Publication No. 807
Farmers' Bulletin 149

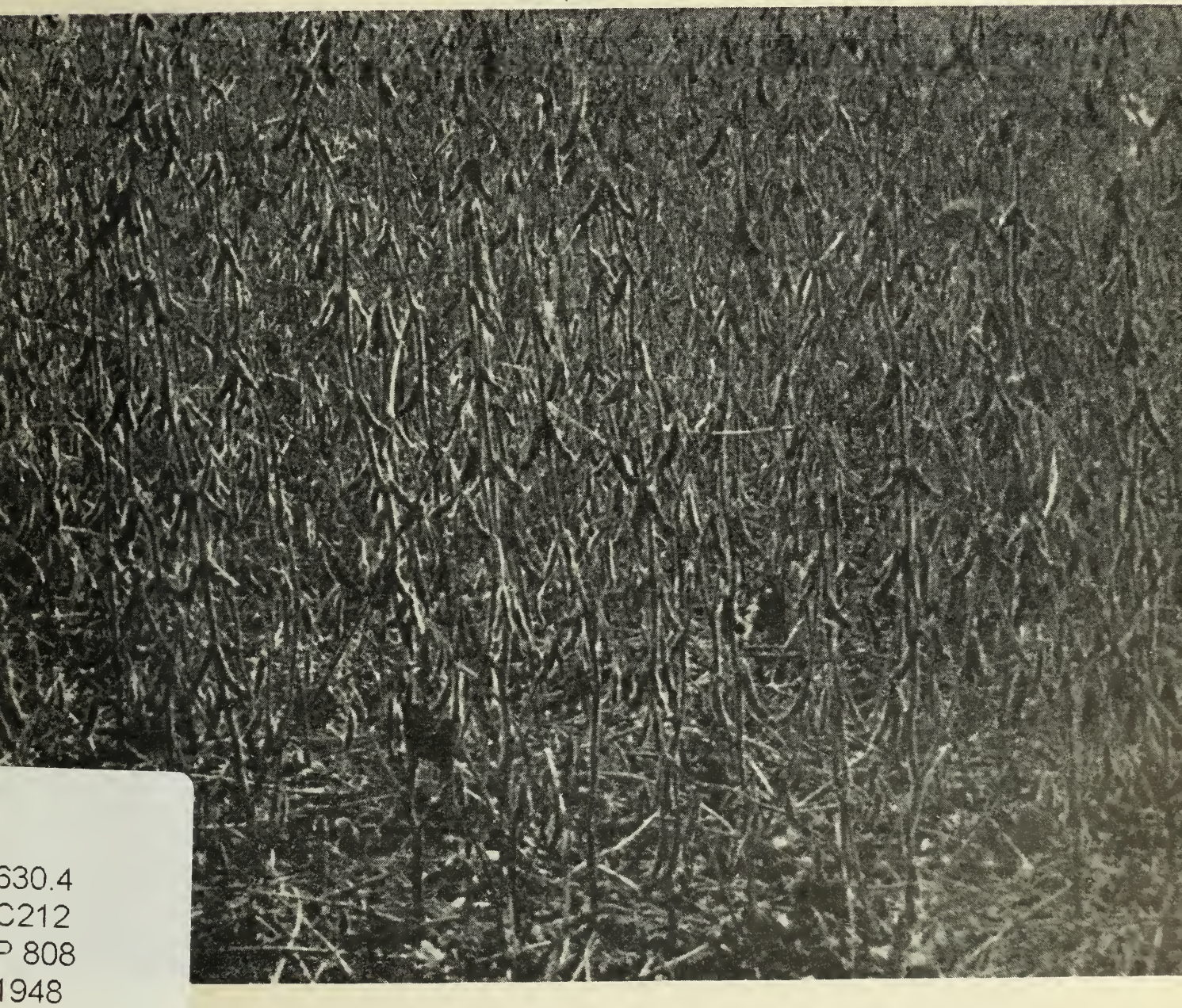
Issued June, 1948
Revision, Farmers' Bulletin 80

DOMINION OF CANADA — DEPARTMENT OF AGRICULTURE

SOYBEANS

By F. DIMMOCK

Division of Forage Plants—Experimental Farms Service



Published by authority of the Right Hon. James G. Gardiner
Minister of Agriculture, Ottawa, Canada

10M-11405-6:48

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SOYBEANS

The soybean is a native of Asia, where it has been of great economic importance for at least 5000 years. It has been grown in Canada to an increasing extent in recent years and has established itself as a valuable addition to the list of field crops. Until 1940 the area devoted to the crop did not exceed 20,000 acres annually, but since then it has increased steadily until it averages 50,000 to 60,000 acres with every indication of still further increase. Nearly all of the present soybean acreage is in Ontario. Small patches are being grown in Quebec, Manitoba, Alberta, and British Columbia and investigations are under way in practically every province to determine the possibilities for soybean production.

Present production of the soybean in Canada is chiefly for seed, which because of its high content of protein and oil, is valuable for both commercial and feed purposes. The industrial uses for which it can be utilized are numerous. In the development of industrial uses for agricultural products the soybean occupies a very prominent place. The seed also has considerable value on the farm for livestock feeding, and since the soybean plant possesses a high nutritive value for fodder, it is quite possible that as production increases, the crop may find an increased use on the farm, as well as in industry.

