30 inches apart. The same planter was used with a pea attachment instead of the bean plates. A beet drill was set to drill the beans in rows 18 and 20 inches apart. The same

Figure 2.—Method of planting soybeans. Narrow rows (20 inches) planted with beet drill; wide rows planted with grain drill (30 inches).

thickness of dropping the beans was maintained as near as possible with all types of machinery. The beans were dropped about 3 inches apart in the rows. The data from the experiment indicate that the heaviest yields under irrigated conditions were obtained from the narrow rows, 18 and 20 inches. The wider rows, 30 inches, did not yield so well. The pea attachment to the corn planter gave very poor yields. The average yields of the plats were as follows:

Beet drill	18 inches between rows	17.8±0.7 bushels
Beet drill	20 inches between rows	16.5±0.7 bushels
Grain drill	30 inches between rows	14.3±0.7 bushels
Corn planter	30 inches between rows	12.7±0.6 bushels

Figure 3.—Plat of Soysota with leaves about half off and most of the pods mature. Beans harvested at this stage give good yields of grain.

The 20-inch rows are undoubtedly the best as the beans can be cultivated with the usual beet machinery. A low yield was obtained with the corn planter, due to a poor stand. This helped somewhat to lower the yield. However, with a good stand on the 30-inch rows with the grain drill, the yield was slightly lower than that of either the 20-inch or 18-inch rows.

STAGE TO HARVEST SOYBEANS.—It has been found that, under Colorado conditions, some high-yielding soybeans would not mature. In order to determine if soybeans could be harvested before maturity without damaging the quality of the bean, a test was conducted in 1924, 1925 and 1926. Yield data were taken in all 3 years. The beans

harvested in 1925 and 1926 were analyzed for protein and fats soluble in ether.[1] The Mandarin variety was used for this test. The following stages in the growth of the plant were used as harvesting stages:

1. Leaves and pods turning yellow.
2. Leaves yellow, some leaves dropping and a few pods turning brown.
3. Leaves half off, all pods yellow, 5 to 20 percent brown.
4. Majority of leaves dropped. Majority of pods brown, few shatter at harvest.
5. Dead-ripe stems drying.
6. Most of the stem dry, pods beginning to shatter.
7. Stems dry. Pods shattering.
8. Stems dry. Pods shattering.
9. Stems dry. Pods shattering.

After the first date of harvest, the plats were harvested at 5-day intervals and the stage in the development of the plant given. Table V gives the data for yield, ether extract in percentage and protein in percentage. All chemical analyses are based on oven-dry weights. The factor 6.25 was used to obtain the protein percentage. The yield data increase up to stage 5, the dead-ripe stage, altho the difference between stage 4 and 5 is slight. If machinery were used in harvesting, undoubtedly better yields would be obtained if the crop were cut when the majority of leaves had dropped and the majority of the pods were brown. After this stage, many beans might be lost thru shattering. The percentage of protein drops as the season advances, altho the curve is somewhat erratic after the fifth period. The ether extract or fat content increases as the protein content drops, in a general way, altho there is quite a fluctuation in the curve. In general, it might be said that beans harvested when ripe are of high protein and fat content, but the quality decreases if the beans are left to over-ripen in the field. This is particularly true with regard to the protein content. Soybeans may be harvested before ripening, stage 3, when the leaves are dropping and about 5 to 20 percent of the pods are yellow, without any loss in quality, but with considerable loss in yield. Early harvesting "after the leaves have commenced to drop" has more effect on yield than quality of the bean. The range of the 2-year average for protein content is from 35.89 to 37.28 percent and for ether extract from 19.20 to 20.41 percent. The differ-

[1]Prof. R. D. Hockensmith kindly analyzed the beans for fats and protein.

