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Article Summary: Soybeans had proven to be well-adapted to eastern Nebraska, but other crops had been more profitable. The author suggests that by the early 1940s soybeans were becoming a more important crop.

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Soybeans In Nebraska

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Adaptation and Economics of Production

Soybeans have been a very minor crop in Nebraska to date. They bid, however, to become a more important factor in our agriculture. More is known of successful production practices; superior varieties are available; local markets for the grain have been established; domestic and foreign demand have greatly increased; and because of accelerated industrial utilization the ratio of price paid for soybeans compared with that paid for other standard grain crops has turned in favor of soybeans. Furthermore, under present conditions of acreage control and stress of war, special encouragement to increase the soybean plantings of the United States seems to be in the offing. The Federal Government has recently proposed an increase from the 1941 national acreage of 5,550,000 to 7,000,000 acres. A logical outcome would appear to be a westward extension of the recognized soybean territory. How lasting this more western production may be will depend upon the unforeseen developments of the future.

Farmers of eastern Nebraska have been "exposed" to soybeans for many years, but under the prevailing conditions the new crop seemed to lack certain characteristics to bring it into extensive production along with the generally accepted standard crops. Here corn, winter wheat, oats, barley, sorghum, alfalfa, and sweet clover thrived with comparative ease and low cost of production. To insure a successful crop the soybeans require more careful field management for weed control than do any of these standard crops. Competition with weeds, due partly to inexperience, has discouraged many a would-be soybean grower. The necessary tillage for weed control, before and after planting, raises the cost of production under our Nebraska conditions materially above that for oats, which is our least profitable stand-

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ard grain crop and the most logical one to give way to soybeans. Under proper management, weeds may usually be controlled by reasonable practices. More erect-growing and shatter-resistant varieties suitable for combining, and the greater availability of combines, also facilitate harvest and make the crop more attractive from this standpoint. Soybeans, in general, have proved fairly well adapted to eastern Nebraska soil and climate and it is not inadaptation that has held down their acreage. Other crops have simply been more profitable.

About the eastern fifth of the state is best suited for this crop, the area being roughly outlined on the west by a line connecting Beatrice, Genoa and Randolph. While it may be successfully grown farther west under irrigation, it is likely that other crops will prove more profitable because of greater response to the combination of ample moisture and high fertility. Intermittently, depending on the season, attractive yields may be obtained almost anywhere in the state provided suitable varieties are planted. But, in general, production should preferably be confined at first to the eastern area indicated, and further experience will indicate whether more westward production is warranted.

Attention should be called emphatically to the country-wide experience that soybeans are no crop for rolling land. They leave the soil in a relatively loose condition, especially subject to water erosion. Production should therefore be restricted to the more level lands in the best interests of soil conservation.

Plant diseases have not proved a serious factor with the soybeans. The grasshopper is their most serious insect enemy and may do great damage, as with other susceptible crops when prevalent in epidemic numbers. Being highly resistant to chinch bugs, soybeans may be regarded as a definitely suitable crop to replace at least part of the oats and barley acreage where and when this insect threatens, as is now the case in east-central and southeastern Nebraska. This chinch-bug resistance gave their expanding production in Illinois its greatest impetus several years ago.

While enumerating the various pests which need to be considered, the jackrabbit should not be forgotten. In some communities, small isolated plantings of five to ten acres may be virtually destroyed by this unwelcome guest. This has been one

cause of the failure of many small trial plantings. The damage is less concentrated in large fields and in localities where the crop is more general.

A study of the regions where soybeans are most extensively grown in the United States reveals that the crop is concentrated largely in areas where the soil tends to be acid and must be limed for the sucessful growing of alfalfa. Soybeans endure acid soil relatively better than does alfalfa, and therefore are grown to a considerable extent in such areas as a substitute forage crop in place of alfalfa. For example, the great soybean acreage of Iowa is found largely in the eastern half of the state where alfalfa is rather limited. In the western counties of Iowa with soil conditions similar to those of eastern Nebraska, the alfalfa acreage is high and soybeans are only a very minor crop. The crops that farmers grow under a common set of conditions as a matter of their own choice may doubtless be regarded as a fair barometer and guide as to which are the most profitable.