The Dominion Department of Agriculture has introduced and tested hundreds of varieties and strains of soybeans from various parts of the world during the past 25 years. Through selection and breeding several new varieties have been obtained which are well adapted to a wide range of conditions throughout the country. While it is true that soybeans have a much more limited adaptation in Canada than in the United States, where approximately 10,000,000 acres are grown, the development of these new and better adapted varieties will constantly enlarge the area throughout the Dominion in which the crop can be successfully produced.

Since the soybean is a comparatively recent farm crop in Canada, this bulletin is intended to give information on the characteristics of the soybean plant and seed; its adaptation to soil and climatic conditions; the various purposes for which soybeans are used; the most suitable varieties that are available and general instructions on the growing and handling of the crop.

Description of the Soybean Plant

The soybean is an annual plant belonging to the family, Leguminosae. It has an erect, bushy habit of growth, and varies in height from one to five feet according to variety and season. The stems, leaves and pods are covered with fine, short hairs, either grey or tawny (brown) in colour. In some varieties growth at the tips of the main axis and branches is so slender that there is a tendency towards vining for support. Branching occurs at the lower nodes and varies in amount in different varieties and seasons, and under different conditions of growth. The type of branching may be described as erect, mid-erect, spreading or spreading widely. In the latter types especially, there is a tendency for splitting to occur at the point of attachment of the lower branches to the main stem, causing them to lodge on the ground. To some extent, this appears to be a varietal characteristic, although unfavourable weather during a season of heavy growth may bring about this condition in almost any variety.

12076—2½

A mature soybean plant of good type.

The soybean is normally self-fertilized. Natural crossing occurs to a limited extent but conclusions reached by numerous workers place the amount at considerably less than one per cent. The flowers are small, white or purple in colour, and are borne in axillary clusters. The flowering period of a single plant is comparatively short, hence all of the pods develop and mature at approximately the same time. The pods bear from one to four seeds and their shape and size depends upon the number, shape, and size of seeds contained in them. The seed varies in shape from round to elliptical according to variety. Variety also determines the colour of the seed, which may be yellow, green, brown, or black, or various combinations of these, and in the case of yellow or green seed may have brown or black hilums. Under certain conditions yellow seed seed may show brown or black mottling, the cause of which has not been definitely established. Black mottling may also be observed in green seed. Undoubtedly environment and heredity both have a definite influence on mottling. Mature seed may be lost by shattering, either before, during, or after harvest, through bursting of the pods. This is an objectionable feature and to some extent a varietal characteristic. The amount of shattering is influenced by the nature of the weather at the time it is likely to occur.

The leaves of the soybean are trifoliate, and with the exception of being more or less pointed at both ends, are generally egg-shaped or triangular, with the greatest width towards the base. They vary in shape and size to some extent depending upon variety. In the great majority of varieties the leaves turn yellow and drop off as the plant approaches maturity.

The soybean develops a strong tap-root with numerous branching rootlets. Nodules develop freely under suitable conditions of growth, provided the necessary bacteria are present in the soil or are supplied by direct inoculation of the seed.

Soil and Climatic Adaptation

The soybean is adapted to a wide range of soils but does best on the loam types, sandy to clay loams. Generally speaking the soil requirements are similar to those for corn and other grain crops. A soil too acid for clover will often produce a good crop of soybeans, although under such conditions the application of lime is usually beneficial.

The variation in maturity of soybean varieties gives the crop a wide climatic adaptation. In general, the early maturing varieties require approximately the same seasonal conditions as early varieties of flint and dent corn, while the late varieties are adapted to conditions in which the late dents are successfully produced.

Uses of Soybean Seed

The mature seed of the soybean plant is valuable on the farm for feeding to livestock, while commercially it has a multiplicity of uses which are constantly being extended. It contains on the average 30 to 40 per cent of protein, 15 to 20 per cent of oil, and 25 to 30 per cent nitrogen-free extract, starch being almost entirely absent. Composition of the seed of any one variety appears to be influenced considerably by the environment in which it is produced.

Soybean seed is a protein concentrate. It is a valuable source of protein in the grain rations of dairy cattle, beef cattle, sheep and brood sows. It should not be fed to market hogs in any quantity, because the high oil content tends to produce soft carcasses. For dairy cattle the seed should be ground, but for other livestock the whole beans are satisfactory. Very good results have been reported from feeding the mature seed in the sheaf, thereby eliminating the cost of threshing and grinding. Frequently the seed is ground together with the pods and stems, and fed in the form of a meal. It is a distinct advantage to be able to

feed the beans whole, as there is a tendency for the ground beans to become rancid on standing. Owing to the difficulty of grinding soybeans alone, because of the high oil content, the seed should first be mixed with barley, oats, or corn. It is usually recommended that soybeans constitute about 15 to 20 per cent of the grain mixture for dairy cattle. Feeding trials indicate that soybeans may satisfactorily replace linseed or cottonseed meal as a source of protein for cattle and hogs. The results from feeding whole or ground soybeans to poultry have not been very satisfactory. However soybean meal is an excellent protein concentrate for poultry. Both soybean seed and soybean meal need to be supplemented with a suitable mineral mixture when fed to either poultry or hogs.

