No. 311 BULLETIN JANUARY, 1950
OF THE
AGRICULTURAL EXTENSION SERVICE, THE OHIO STATE UNIVERSITY

Putting SOYBEANS into Permanent Farming

THE OHIO STATE UNIVERSITY AND THE U. S. DEPARTMENT OF AGRICULTURE, COOPERATING
AGRICULTURAL EXTENSION SERVICE, C. M. FERGUSON, Director, Columbus, Ohio
Printed and distributed in furtherance of Acts of May 8 and June 30, 1914

An Accepted Newcomer

WITHIN 30 YEARS, a newcomer among Ohio's field crops, the soybean, has risen to fourth place in acreage and in value.

IN our economy, the soybean crop provides:

—food for humans—as oil
—feed for livestock—as meal
—a wider range in crop economy
—an expanded livestock economy.

ITS outturn is about $60,000,000 to Ohio farmers and:

—200 pounds of commercial oil
—plus 500 pounds of protein an acre.

PROMISE of 40 and 45 bushels an acre are in store for the user of purposeful practices.

OHIO has the soil—four great groups—suited to the soybean enterprise. On two of these, the soybean offers greater safety to the soil and better income to the farmer.

On the other two, it can mean greater variety to the farm enterprise, and a less strenuous pace to the soil.

SOYBEAN'S merited place will come with understanding and application of the principles peculiar to its culture and true soil use.

Putting Soybeans into Permanent Farming

E. P. REED,[1] J. A. SLIPHER,[2] D. F. BEARD[3]

To Asia we are indebted for the soybean plant. Its wild form was native to China, Manchuria, and Korea. Its culture for human use among the Chinese antedates the most ancient written literature of that country. Authoritative research places the stamp of antiquity upon it.

With both the Chinese and Japanese, the soybean has been an important food crop since ancient times, supplying their peoples with nitrogenous food, including two vitamins necessary to higher animal life, and to man.

FROM EAST TO WEST

Having arisen in the east, the soybean now climbs to stellar position in the west. It ranks as one of the four great grain crops of the Corn Belt (Figure 3). The soybean was first introduced into the United States in 1804, but attracted little attention until 1900, at which time the United States Department of Agriculture began planting and testing a large number of varieties.

In Ohio, the farmer's interest in growing the crop began in the early 1920's. During the following 10 to 15 years, he soybean was grown chiefly for forage and, to a lesser extent, for seed and market grain. It was due largely to lack of a ready market for soybean grain that the acreage failed to expand more rapidly.

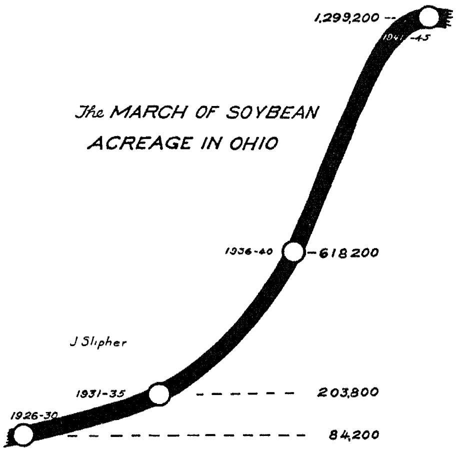


FIG. 1

SUDDEN SURGE

However, in the last 10 years there has been a remarkable increase in Ohio's soybean acreage (Figure 1) due chiefly to:

a. Better outlet facilities through regular grain handling channels that supply numerous processing plants in the state;
b. The development of adapted, high-yielding varieties; and
c. The higher market price brought about by the need for more protein feed and for oil.

[1] Extension Agronomist, [2] Extension Soil Conservationist, and [3] Extension Agronomist respectively, The Ohio State University. The authors appreciate and acknowledge the helpful suggestions made by fellow members of the Department of Agronomy.