Stage of Maturity	Year	Date	Yield Bushels Per Acre	Average Yield Bushels Per Acre 3 yrs.	Average Yield Bushels Per Acre 2 yrs.	Ether Extract Percentage	Protein
1. Leaves and pods turning yellow	1924	Sept. 1	7.0 ±0.28			19.51	36.84
	1925	Aug. 28	9.32±0.46			18.89	37.72
	1926	Aug. 23	8.24±0.22				
				8.1±0.19	8.16±0.27	19.20	37.28
2. Leaves yellow. Some dropping. A few pods brown	1924	Sept. 6	11.1 ±0.44			20.61	36.84
	1925	Sept. 2	11.08±0.55			19.17	37.40
	1926	Aug. 28	12.16±0.32				
				11.4±0.26	11.09±0.25	19.89	37.12
3. Leaves half off. All pods yellow 5 to 20 percent brown.	1924	Sept. 11	12.5 ±0.50			20.57	36.67
	1925	Sept. 7	16.76±0.98			20.18	37.40
	1926	Sept. 2	15.80±0.41				
				15.0±0.39	14.63±0.39	20.38	37.04
4. Majority of leaves dropped, majority of pods brown, few shatter at harvest.	1924	Sept. 16	14.9 ±0.60			20.45	36.21
	1925	Sept. 12	20.16±1.0			19.70	37.66
	1926	Sept. 7	18.08±0.47				
				17.7±0.42	17.53±0.58	20.08	36.94
5. Dead-ripe stems drying	1924	Sept. 20	16.4 ±0.66			20.16	36.32
	1925	Sept. 17	18.84±1.01			20.45	36.59
	1926	Sept. 13	17.16±0.45				
				17.5±0.43	17.62±0.60	20.31	36.46
6. Most of the stems dry, pods beginning to shatter	1924	Sept. 26	14.12±0.56			20.29	35.44
	1925	Sept. 22	17.18±1.16			19.13	38.35
	1926	Sept. 17	16.68±0.44				
				16.2±0.45	15.65±0.64	19.71	36.89
7. Stems dry, pods shattering	1924	Oct. 1	13.9 ±0.56			20.31	35.50
	1925	Sept. 28	17.84±0.88			20.50	36.29
	1926	Sept. 22	16.44±0.43				
				16.1±0.38	15.54±0.52	20.41	35.89
8. Stems dry, pods shattering	1924	Oct. 6	11.2 ±0.45			20.22	36.19
	1925	Oct. 2	18.76±0.93			20.48	36.54
	1926	Sept. 27	16.48±0.43				
				15.5±0.37	14.98±0.52	20.35	36.32
9. Stems dry, pods shattering	1924	Oct. 11	12.0 ±0.48			20.32	36.92
	1925	Oct. 9	19.46±0.97			19.98	36.46
	1926	Oct. 4	15.08±0.37				
				15.6±0.38	15.73±0.54	20.15	36.69

ence in range between the highest and lowest percentages is 1.39 for protein and 1.21 for ether extract. Seven replications, eight plats, were used in the yield tests. The chemical analyses were run on composite samples.

TIME OF IRRIGATION.—In order to determine which was the best time to irrigate soybeans, several different applications and combinations of time of application were made in 1924 and 1925. Four plats of each treatment were grown in 1924 and five plats in 1925. The furrow method of irrigation was used and, as nearly as possible, a uniform amount was applied at each irrigation. No actual measurements were taken. This may have some influence on the results. Since the experiment was conducted for only 2 years, the results should be considered only as an indication. Table VI presents the data obtained. In 1924, early irrigations seemed to retard growth. The data from both years indicate that two irrigations, one when the plants are about 6 inches high and the other at flowering, give good results. Good yields were also obtained when three irrigations were applied.

Soybeans are very sensitive to over-irrigation and great care should be taken not to supply too much water at one time. Small frequent irrigations from the time the plants are 6 inches high to podding give good results.

MIXTURES OF SOYBEANS AND CORN.—Various methods of planting soybeans and corn were tried in 1923, 1924 and 1925.