TABLE 1.—DIGESTIBLE NUTRIENTS IN 100 POUNDS OF SOYBEAN SEED AND MEAL, LINSEED AND COTTONSEED MEAL[1] BARLEY AND OATS[2] INCLUDED FOR COMPARISON

Feed	Crude Protein	Carbo-hydrates	Fat	Total	Nutritive ratio
	lb.	lb.	lb.	lb.	
Soybean seed	33·2	24·7	16·1	94·1	1 : 1·8
Soybean meal	39·7	34·7	4·5	84·5	1 : 1·1
Linseed meal	30·2	32·6	6·7	77·9	1 : 1·6
Cottonseed meal (prime)	33·4	24·3	7·9	75·5	1 : 1·3
Barley	9·0	66·8	1·6	79·4	1 : 7·8
Oats	9·7	52·1	3·8	70·4	1 : 6·3

[1] From Soybeans in Minnesota, Univ. of Minnesota, Spec. Bull. 134, 1930.
[2] Henry & Morrison, Feeds and Feeding.

In the Orient the soybean is used very extensively for human food. Although the mature beans may be prepared similar to navy or field beans, generally speaking they are more difficult to cook. In the green stage at the time when the beans have become fully developed, they may be used as a vegetable similar to the green pea or lima bean. Boiling the pods for several minutes facilitates the shelling of the beans.

Soybean Oil.—Soybean oil is extracted from the mature beans at the oil mills either by pressure or by the use of solvents. It is a drying oil, inferior in drying qualities to linseed oil but superior in this respect to the semi-drying cottonseed oil. With proper treatment or with suitable driers, soybean oil is being used successfully in certain kinds of paint. It is an excellent source of lecithin and has proved satisfactory as a core binder for foundry work. It is also used in the manufacture of soft soap, enamels, lacquers, varnishes, cooking and salad oils, lard and butter substitutes, waterproof goods, and numerous other products.

Soybean Meal.—Soybean meal or cake is a by-product of the oil extraction process. It is the residue after the oil has been extracted from the beans. The meal produced as the result of the expeller process contains from 4·0 to 5·0 per cent of oil, but the solvent method of extraction reduces the oil content of the meal to one per cent or less. Removal of the oil raises the percentage of protein, which accounts for the fact that soybean meal has a higher protein content than the seed itself. Being rich in protein of high digestibility soybean meal can be used to advantage to balance the grain rations of all classes of livestock. In feeding trials it has compared favourably with other high protein concentrates, such as linseed meal and cottonseed meal. Like the seed, it is deficient in minerals and requires the addition of a simple mineral mixture when fed to poultry or hogs.

As a source of organic nitrogen in fertilizer mixtures for tobacco production, soybean meal compared very favourably with cottonseed meal in experiments conducted by the Dominion Experimental Station, Harrow, Ont.

Soybean meal is being used also in the manufacture of flour, vegetable casein, glue, plastics, sauces, synthetic fibre and many other products.

Soybean Flour.—Soybean flour is made from the whole beans or from soybean meal, and depending upon its origin from either of these is high or low in fat. Flour made from the whole beans tends to become rancid on standing, because of the high content of oil, although it is claimed that treatment by a special process has overcome this objectionable characteristic. Soybean flour is being used successfully in the making of bread, biscuits, muffins, pastry, chocolate bars, etc. and because of its composition it improves the nutritive value of these products. The percentage of soybean flour used varies for each of the products mentioned. On account of its extremely low starch content soybean flour is especially valuable for diabetics.

Uses of the Soybean for Forage and Soil Improvement

The soybean may be grown as an annual hay or as a pasture crop; it may be ensiled or fed green; or it may be ploughed down as green manure to improve the soil.

The soybean is one of the few annual legumes suitable for the production of hay and can be used for this purpose in the event of clover or alfalfa failure. In about three months after seeding it produces hay equal in quality to alfalfa hay, suitable for feeding to all classes of livestock including poultry. Possessing a high content of digestible protein, it can be used to reduce the amount of costly concentrate feeds. It is usually recommended to feed it along with other kinds of hay, as it is claimed that there is a possibility of digestive trouble from feeding soybean hay alone. Choice of a suitable variety combined with seeding at the proper rate and harvesting at the right time will result in the production of good quality hay with fine stems, and will largely overcome wastage which sometimes occurs in feeding soybean hay with a high percentage of coarse stems. The main objection in Canada to the use of soybeans for hay has been the difficulty of curing the crop. This may be overcome to some extent by using varieties that will reach the hay stage during suitable curing weather, combined with seeding rates that will result in the production of fine stems.

Table 2 shows the analysis of soybean hay compared with that of several other crops commonly used for this purpose.

Table 3 shows the analysis of hay produced by soybean varieties grown at Ottawa.

TABLE 2.—ANALYSIS OF SOYBEAN HAY IN COMPARISON WITH OTHER IMPORTANT HAY CROPS[1]

Kind of Hay	Moisture	Ash	Crude Protein	Carbohydrates		Fat	Digestible Protein	Digestible carbohydrate equivalent[2]
				Crude Fibre	Nitrogen-free extract			
Soybean	8·4	8·9	15·8	24·3	38·8	3·8	11·2	44·0
Alfalfa	8·3	8·9	16·0	27·1	37·1	2·6	11·5	42·0
Red clover	12·9	6·9	13·6	24·1	39·1	3·4	8·3	43·2
Timothy	12·5	5·4	6·8	28·3	44·3	2·7	3·3	41·7

[1] From Soybean Utilisation by W. J. Morse, Farmers Bull. No. 1617, U.S.D.A.

[2] The carbohydrate equivalent shown is the sum of the digestible crude fibre and nitrogen-free extract, plus 2·25 times the digestible fat.