Production

The acreage and production of soybeans in Ohio for the past 24 years are shown in the following table:

Table I	*Total Acres*	*Acres for Grain*	*Acres for Hay*	*Yield Bu./A.*	*Total Grain Production, Bu.*
1924	66,000	20,000	44,000	11.5	230,000
1925	57,000	17,000	38,000	14.0	238,000
1926	61,000	18,000	41,000	11.5	207,000
1927	72,000	21,000	49,000	14.5	304,000
1928	84,000	24,000	58,000	15.0	360,000
1929	92,000	23,000	66,000	15.1	347,000
1930	112,000	31,000	77,000	14.0	434,000
1931	157,000	47,000	105,000	20.0	940,000
1932	156,000	34,000	117,000	15.5	527,000
1933	148,000	33,000	110,000	16.0	528,000
1934	203,000	41,000	155,000	17.0	697,000
1935	335,000	124,000	220,000	21.0	2,604,000
1936	330,000	132,000	162,000	15.5	2,046,000
1937	380,000	171,000	190,000	19.0	3,249,000
1938	480,000	281,000	161,000	21.0	5,901,000
1939	864,000	500,000	310,000	21.1	10,550,000
1940	1,037,000	570,000	353,000	15.5	8,835,000
1941	923,000	674,000	221,000	19.5	13,143,000
1942	1,440,000	1,109,000	158,000	22.0	24,398,000
1943	1,469,000	1,308,000	132,000	21.0	27,468,000
1944	1,484,000	1,321,000	133,000	17.0	22,457,000
1945	1,184,000	1,077,000	83,000	18.0	19,386,000
1946	971,000	903,000	53,000	18.0	16,254,000
1947	1,000,000	950,000	42,000	18.5	17,565,000
1948	940,000	908,800	24,000	20.5	18,614,000
1949	902,000	858,000	36,000	24.0	20,592,000

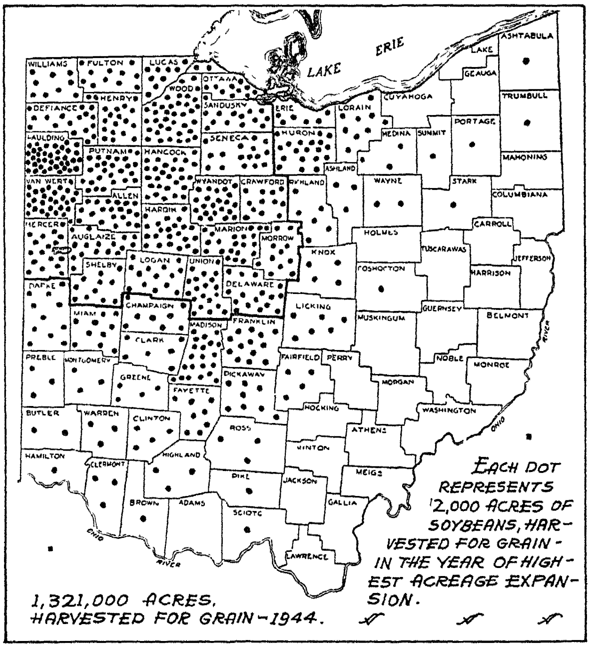


Fig. 2

Distribution

The map of Ohio (Figure 2) shows, by counties, the general distribution of the 1944 soybean acreage (the record crop) harvested for grain. Of Ohio's soybean patch, 939,000 acres, or 71 per cent, lie within 25 northwestern counties, and much of the remainder grows in the western half of the state, little appearing in northeastern Ohio.

A Crop of Many Uses

The soybean oil mills produce two products—oil and oil meal (Figure 4). The removal of oil from whole soybeans is accomplished by two means: by the expeller (pressure) process and by solvent extraction. A ton of soybeans produces 300 pounds of oil plus 1,650 pounds of meal (Figure 5). That outturn represents averages of the two processes. More thorough recovery of oil results from the solvent process, it leaving less than 1 per cent in the meal.

Oil to Humans

The oil content of soybeans ranges from 14 to 24 per cent, the average for soybeans marketed being 18 to 19 per cent. The oil is utilized in several manufactured products. Of the total output, about 85 per cent is used in edible food: vegetable shortening, margarine, and salad oil in descending order. The remainder goes into industrial products, chiefly in paint, varnish, artificial rubber, linoleum, soap, ink and similar products.

Meal to Animals

The protein content of soybean meal averages 40 per cent, ranging from 30 to 50 per cent. More than 95 per cent of our soybean meal is used in feeds for all classes of livestock, only 1.5 per cent disappears into the industrial channels to reappear as glue, plastics, flour, and nitrogenous fertilizer. Through the results of continued research studies, many new and useful products may be expected from both soybean oil and oil meal.