Comparative crop yields, cost of production, location of markets, and relative prices must all be taken into consideration in making this decision as to choice of crops. As an average for thirty years, the Nebraska Agricultural Experiment Station has had a yield ratio of 7 to 3 for corn and soybeans. Under normal conditions in the past the price ratio for these crops has been about 2 to 3. Thus the greater price paid for the soybeans was insufficient to offset the greater yield of the corn. Under current conditions in eastern Nebraska one may expect a yield ratio of about 2 to 1 and the price ratio has assumed the abnormal proportion of about 1 to 2. So long as this more favorable price ratio for soybeans prevails the crop will be definitely inviting.

Comparative farm-price[1] data for various crops are available for the four most important soybean states for the five-year period 1933 to 1937, and these serve to show the price relationships of the recent past. In Iowa these five-year average prices were: Soybeans, $1.04; oats, $0.38; corn, $0.73; and wheat, $0.89. The prices in the four Corn Belt states of Iowa, Illinois, Indiana and Ohio have averaged: Soybeans, $0.98; oats, $0.35; corn, $0.68; and wheat, $0.92.

[1] Prices are summarized from the U. S. Department of Agriculture Yearbook for 1934 to 1938.

In the past the distance to a market has been a deterring factor in the popularity of soybeans as a cash grain crop. Scattered farmers with less than carload lots found freight costs to distant markets prohibitive. The recent location of processing plants for oil extraction and meal manufacture at Omaha and Fremont as well as at St. Joseph, Missouri, provides markets which may be reached by truck.

Official acreage data supplied by the Nebraska State-Federal Division of Agricultural Statistics show an upward trend for soybeans in Nebraska during the last five years. In round numbers, the following annual acreages were grown: 1936, 3,000 acres; 1937, 4,000 acres; 1938, 7,000 acres; 1939, 14,000 acres; and 1940, 20,000 acres. The farmer's chief interest in this crop has been its use for forage, as evidenced by the official estimate that only 20 per cent were planted for the grain in 1940. From the farmers' planting intentions indicated this last spring, the acreage in 1941 promised to be the same as in 1940, though later planting developments make it appear that this year's planting will approach 25,000 acres. A larger portion than usual will doubtless be harvested for grain because of attractive prices.

This does not yet represent a great attraction of our farmers to soybeans, considering that the Nebraska Agricultural Experiment Station has grown the crop for forty years. During this period frequent distributions of seed were made for cooperative testing on farms. Until recently, few farmers grew them longer than two years and then gave them up for the old stand-by crops.

Nine varieties were tested at the Station during 1903 and 1904, with an average grain yield of 16.2 bushels per acre. There is a continuous-yield record for this crop at the Agricultural Experiment Station for the last thirty-two years, beginning with 1909. This record in comparison with the yields of other standard crops as given by five-year averages in Table 1 is of considerable interest and importance.

As an average for the thirty-two years, the respective crop yields were: Soybeans, 14.8 bushels; corn, 34 bushels; oats, 42.8 bushels; winter wheat, 29.0 bushels; and spring wheat, 14.6 bushels. It is interesting to note that soybeans have experienced relatively less yield reduction in the recent years of severe drouth than has corn, though somewhat more than the small grains.

During the seven years of continuous drouth at Lincoln, the Experiment Station averaged the following yields per acre: Soybeans, 6.9 bushels; corn, 5.4 bushels; oats, 26.6 bushels; winter wheat, 18.9 bushels; and spring wheat, 9.3 bushels.

Composition

Soybeans are prized for the high protein content of their forage and the high protein and oil content of the matured beans. Their composition, compared with other forage and grain crops, is shown in Table 2. The composition of the cured forage is very similar to that of alfalfa and red clover hay, all of which greatly surpass such carbohydrate forage as prairie hay and sorghum in their protein content.