TABLE 3.—ANALYSIS OF SOYBEAN HAY PRODUCED AT OTTAWA, ONT.[1]

Variety[2]	Percent Dry Matter						
	Protein (Nx6·25)	Crude fat	Carbohydrates		Ash	Calcium	Phosphorus
			Nitrogen-free extract	Crude fibre			
Mandarin	20·52	2·09	40·36	27·34	9·69	1·52	0·29
Wisconsin Black	20·46	3·14	36·04	31·10	9·26	1·63	0·27
Cayuga	19·10	2·13	38·66	31·02	9·09	1·33	0·27
O.A.C. No. 211	20·95	2·55	39·66	27·64	9·20	1·29	0·30
Kabott	18·73	2·31	42·98	26·32	9·66	1·42	0·28
Goldsoy	19·10	2·68	40·34	28·82	9·06	1·47	0·29

[1] Analyses made by the Division of Chemistry, Science, Service, C. E. Farm, Ottawa, Ont.
[2] Each variety harvested when the beans had developed to approximately half-full size.

Soybean straw obtained from threshing has a definite although limited feed value and can be fed to all classes of livestock. When used in addition to grain it has given better results than corn stover.

While soybeans provide a highly nutritious type of pasture they do not recover quickly when once grazed and consequently under average conditions they are not very productive. When bad weather or other conditions interfere with harvesting the seed crop, it may be hogged off and used to supplement the grain ration. In parts of the United States it is a common practice to seed soybeans and corn together for pasturing both hogs and sheep after the seed has matured.

The use of soybeans alone for silage is not recommended, but high quality silage is produced by a combination of soybeans and corn mixed in the proportion of about one part soybeans to three parts corn. The two crops can be grown together or they may be produced separately and mixed at the time of filling the silo. The most common practice is to grow the two crops together.

A.K. variety being harvested for hay at the Dominion Experimental Station, Harrow, Ont.

The soybean crop may be used very effectively for soil improvement. Being a legume crop, the soybean plant is able to utilize nitrogen directly from the air through the medium of the root nodules. To secure the greatest advantage for this purpose, therefore, it is necessary that the plants be plentifully supplied with root nodules and that the entire crop be ploughed under not later

than the flowering stage. Simply ploughing down the roots and stubble after the crop has been harvested for hay or seed will not increase the nitrogen supply of the soil or have any marked effect upon the soil condition. Only by ploughing under the entire crop at the proper stage can this be done.

Marked improvement in grain crops following soybeans is sometimes observed, however, even when the crop has been harvested for hay or seed, a result which is due probably to the greater availability of nitrogen previously stored by the soybean roots and an effect upon the physical condition of the soil

Varieties

Soybean varieties are very numerous. They include many types and cover a wide range in maturity. In Manchuria, the home of the soybean, almost every district is said to have its own particular strain. In the United States, it is reported that many thousands of seed samples have been collected and planted for study. In Canada, hundreds of samples of seed have been secured from various sources, but only a comparatively few of those tested have been found suitable for growing in this country.

Based upon results of tests conducted by the Dominion Experimental Farms, the following varieties are considered the best of those available at present for production in Canada.

Variety	*Maturity*	*Seed Colour*
Pagoda	Very early	Yellow
Kabott	Early	Yellow
Flambeau	Early	Yellow (black hilum)
Goldsoy	Early	Yellow
Capital	Medium early	Yellow (buff hilum)
Mandarin (Ottawa)	Medium early	Yellow
Earlyana	Medium late	Yellow (pale hilum)
Richland	Late	Yellow (dil. black hilum)
Harman	Late	Yellow (black hilum)
A. K. (Harrow)	Very late	Yellow (buff hilum)
Lincoln	Very late	Yellow (black hilum)

NOTE.—Hawkeye, a promising new variety of similar maturity to Richland, is not included in the above list because of insufficient data.

TABLE 4.—AVERAGE MATURITY PERIOD[1] SOURCE AND ORIGIN OF SOYBEAN VARIETIES

Variety	Average Maturity Period		Source	Origin
	Ottawa	Harrow		
	Days	Days		Selection from
Pagoda	102—108	.....	C. E. Farm, Ottawa	Mandarin × Manitoba Brown
Kabott	113—118	.....	C. E. Farm, Ottawa	Intr. from Ninguta, Manchuria
Flambeau	113—118	.....	A. E. S. Spooner, Wisconsin	Manchu
Goldsoy	116—121	.....	O. A. C. Guelph	O.A.C. No. 211
Capital	119—123	.....	C. E. F. Ottawa	Strain 171. × A. K. (Harrow).
Mandarin (Ottawa)	122—127	114	C. E F. Ottawa	Mandarin
Earlyana	.....	124	A. E. S. Purdue, Ind.	Natural hybrid
Richland	.....	130	A. E. S. Purdue, Ind.	P.I. 70502-2
Harman	.....	131	D. E. S. Harrow	Intr. from Hailin, Manchuria.
A. K. (Harrow)	.....	135	D. E. S. Harrow	A.K.
Lincoln	.....	137	A. E. S. Urbana, Ill.	Mandarin × Manchu

[1]Seeding to maturity.

NOTE:—C.E.F.—Central Experimental Farm.
D.E.S.—Dominion Experimental Station
O.A.C.—Ontario Agricultural College
A.E.S.—Agricultural Experiment Station

Yield.—In general, the yields of soybean varieties vary according to maturity, the later the variety the higher the yield. In recent years several new varieties have been developed, principally through hybridization, which are earlier in maturity than some of the older varieties, and yet yield equally as well or even better. As yields are influenced by so many factors, data from performance trials are not included here, although all of the varieties listed were selected on the basis of their ability to yield in addition to other desirable agronomic characters. Grown under suitable conditions and with proper management any of the varieties should produce satisfactory yields in areas to which they are adapted. The best average yields may be expected from those varieties which require the full season to mature, but can be depended upon to ripen regularly under average seasonal conditions.