METHOD OF CONDUCTING EXPERIMENTS.—Minnesota No. 13 corn was used as the corn variety and Wisconsin Black soybeans were used in 1923. In 1924 and 1925, Ito San soybeans were used. The following methods were used for the 3-year test:

1. Corn and soybeans were planted in the same hill by hand.
2. Corn planted in hills; soybeans in hills between the corn hills.
3. Soybeans and corn were planted in alternate rows with a corn planter.
4. Soybeans and corn planted in alternate hills by hand.

In planting soybeans with corn, the beans are usually planted at the same time and in the same rows with the corn. Special attachments can be used for this method of planting; the attachments consist of separate boxes placed on the planter and operated by an additional gear wheel. In the experiments in which the corn planter was used, a special pea attachment was used for planting the beans. In this way, the corn and beans are kept separate in the boxes, but dropped together in the row or hill.

Table VI.—Time to irrigate soybeans in Colorado in 1924 and 1925.

Stage Irrigated	Date Planted	Dates Irrigated			Days to Mature	Ether Extract Percentage	Protein Percentage	Yield Bushels Per Acre
1924 Data								
No irrigation	May 16				91	18.28	40.94	10.2±0.67
1 Irrigation								
3 inches high	May 16	6/16			94	20.49	34.33	8.2±0.53
6 inches high	May 16	7/3			93	20.85	35.38	11.9±0.77
2 Irrigations								
3 inches and flowering	May 16	6/19	8/4		95	21.09	33.58	9.3±0.60
6 inches and flowering	May 16	7/3	8/4		95	20.29	34.74	11.3±0.73
6 inches and pod forming	May 16	7/3	8/12		96	20.71	33.98	12.7±0.82
3 Irrigations								
3 inches high. Budding and pod forming	May 16	6/16	7/22	8/12	95	21.52	32.17	11.5±0.74
1925 Data								
No irrigation	May 22	6/1			99	20.01	37.64	11.0± 1.0
1 Irrigation								
Flowering	May 22	7/28			102	20.41	35.80	9.8± 0.9
2 Irrigations								
First trifoliate leaf well formed and flowering	May 22	6/25	7/28		104	20.58	34.09	16.1± 1.4
Fourth trifoliate leaf and 6 in. high	May 22	6/25	7/8		99	21.06	34.63	12.8± 1.1
Early budding and pod forming	May 22	7/13	8/13		104	22.07	31.15	13.5± 1.2
3 Irrigations								
Fourth trifoliate leaf, 6 in. high and flowering	May 22	6/25	7/8	7/28	104	20.98	33.81	15.9± 1.4
Fourth trifoliate leaf, 6 in. high and podded	May 22	6/25	7/8	8/13	101	21.33	33.17	15.0± 1.3
First trifoliate leaf well formed Early budding and pod forming	May 22	6/25	7/13	8/13	104	22.43	31.52	16.0± 1.4

Several methods of using the planter to drop the corn and beans were tried in 1924 and 1925. The following combinations were used:

5. Corn and soybeans in hills. Corn planter and pea attachment.
6. Corn in hills, beans drilled in same row. This method required two rounds to sow each set of rows. The corn was planted first and a second sowing was made to drop the beans.
7. Corn and beans in hills. Seed mixed in same box. Bean plates were used in the corn box.
8. Corn and beans drilled. Corn was planted alone in 1923 and 1925 and the soybean yields alone are taken from the adjacent variety test.

The plats used consisted of three or four rows 132 feet long. The middle rows were harvested and the yields calculated as shelled corn weighing 56 pounds per bushel and beans weighing 60 pounds per bushel. The plats were irrigated twice. Table VII gives the yields of beans and corn in bushels.