The grain of soybeans contains approximately three times as much protein and four times as much fat as oats. Since the meal remaining after oil extraction is a superior protein concentrate for livestock feeding, its composition compared with that of other protein concentrates is also given in Table 2.

Utilization

FEED. Nebraska-grown soybeans have the same utilization as those grown in the more important soybean territory to the east except that a higher percentage is used for forage. According to E. W. Grove, two-thirds of the soybean acreage grown in the United States in 1937 was used as forage, and in 1936 sixty-eight per cent of the grain was crushed for oil extraction. Being extremely high in oil content, the whole grain is unsuitable for feeding hogs as it results in "soft-pork." Thus, except for very limited use in the feed of cattle and poultry, the whole soybean grain should not be thought of as a farm feed. However, after the oil has been extracted at a processing plant, the resulting meal is unsurpassed as a protein-concentrate for feeding livestock. Ninety per cent of all soybean meal has been fed to livestock.

FOOD. Soybeans have an extremely high value as food for human consumption. Especially the oil is extensively used in this manner, entering into the makeup of such commodities as salad dressing, vegetable shortening, and oleomargarine. Many palatable baked foods may also be prepared with the flour, though this has not come into very general use. Special varieties are

TABLE 1. Summary by five-year periods of annual yields of soybeans and other crops; maximum and mean temperatures during the four months, June to September; and annual precipitation October 1 to September 30 Nebraska Agricultural Experiment Station, 32 years, 1909-1940.[1]

Years averaged	Temperature 4 months, June - Sept. Maximum ° F.	Mean ° F.	Precipitation Oct. 1 to Sept. 30 Inches	Yields of grain per acre Corn Bu.	Soybeans Bu.	Oats Bu.	Winter wheat Bu.	Spring wheat Bu.	Barley Bu	Kafir Bu.
Five-Year Periods										
1909-13	106.4	73.8	27.1	39.6	13.0	45.8	37.0	19.0	.....	.....
1914-18	103.0	72.4	28.8	48.0	17.8	53.8	30.6	18.6	.....	.....
1919-23	101.8	74.4	28.5	49.6	20.6	52.2	31.8	15.0	.....	.....
1924-28	102.0	72.2	23.3	36.8	11.0	34.2	24.8	9.8	29.4	25.4
1929-33	105.2	74.8	27.2	35.8	22.8	50.6	35.0	17.8	37.4	54.2
1934-38	108.8	77.0	20.8	3.2	5.8	28.0	18.6	9.8	17.6	12.8
1939-40[2]	110.5	75.8	19.7	11.0	9.0	23.0	19.0	8.0	14.0	19.5
Thirty-two-Year Average										
1909-40	.....	.....	.....	34.0	14.8	42.8	29.0	14.6	.....	.....

highly attractive as a vegetable and are gradually coming to be used.

Not only are soybeans rich in protein and fat, but they are outstanding in their content of calcium, iron, phosphorous, and vitamins B_1 and B_2. Their protein is unusual in that it is a "complete" protein. Because of these exceptional characteristics soybeans are destined to be important in the food rations of the allied armies.

INDUSTRIAL USES. The oil and the protein are the chief constituents of soybeans sought in industry. The oil enters extensively into food products, soaps, paints, varnishes, and many other industrial products. Since great quantities of various oils

[1] The yields are for standard, adapted varieties grown throughout the 32 years as follows: Hogue Yellow Dent corn to 1933 and Krug thereafter, Habaro soybeans to 1923 and Aksarben thereafter, Kherson oats, Turkey winter wheat, Early Java spring wheat, Trebi barley, and Pink kafir to 1934 and Kalo thereafter. The temperature and precipitation data are compiled from annual records of the Nebraska Section of the U. S. Weather Bureau.

[2] Two-year period.