Increase field of Mandarin at maturity, grown at Central Experimental Farm, Ottawa, Ont.

Varietal Adaptation.—The adaptation of soybean varieties to the various parts of the Dominion is indicated to some extent by the data presented on maturity in Table 4. Choice of a suitable variety for a locality is very important. There are indications that certain varieties have a much more limited adaptation than others. The following suggested adaptations therefore, must be regarded as general rather than specific. They have in mind the use of the crop for the production of seed.

In Quebec and the Maritime Provinces, Goldsoy, Capital, or Mandarin can be expected to mature only in those areas most favoured with respect to both soil and season. Pagoda, Kabott, or Flambeau should prove suitable in districts with somewhat less favoured conditions. In Ontario, the following recommendations have reference to the areas shown in the map of climatic zones, Fig. 1.

The Prairie Provinces are limited almost entirely to the early maturing varieties, Pagoda, Kabott, Flambeau, and possibly Goldsoy. It is doubtful that soybeans will attain much importance in this area outside of southern Manitoba and irrigated districts in southern Alberta. In British Columbia, Pagoda, Kabott, Flambeau, Goldsoy, and Mandarin have been matured and it seems likely that these varieties may be adapted for production in certain districts. Tests conducted in the Fraser Valley have lead to the general conclusion that weather conditions in that area during the fall season are not too satisfactory for the harvesting of soybean seed to best advantage.

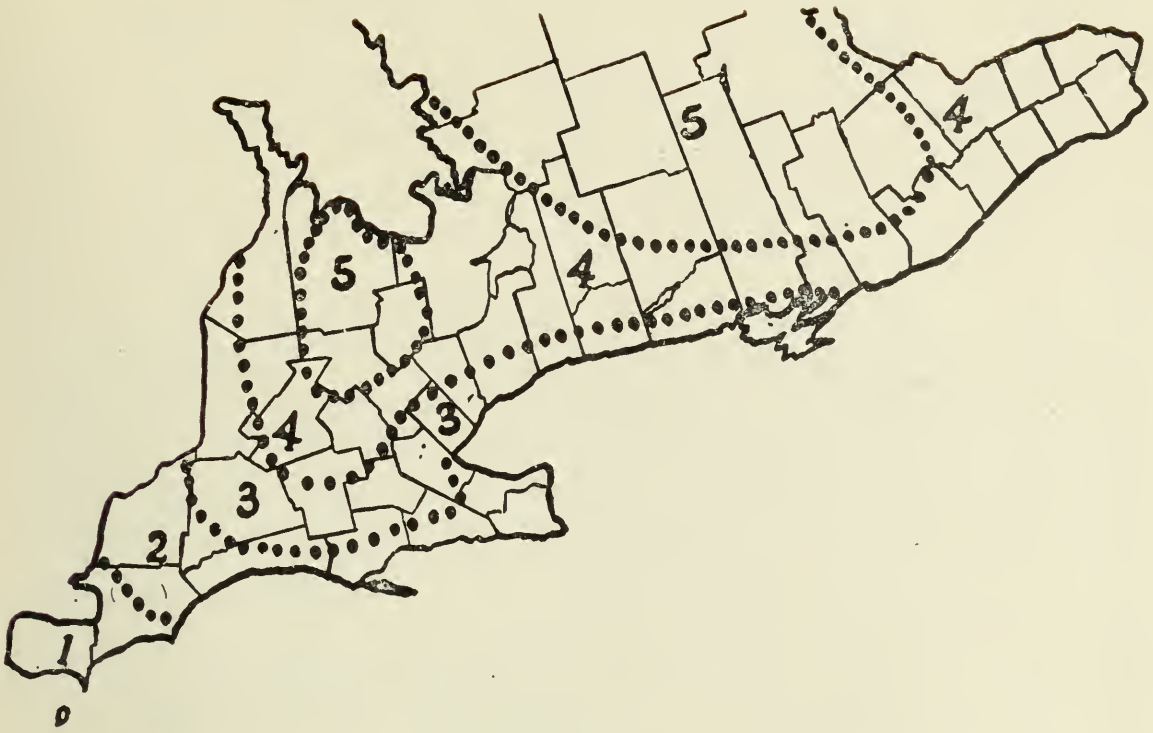


FIG. 1. Ontario climatic zones for soybeans.

Zone	*For later areas*	*For earlier areas*
1.	A.K. (Harrow), Lincoln	Earlyana, Richland, Harman
2.	Richland, Harman	Capital, Mandarin, Earlyana
3.	Earlyana, Richland, Harman	Goldsoy, Capital, Mandarin
4.	Goldsoy, Capital, Mandarin	Pagoda, Kabott
5.	Kabott	Pagoda

Generally speaking the soybean is not too well adapted as a hay crop in Canada, because of difficulties in curing satisfactorily. Where clover and alfalfa can be grown for hay there seems to be no purpose in recommending soybeans, except as an emergency crop.

Varieties best adapted for hay are those that will reach the desired stage of maturity to permit of harvesting during favourable conditions for curing.

In eastern Ontario it is becoming a fairly common practice to use soybeans with corn for silage production. The varieties A.K. (Harrow) and Lincoln seem to be well adapted for this purpose in this area.