The corn retards the growth of the beans, as only small yields were obtained, especially when they were planted in the same row or

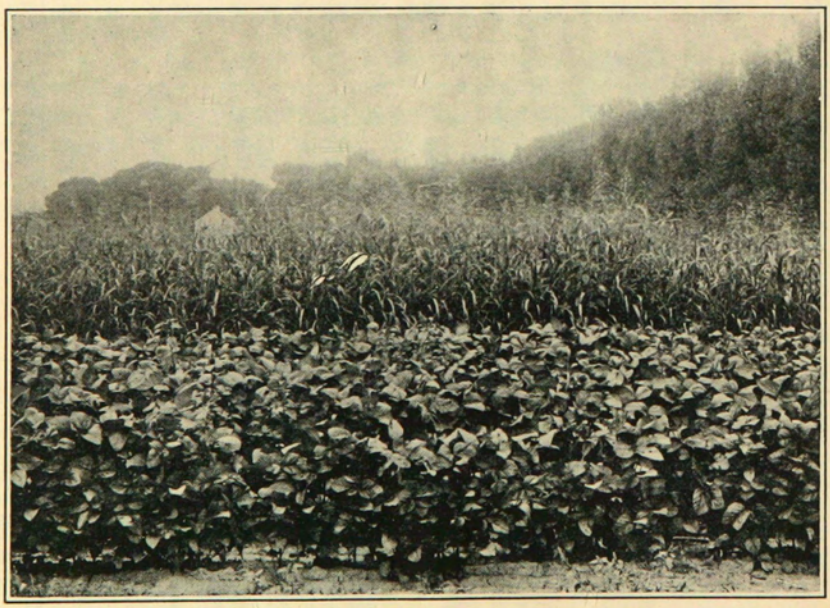

Figure 4.—Soybeans sown for hay. Sudan grass in the background.

		Yield Bushels Per Acre				Average Pounds	
		1923	1924	1925	Total	Average	Per Acre
Corn and soybeans in hills	Corn	76.90	40.60	51.8	169.3	56.4	3158
	Beans	1.09	1.60	3.4	6.09	2.03	122
	TOTAL	77.99	42.20	55.2	175.39	58.5	3280
Soybeans planted between hills	Corn	61.80	38.50	51.1	151.4	50.5	2828
	Beans	2.10	2.60	4.0	8.7	2.9	174
	TOTAL	63.90	41.10	55.1	160.1	53.4	3002
Soybeans and corn in alternate rows (hills)	Corn	49.7	28.5	35.4	113.6	37.9	2122
	Beans	2.20	4.7	7.5	14.4	4.8	288
	TOTAL	51.9	33.2	42.9	128.0	42.7	2410
Soybeans and corn in alternate hills	Corn	50.8	36.3	45.3	132.4	44.1	2470
	Beans	2.55	3.0	4.1	9.65	3.2	192
	TOTAL	53.35	39.3	49.4	142	47.3	2662
Corn and soybeans in hills. Corn planter and pea attachment	Corn		45.9	62.5	108.4	54.2	3035
	Beans		0.6	1.4	2.0	1.0	60
	TOTAL		46.5	63.9	110.4	55.2	3095
Corn in hills. Beans drilled in same row	Corn		26.9	41.0	67.9	34.0	1904
	Beans		3.9	5.4	9.3	4.6	276
	TOTAL		30.8	46.4	77.2	38.6	2180
Corn and beans in hills. Seed mixed in box	Corn		39.6	46.9	86.5	43.3	2425
	Beans		1.5	3.6	5.1	2.6	156
	TOTAL		41.1	50.5	91.6	45.8	2581
Corn and beans drilled. Seed mixed in box	Corn		43.4	52.6	96.0	48.0	2688
	Beans		1.7	4.75	6.45	3.2	192
	TOTAL		45.1	57.35	102.45	51.2	2880
Corn—Minnesota 13 alone		69.8		78.3	148.1	74.0	4144
Soybeans—alone		19.4	17.2	18.6	55.2	18.4	1104

hill. There seems to be no benefit to the corn, since in the 2 years, where a comparative test could be obtained with corn, the yield was highest for the corn planted alone. One set of plats in 1923 where corn and beans were mixed outyielded the corn alone. Where the number of hills per acre of corn were reduced, the yields were low. The soybeans replacing the corn could not yield sufficient grain to make up the yield of corn alone or corn and soybeans in the same hill.