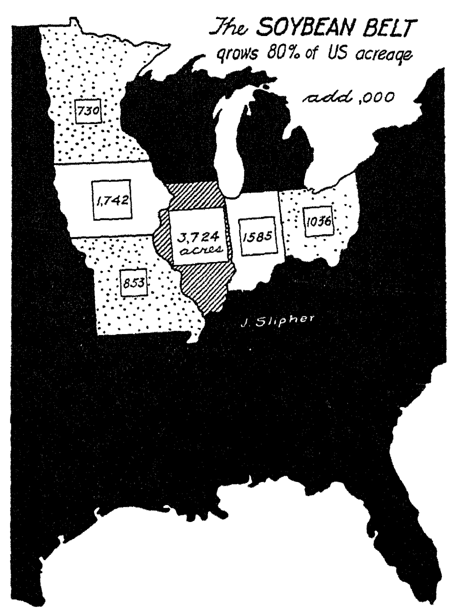


Fig. 3.—Three-year average acreage (in 1,000's) for 1945–46–47 of soybean crop alone for all purposes (BAE data).

A Forage Excelled by None

Soybeans cut for hay while retaining all their leaves, when well cured, make an excellent legume feed for livestock. The yield is equal or superior to that of red clover and the feeding value on a par with good alfalfa. The protein content of good soybean hay ranges from 14 to 17 per cent, and the later maturing grain varieties, adapted to a particular area, produce the greatest yields of hay.

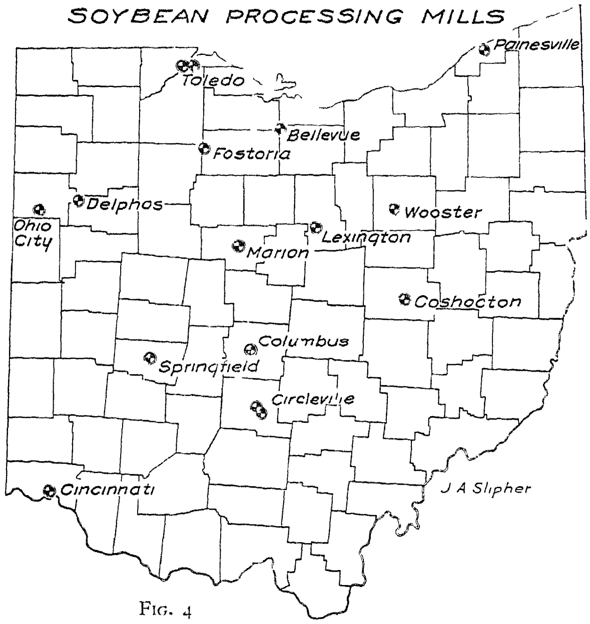


Fig. 4

As a Green Manure

The whole soybean crop plowed down green about August 20 to September 10 brings to the soil: (a) as much as 100 pounds of atmospheric nitrogen, (b) 6,000 pounds of hum--us-making substance and (c) some renewal of tilth. Taken collectively, these betterments warrant crediting the practice with a "productivity factor" of +1.5. When the seeds of the later maturing varieties are about two-thirds formed, the plants contain about the maximum amount of nitrogen and organic substance.

Cash Crop of Worth

The present cash returns from soybeans, in the Corn Belt area, compare favorably with other grain crops produced. Data assembled at the University of Illinois for the year of 1943 show that relative profit per acre from a 25-bushel soybean yield, as compared with a 67-bushel corn yield, was approximately one-half as much; but when compared to an 18-bushel wheat yield, it was two and one-half times as much; and with a 33-bushel oat yield, three times higher. Furthermore, it is entirely possible, that on Ohio land, capable of producing 67 bushels of corn, soybean yields of 30 to 35 bushels could be obtained by improved soil management practices.

Land and the Soybean Enterprise

The widespread development of the soybean enterprise has been made possible by the combine harvester-thresher. Soybeans are produced at a labor cost per acre approaching that for wheat and approximately one-half that for corn. Since on good land, corn excels soybeans as a producer of gross as well as net income, competition will continue to hold the soybean in a secondary position acreagewise. However, on land ill-adapted to corn, the soybean enterprise can and should partly or wholly supplant corn. (See Figure 6).