Protein, Oil and Iodine Number.—The percentage protein and oil content of soybean seed tends to vary inversely—the higher the protein the lower the oil and vice versa. Grown under the same conditions certain varieties are consistently high protein producers, while others are uniformly high in oil production. The majority of varieties, however, approximate the average in the percentage of protein and oil.

The iodine number is a measure of the quality of the oil from the standpoint of its drying properties. Soybean oil is classified as a drying oil and has an average iodine number of about 130.

The protein and oil content, and iodine number of the oil of soybean seed produced in various parts of the Dominion is presented in Table 5.

TABLE 5.—PROTEIN AND OIL CONTENT OF SOYBEAN SEED AND IODINE NUMBER OF THE OIL[1]

(Moisture-free basis)

Variety	Ottawa, Ont.[2]			Harrow, Ont.[3]			Nappan, N.S.[4]			Fredericton, N.B.[5]		
	Protein	Oil	Iodine No.	Protein	Oil	Iodine No.	Protein	Oil	Iodine No.	Protein	Oil	Iodine No.
	%	%	(WIJS)	%	%	(WIJS)	%	%	(WIJS)	%	%	(WIJS)
Pagoda	38·9	19·7	130	.....	.....	.....	38·1	19·0	134	38·2	18·8	135
Kabott	40·1	19·3	134	.....	.....	.....	38·1	18·2	137	38·7	18·6	138
Goldsoy	38·5	20·7	136	.....	.....	.....	.....	.....	.....	.....	.....	.....
Capital	38·7	20·6	138	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mandarin	38·7	20·2	132	41·6	19·8	127	39·0	19·0	136	37·1	20·0	137
Earlyana	.....	.....	.....	44·2	18·4	133	.....	.....	.....	.....	.....	.....
Richland	.....	.....	.....	40·8	18·0	125	.....	.....	.....	.....	.....	.....
Harman	.....	.....	.....	43·9	18·3	133	.....	.....	.....	.....	.....	.....
A.K.	.....	.....	.....	40·9	19·3	133	.....	.....	.....	.....	.....	.....
Lincoln	.....	.....	.....	41·1	18·9	137	.....	.....	.....	.....	.....	.....

Variety	Lennoxville, Que.[6]			Brandon, Man.[5]			Lethbridge, Alta.[4]			Agassiz, B.C.[7]		
	Protein	Oil	Iodine No.	Protein	Oil	Iodine No.	Protein	Oil	Iodine No.	Protein	Oil	Iodine No.
	%	%	(WIJS)	%	%	(WIJS)	%	%	(WIJS)	%	%	(WIJS)
Pagoda	38·3	19·6	131	41·9	18·6	130	41·9	18·4	132	38·1	19·6	131
Kabott	39·2	18·6	135	44·4	16·5	133	44·9	16·4	136	38·6	19·0	133
Goldsoy										39·4	19·6	134
Capital												
Mandarin	36·9	20·2	133				43·6	17·8	136	37·4	20·1	134
Earlyana												
Richland												
Harman												
A. K.												
Lincoln												

[1] Analyses made by the Chemistry Division, Science Services, Ottawa.
[2] Averages, 12 years, except Goldsoy (8 years), Capital (4 years).
[3] Averages, Mandarin, A.K. (9 years), Harman (7 years), Richland (3 years), Earlyana and Lincoln (2 years).
[4] Averages, 5 years; except at Lethbridge, Mandarin (3 years).
[5] Averages, 8 years.
[6] Averages, 7 years.
[7] Averages, 4 years; except Goldsoy (3 years).

It would seem that the composition of soybean seed is influenced both by heredity and environmental factors. The data in Table 5 show that with respect to Pagoda, Kabott, and Mandarin, the varieties which have been tested at most stations and for a considerable period of years, Pagoda is consistently lower in protein, higher in oil and lower in iodine number than Kabott. Mandarin is generally lower in protein, higher in oil and intermediate between the other two varieties in iodine number. Environmental influences are most noticeable at Brandon and Lethbridge, where lower rainfall than at most other stations tends to increase the percentage of protein and lower the percentage of oil in the seed.

Size of Seed.—Size of seed is of some importance in estimating the amount required per acre in the seeding of any particular variety. Following is the average weight in grams of 1,000 seeds. The weights were obtained from seed grown at the Dominion Experimental Station, Harrow, Ont. and the Central Experimental Farm, Ottawa, Ont.

Pagoda	175	Earlyana	181
Kabott	235	Richland	188
Flambeau	185	Harman	185
Goldsoy	225	A.K. (Harrow)	165
Capital	162	Lincoln	175
Mandarin (Ottawa)	218		

The seed weights may vary to some extent in different years and at different stations, but the relationship between them when produced under similar conditions should remain approximately the same.

The weights do not indicate any relationship between size of seed and either maturity or yield.

Colour of Seed.—Soybean seed colour is important only from the standpoint of commercial utilization, yellow seed being preferred to either brown or black.