When machinery was used, low yields were obtained when the corn and beans were mixed in the grain box. The lowest yield of corn was obtained from the double drilling, but the highest yield of beans was obtained in this mixture.

The results, while only preliminary, would indicate that no benefit in yield of shelled corn or beans is obtained from mixing the seed in the row. Higher yields of corn are obtained when grown alone than the total yield of corn and beans grown together. When beans are grown alone, they far outyield the beans grown with corn.

SOYBEANS FOR HAY.—A test was conducted for varying lengths of time from 1923 to 1927 to determine the value of different annual crops for hay under irrigated conditions in Colorado. The plats were sown in late April or early May, due to the fact that soybeans might be damaged by frost. This gave them an advantage over the oat, barley and field-pea mixtures which can be sown earlier in April, with little danger of frost damage. The soybean crops were sown in rows 36 inches apart and were cultivated and irrigated twice. Some soybean plats were broadcast. The oat, barley, peas, sudan grass and sweetclover plats were sown with a grain drill. The following rates of seeding were used:

When soybeans were sown in rows 36 inches apart, spacing the beans from 4 to 5 inches in the row, from 20 to 35 pounds of beans were used, depending on the variety (size of bean).

When broadcast with a grain drill, about 130 pounds of seed were used.

Field peas were sown at the rate of about 120 pounds per acre.

The oat and pea mixtures were sown in proportion of 1 bushel to 1 bushel.

Sudan grass was sown at the rate of about 50 pounds per acre.

The dates of harvesting varied with the crop. The oat and pea mixtures were cut when the oats were turning yellow. Barley and peas were cut about the same stage. Field peas sown alone were cut when about half the pods were well filled. Sudan grass was cut when the plants were well headed in the early bloom stage. The second crop was cut before frost. The soybeans were cut after the pods were formed, but before the leaves began to show signs of turning yellow and dropping.

Table VIII gives the date of harvesting of the different forage crops. It will be seen from this table that the oats and peas, barley and peas and peas alone can be harvested much earlier than the other forage crops tested. This is an advantage in that the crop can be removed earlier and allows more time for fall preparation, if a winter crop should follow the hay crop.

Yield data were taken on all crops. Field weights were taken and composite samples drawn for moisture determinations. All of the yields are based on oven-dry weights. No attempt will be made in this paper to discuss the feeding values of the different hays—only the yield data will be discussed.

Figure 5.—Soybeans, a good hay crop. This plat yielded 3,784 pounds of oven-dry hay.

Table IX gives the oven-dry weight (moisture free) of hay in pounds per acre of the different annual hays grown in the test. In summarizing the results, it will be noted that soybean hay yields about 1 and three-quarters tons of hay per acre, when grown in rows. The yield of the broadcast plats is slightly higher, but there is danger of over-irrigation when the plats are planted this way. The broadcast plats are more weedy than the rowed plats which are cultivated. Soybeans, while yielding well, take a long time to mature and higher yields can be obtained in a shorter period with an oat and pea mixture. Colsess and peas and peas alone yielded about the same but matured about a month earlier. They were planted too late to obtain the best yields. Sudan grass gave the highest yield. Hubam sweet clover

yielded well but starts slowly. Unless the soil is clean and free from weeds, considerable trouble will be experienced in obtaining good stands. Soybeans may be sown for hay and give a yield of about 2 tons. They should not be sown unless the season is too far advanced for an oat or pea mixture or for field peas alone. If sown, a 20-inch row is recommended, if beet machinery for cultivation is available.

Figure 6.—Hubam sweet clover. Crop is weedy unless planted on very clean land.

Table VIII.—Date of harvesting the various crops at Fort Collins, Colorado, during the years 1923 to 1927.