TABLE 2. Composition of soybeans and other grains, forage, and certain by-products.[1]

Crop or by-product	Total dry matter Per Cent	Protein Per Cent	Fat Per Cent	Fibre Per Cent	Nitrogen-free extract Per Cent	Mineral matter Per Cent
Grain						
Soybeans	90.2	36.9	17.2	4.5	26.3	5.3
Corn	88.5	9.7	4.0	2.3	71.1	1.4
Wheat	89.6	13.5	2.1	2.4	69.8	1.8
Oats	91.1	12.0	4.7	10.6	60.2	3.6
Barley	90.4	11.8	2.0	5.7	68.0	2.9
Kafir	88.6	11.2	3.0	2.3	70.3	1.7
Forage						
Soybean hay	90.8	14.8	3.3	28.4	37.0	7.3
Alfalfa hay	90.4	14.7	2.0	29.0	36.4	8.3
Red clover hay	88.2	11.8	2.6	27.3	40.1	6.4
Prairie hay	90.4	5.7	2.4	30.3	44.4	7.6
Sorghum fodder	89.2	6.4	2.5	25.8	47.3	7.2
By-products						
Soybean meal	91.7	44.3	5.7	5.6	30.3	5.7
Cottonseed meal	93.5	43.2	7.2	10.6	27.0	5.5
Linseed meal	91.3	35.2	6.3	8.0	36.3	5.5
Wheat shorts	90.1	17.9	4.5	5.6	57.8	4.1
Wheat bran	90.6	15.8	5.0	9.5	54.3	6.0

are imported annually to augment the limited domestic supplies, increase in the domestic production becomes of special concern in times of warfare. Ship capacity must be conserved for other transportation, or shipping becomes hazardous and rates become prohibitive, thus encouraging home production. Increased production of both animal and vegetable fats is vital to the national welfare at such times.

The protein is a portion of the meal remaining after oil extraction. It is still largely used for livestock feed, though to some extent it does enter into the manufacture of plastics. It has recently been found that a very good substitute for wool may be made from this protein, though it is somewhat more expensive than sheep wool.

Along with industrial discoveries by Industry itself, the Regional Soybean Industrial Products Laboratory, located at

[1] From Nebraska Agricultural Experiment Station Bulletin 322.

Urbana, Illinois, has made important contributions to the use of this crop by Industry. As illustrations, it has perfected the methods for manufacturing plastics and this information is available whenever wanted. A revolutionizing process for separating the drying oil and the edible oil from their natural mixture approaches completion. This will greatly improve the drying properties of the soybean oil for use in paint manufacture and will also improve its quality for food.

A ton of soybeans (33 1/3 bushels) containing 19 per cent oil will yield approximately 250 pounds of oil and 1,600 pounds of meal by the expression method. The remaining 150 pounds is lost as moisture and waste in milling.

Growing the Crop

CROP ROTATION VALUE. Although the soybean is a legume, it has come to be recognized as having materially less soil-improvement value than do alfalfa, sweet clover and red clover when grown in the rotation. Alfalfa and the clovers leave the soil higher in available nitrogen supply. Accordingly they have a greater beneficial effect on succeeding crops in years of favorable rainfall and under irrigation. On the other hand, in years of severe moisture-deficiency, crops suffer less from over-stimulation following soybeans. Soybeans are rated as a soil depleting crop by the U. S. Department of Agriculture Soil Conservation Service.[1]

VARIETIES. The grain varieties now recommended as a result of experiment station tests are the Illini, Dunfield, and Richland, listed in order from the latest to the earliest. These are suitable for both grain and forage. The Virginia and Kingwa are exclusive forage varieties with dark seeds. Nine additional varieties are being tested in experiment-station field plots and over a hundred selections and hybrids are included in nursery tests. These grain varieties all have the yellow grain color and high oil content as demanded by industry.

Outlying tests of four grain varieties and two forage varieties are this year being conducted in twenty-seven Nebraska

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[1] *Pieters, A. J.* Soil-depleting, soil-conserving, and soil-building crops. U. S. D. A. Leaflet No. 165. 1938.

counties, in cooperation between local farmers, county agricultural agents, the Agricultural Extension service, the Nebraska Grain Improvement Association, the Agricultural Experiment Station, and three processing plants: The Allied Mills, Incorporated, at Omaha, Peter Marr at Fremont, and the Dannen Mills at St. Joseph, Missouri.