Culture

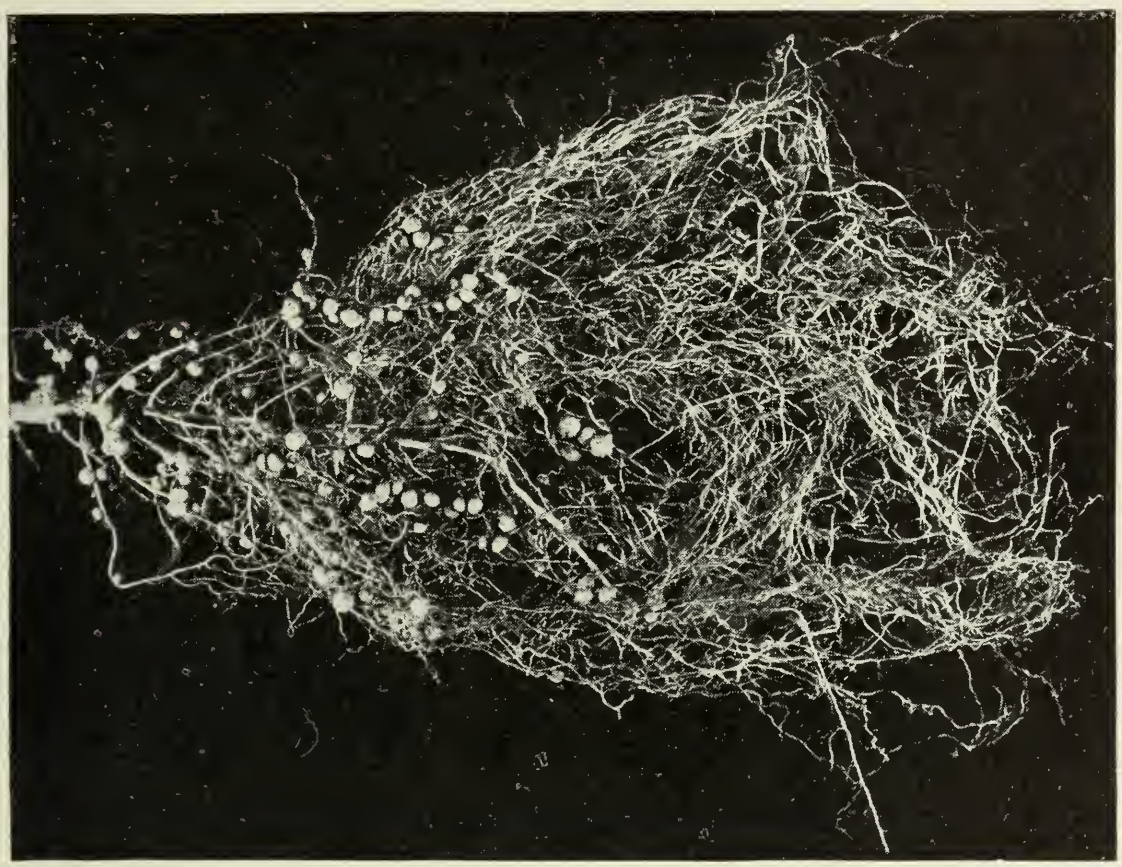
Soil Preparation.—Essentially the same as for corn. Fall ploughing is preferable, followed by thorough working early in the spring to provide a fine, smooth seed-bed. This should be followed by shallow cultivation at intervals before seeding in order to destroy weeds. Proper spring preparation will help materially in overcoming the weed menace later in the season. Unless weeds are effectively controlled by cultivation both before and after planting, they will give the soybean crop severe competition and reduce both the stand and the yield.

Lime and Fertilizers.—Soybeans will grow on fairly acid soils but they do best on soils containing enough lime to grow red clover well. On strongly acid soil the use of lime will be more beneficial than the application of fertilizer without lime, but the requirements of both should be determined and supplied in order to secure best results.

Soybeans will grow on poor soils of low fertility but for most satisfactory returns, the requirements are similar to those of other grain crops. Soybeans are efficient feeders and make good use of residual fertility. Grown following corn that has been well manured and fertilized, they should produce a good crop without the direct application of additional fertilizers. Good crops can be expected also on sod that has been manured and ploughed in the fall. When the crop is well inoculated its nitrogen requirements are largely taken care of, as it is able to secure most of its nitrogen supply from the air, through the nodules on the roots.

Soybeans are fairly heavy users of phosphorus and potash and on soils where these are deficient they must be supplied in amounts sufficient to meet the requirements for a good crop. Where a clover sod has been ploughed down, 0-12-6 fertilizer is satisfactory but on soils low in nitrogen, 2-12-6 should be used. An application of 250 to 300 pounds per acre is recommended.

Soybean seedlings are very subject to injury from fertilizers and for this reason the seed should never be drilled in direct contact with the fertilizer. Unless the drill or planter separates the seed from the fertilizer when planted together, the fertilizer should be drilled into the soil before seeding is done.



Root of soybean plant showing presence of nodules.

Inoculation of Seed.—For best results this is important, especially where the crop is being grown in a field for the first time. One of the most frequent causes of failure with soybeans is the lack of proper inoculation. This is usually indicated in the crop by a yellowish-green colour of the plants which results from nitrogen starvation.

Inoculation of the seed may be best accomplished through the use of pure cultures of bacteria, which can be purchased from many of the commercial seed companies. The necessary instructions for applying the inoculum are supplied with the cultures and these should be followed carefully. Seed should be planted on the same day that it is inoculated.

Another satisfactory method of inoculation is to use soil from a field which produced a well-inoculated crop the previous year, mixing a quart of sifted soil with a bushel of seed that has been slightly moistened with water, milk, or a sugary solution. Care must be taken to avoid making the seed too wet as wet seed will not drill satisfactorily.

Time of Seeding.—This should be done about the middle of May, a little earlier or a little later depending upon the locality, the season and the preparation of the land, particularly with respect to weed growth. Although the soybean will

withstand a certain amount of frost in the early stages of growth, there is no purpose in seeding until the soil is warm enough to bring about quick germination and emergence.