	1923	1924	1925	1926	1927
Sudan Grass, first cutting	Aug. 17	Aug. 21	Aug. 20	Aug. 9	Aug. 12
Sudan Grass, second cutting	Sept. 27			Sept.	Sept. 17
Hubam sweet clover	Aug. 17	Aug. 29	Sept. 4	Aug. 27	Sept. 3
Oats and peas	July 30	Aug. 8	July 28	Aug. 27	Aug. 12
Colsess and peas	July 19	Aug. 8	July 28	Aug. 9	Aug. 12
San Luis field peas	July 30	Aug. 8	July 28	Aug. 10	Aug. 20
Oats	Aug. 13	Aug. 21			
Marrowfat field peas		Aug. 8	July 28		
A K soybeans	Sept. 5	Sept. 13	Sept. 4	Sept. 7	
A K soybeans, drilled				Sept. 7	
Mongul soybeans	Sept. 29	Sept. 13	Sept. 4		
Early Brown soybeans	Sept. 5	Sept. 13	Sept. 4		
Ito San soybeans	Sept. 5	Sept. 13	Sept. 4		
Manchu soybeans	Sept. 5	Sept. 5	Sept. 4		
Black Eyebrow soybeans	Sept. 5	Sept. 5	Sept. 4		
Soysota soybeans			Sept. 4	Sept. 7	Sept. 3
Soysota soybeans, drilled				Sept. 7	Sept. 3
Wisconsin Black	Aug. 13	Aug. 21			

Table IX.—Hay yields of soybeans and other annual crops grown at Fort Collins, Colorado, for varying periods from 1923 to 1927.

	Yield Pounds of Oven-Dry Hay Per Acre							
	1923	1924	1925	1926	1927	Years Grown	Average Yield	3-year Average 1923-1925
1. Sundan grass	*6856	4295	4300	*7158	*5749	5	5672	5150
3. Oats and peas	4842	4625	4080	5878	6180	5	5121	4516
2. Hubam sweet clover	4126	4446	5907	4962	5430	5	4974	4826
4. Colsess and peas	3934	4177	3773	4972	4380	5	4247	3961
5. San Luis field peas	3739	3846	3294	5450	4680	5	4202	3626
6. Oats	3660	4133	3957			3	3917	3917
7. Marrowfat field peas		3501	3628			2	3565	
11. Early Brown soybeans	3620	3283	4058		4352	4	3828	3654
10. Mongul soybeans	3794	3501	3747			3	3681	3681
8. A K soybeans	3764	3759	4020		3196	4	3685	3848
9. A K soybeans, drilled					5444	1	5444	
12. Ito San soybeans	2832	3977	4018			3	3609	3609
13. Manchu soybeans	3132	3434	4091			3	3552	3552
14. Black Eyebrow soybeans	3080	3549	3883			3	3504	3504
15. Soysota soybeans, rows			4260	4842	3923	3	4342	
16. Soysota soybeans, drilled				5954	4782	2	5368	
17. Wisconsin black soybeans	1738	1817				2	1778	

*2 crops.

DESCRIPTION OF VARIETIES[1]

MINSOY.—A fairly early maturing variety under Colorado conditions. The plants are small and bushy. The pods are medium in size and straw colored.[1] The seed is medium in size and yellow in color. The hilum is clear brown.

WEA.—Matures later than Minsoy under Colorado conditions. The plants are small and bushy. The pods are medium in size.[1] The seeds are medium in size and yellow in color. The hilum[1] is olive gray.

SASKATOON.—Matures in about the same number of days as Wea. The plants are medium in size and bushy. The beans are medium in size and yellow in color. The hilum is brown.

SOYSOTA.—Matures a little later than Minsoy under Colorado conditions. The plants are medium in size and bushy. The beans are medium in size and brown in color.

BLACK EYEBROW.—Plants medium in height and bushy; maturing about as early as Minsoy under Colorado conditions. The seed is yellow-brown, with a black saddle.

1Etheridge, W. C., Helm, C. A. and King, B. M. A Classification of Soybeans. Missouri Research Bulletin 131. 1929.