SEEDBED PREPARATION. Early-spring seedbed preparation, designed to conserve moisture and to destroy several crops of weeds in the seedling stage before planting the beans, is highly important for successful soybean production. Since planting is seldom done before May 25, there is a period of four to six weeks for this seedbed preparation. A satisfactory procedure is to double-disk cornstalk land about April 10, followed by plowing and harrowing May 1, harrowing again May 15, and double-disking May 25 just before planting.

SEED INOCULATION. When soybeans are grown on land for the first time it is important to inoculate the seed with the necessary bacteria before planting. This may be done through the use of pure commercial cultures of the bacteria or by application of soil from an inoculated field where beans were successfully grown the previous year.

MANNER AND RATE OF PLANTING. Soybeans may be grown either in cultivated rows or drilled like small grain. Solid drilling is not recommended because of greater weed hazard. In Nebraska Experiment Station tests averaged for a twelve-year period, cultivation rows spaced 35 inches yielded 16.4 bushels compared with 9.1 bushels for solid drilling. In these tests essentially equal yields were obtained whether the rows were spaced 28, 35, or 42 inches. Best results are obtained in eastern Nebraska from spacing viable seed 1½ to 2 inches apart when dropped in rows 35 to 42 inches apart. This provides sufficient plants to permit sacrificing some in the tillage operations to control weeds. Approximately 30 to 40 pounds of seed per acre, depending upon seed size, are required in such planting in cultivated rows. An additional bushel of seed is required when close-drilled. The depth of planting should be 1 to 2 inches. Listing is not recommended be-

cause too much of the plant is covered in cultivation. Seed may be successfully surface-planted by properly adjusted grain drills, and corn planters fitted with bean plates. Furrow-openers on corn planters and also furrow grain drills have proved satisfactory.

TIME OF PLANTING. Planting should be delayed in this region until about May 25 to June 5, since this provides opportunity for previous destruction of several crops of weeds with the plow, harrow, and disk. Late planting should be avoided for a grain crop, as the most desirable varieties require the entire season to mature.

TILLAGE. The need for thorough tillage to control weeds prior to planting has been stated. Whether the beans are solid-drilled or in cultivated rows, it is commonly advisable to harrow or rotary-hoe before they emerge and two times additional before the plants exceed six inches in height. Thereafter two or three cultivations with a shovel cultivator are needed. Cultivation should be discontinued before the plants start blooming, about August 1.

HARVEST. Soybeans give the highest yield of good-quality hay if harvested when the seeds are about half developed and three to four weeks before fully ripe. For grain, the crop should mature fully, harvesting when the leaves have fallen and the stems are bare with their clusters of seed pods. At this time the seeds are in the hard-dough stage and the crop may be harvested with either a binder or a mower with side-delivery attachment.

By permitting the crop to cure thoroughly it may be harvested with a combine. Excessive moisture, as with small grain, results in spoilage in the bin.

THRESHING AND STORAGE. Soybeans may be threshed with an ordinary threshing machine by reducing the speed of the cylinder and replacing part or all of the concaves by blank concaves. Broken seeds lower the market value of the crop. In case of heating in the bin, the grain should be spread out thin to dry.

In conclusion, the time seems ripe for a further material increase in the acreage of soybeans. Success and profit are fairly

well assured, at least during the present emergency, if the principles herein set forth are followed. Aside from questions pertaining to the net income, soybeans may be considered with respect to increased crop diversification and increased employment of home labor.

Soybean Bulletins of the Nebraska Agricultural Experiment Station

Bulletin 150. *Soybeans and Cowpeas,* by T. A. Kiesselbach, 1915.
Bulletin 166. *Soybeans,* by T. A. Kiesselbach, 1918.
Bulletin 322. *Soybeans in Nebraska,* by T. A. Kiesselbach and W. E. Lyness, 1939.