Method of Seeding.—Seeding may be done either in rows 28 to 30 inches apart or in close drills, similar to wheat or oats. The ordinary grain drill provides a very satisfactory means for planting in rows or close drills. The space between rows may be adjusted by covering the feed cups that are not required. For seed production row seeding is best. The rows may be spaced somewhat closer than the distance mentioned, but should be sufficiently wide to permit of machine cultivation. Drilling solid is generally recommended when soybeans are grown for hay. It results in the production or finer stems and if anything, slightly higher yields than row planting. Under no conditions however, should this method of seeding be used if the land is known to be weedy. Soybeans grow very slowly at first and heavy weed growth may ruin the crop entirely.

Rate of Seeding.—The amount of seed to be sown to the acre will vary to some extent according to the variety or size of seed, the germination of the seed, the nature of the soil and the climatic conditions at the time of seeding. The rate of seeding can vary to some extent without greatly affecting the yield of hay or seed.

For seeding in rows 28 to 30 inches apart, it usually requires about 45 to 60 pounds of seed per acre, while drilling solid requires about 1½ to 2 bushels of seed per acre (one bushel=60 pounds).

Early cultivation with the harrow or rotary hoe is certain to destroy some soybeans in addition to weeds and sufficient seed must be sown to take care of this loss. The objective in planting should be to have a final stand of about one plant to every inch or two in the rows.

Seeding soybeans together with corn for silage production requires about 6 to 8 pounds of soybean seed, in addition to the regular seeding of corn per acre. In order to obtain the desired combination of the two crops the corn should average about a plant every 12 to 15 inches, and the soybeans a plant every 6 to 8 inches in the rows, at the time of cutting.

Depth of Seeding.—This depends largely upon the type and condition of the soil. Shallow seeding is necessary and where moisture is adequate, one to two inches is usually satisfactory.

Cultivation.—Shallow cultivation with the harrow or rotary hoe following seeding and just before the young plants break through the soil, may be necessary either as a means to break a surface crust which may have formed or as a weed control measure. After the crop is up it is a good practice to cultivate with the rotary hoe or harrow once or twice from the time the plants are two or six inches high. A light harrow should be used and cultivation should be done in a direction crosswise to the drills or rows. These early cultivations are very important. They should always be carried out in bright, warm weather, preferably during the afternoons when the young plants are tough and not easily broken. Cultivation between the rows should begin when necessary and continue as with corn, as often and as long as may be required to effectively control the weeds.

Level cultivation is desirable and any tendency to produce ridges by throwing soil against the rows should be avoided. Harvesting is much easier on smooth than on ridged fields.

Harvesting.—In harvesting the crop for hay, cut when the pods are about half filled out, using the mower. This should be done in the morning after the dew is off. The crop is usually left in the swath for a day or until the leaves

are thoroughly wilted, then raked into windrows and allowed to cure or, after two or three days in the windrows, put into small cocks. The hay should be thoroughly cured before hauling and handled in such a way as to preserve the leaves as much as possible.

In harvesting the crop for seed, cutting is done after the leaves have dropped. Practically all varieties lose their leaves at maturity. At this stage the pods will be dry. The beans may still be rather soft, however, indicating a high moisture content. Under such conditions the crop should be allowed to remain standing, if possible, until the beans have become quite firm and hard, and the moisture content reduced to a point where storage will not constitute a problem.

Soybeans are admirably adapted to harvesting with the combine and this method has become very popular in those areas where the crop is grown most extensively. Combining the crop not only brings about a great saving in time and labour, but the loss of seed from shattering may also be reduced to a minimum. While it is necessary that the crop be well matured, adjustments to the combine must be made according to the moisture content of the seed. As the beans become drier on warm afternoons adjustments as directed for each combine are necessary in order to reduce the percentage of split and damaged beans. Such damage reduces the value of the crop for seed and lowers the grade and the price for commercial use.

Where a combine is not available, harvesting may be done with the grain binder in the same manner as any other grain crop. Lifter guards are often very useful in picking up broken down branches between the rows. Loss of seed from shattering may be avoided by harvesting when the pods are slightly tough from dew. The sheaves should be made fairly small and not bound too tightly. They may be set up in small shocks to cure, or they may be threshed immediately if the pods are dry and the seed is thoroughly ripe. After curing in the shocks soybeans can be housed or stacked and threshed later. Since the mature plants do not shed water readily themselves, it is necessary to use straw or other material to cover the stack, in order to prevent it from becoming water soaked.

Threshing.—The grain separator may be used to thresh the crop provided a few adjustments are made in order to prevent splitting or chipping of the seed. The speed of the cylinder must be reduced to about one-half, while the speed of the remainder of the machine must be maintained. This may be accomplished by doubling the size of the cylinder pulley. It may also be necessary to substitute a blank plate or a block of wood in place of the concaves. Good judgment is necessary on the part of the operator, as the dryness of soybeans differs so much at threshing time. Soybeans can be threshed with an ordinary bean thresher.

Storage of the Seed

Careful handling of soybeans immediately after threshing is essential. Seed containing more than 14 per cent of moisture should not be stored in a deep bin but should be spread out, not more than a foot in depth, so that it can be turned easily if heating occurs. It might even be advisable, if the quantity is not too large, to put the seed in gunny sacks which can be moved from time to time to allow free circulation of the air. Improper storage may easily result in spoilage from heating and moulding and impaired germination of the seed.

Ottawa: Printed by Edmond Cloutier, C.M.G., B.A., L.Ph., Printer to the King's Most Excellent Majesty. 1948.