Supplant Corn on the Gray Lands

What and where are the soils that hold promise for the soybean enterprise? Descriptively, they are the gray lands, of sluggish internal drainage, of smooth to mildly sloping topography (of less than 4 per cent slope), and occuring in extensive bodies. (See Figure 13). To farmers interested in crop farming, these areas offer opportunity of operating a sequence consisting of: soybeans, oats, winter grain, clover seed; or soybeans, oats, clover seed, winter grain; or soybeans, oats, clover seed. For such a system of seed farming, the equipment needs are simplified to one machine for harvesting. Harvesting periods are comfortably spaced and require a small work crew in the instance of each crop. Evaluated by the "productivity balance" yardstick*, the above 4-year pattern scores favorably.

Share With Corn on Mottled Soil

Of secondary order of preference for this crop are certain light brown soils. These possess imperfect internal drainage, occupy very mild slope and generally are associated with the gray soils already described. See map, Figure 13, for geographic areas of chief distribution. If the soybean were to relieve these soils of part of their burdensome corn acreage it would result in substantial benefit to soil productivity. To carry this out one would best adopt a "split" cropping pattern as exemplified by:

Soybeans / Corn > Small grain — Legume sod — Legume sod

Soybeans / Corn > Small grain — Legume sod

* Principle set forth in Ohio Extension Bulletin No 175—"Our Heritage, the Soil"

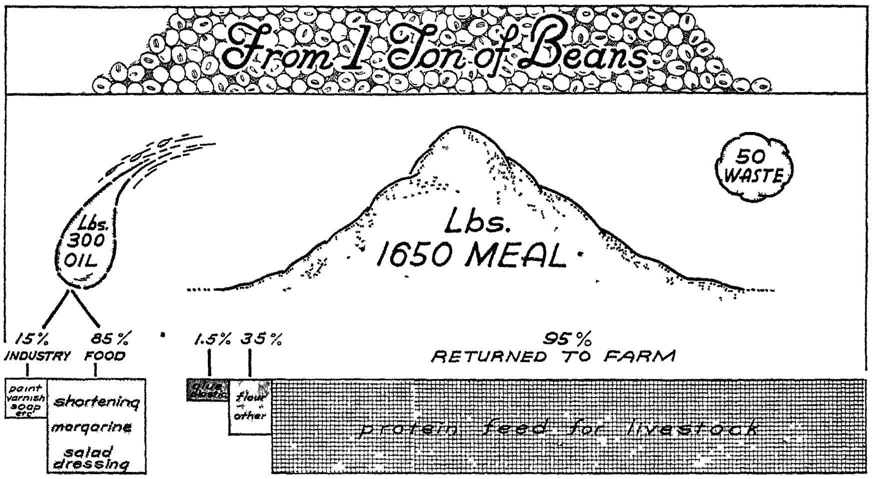


Fig. 5

If such a scheme enjoyed wide usage on these "intermediate" soils, the soybean would occupy less acreage on the farm than the small grain crop. The sum of soybean and corn acreages on this land class dare not exceed one-third of the rotation; otherwise the land will suffer and the yields of all crops lag.

In Sequence on Dark Land

There will continue the practice of growing soybeans in sequence with corn. Only the dark lands, the "corn soils," are capable of that burden. (See map, Figure 13). Even then the practice must be counter-balanced by an added year of some soil building crop in rotation. Toward fulfilling that feature the following pattern has much to commend it:

Corn	Soybeans	Small Grain	Sod	Sod
40%		20%	40%	

Matching corn and soybeans year-for-year with legume sod assures rising productivity. Input of organic matter exceeds outgo; three of the crop years favor tilth renewal to ably offset impairment during the other two (corn and small grain); and the nitrogen balance is better than if the soybean member were omitted, (See page 9). Lopping off the second year of the sod crop weakens the capacity of the rotation to keep land up, even though the soil is "corn land." If one does that, he swells the sum of corn and soybean acreage from 40 to 50 per cent of the rotation. That is definitely border-line position and precarious.

Without Honor Elsewhere

Being vulnerable to erosion, the sloping and permeable brown and yellow-brown soils (designated Profile 4) must of necessity carry a low portion of corn acreage in order to accommodate enough sod to hold rainwater in check. To grow soybeans on these lands would mean diluting still further the acreage of corn. Since the nature of these soils very properly commit them to much sod, feed grain (corn) stands at a premium. To further shrink it weakens the total farm enterprise, which rests heavily upon livestock in areas where these well-drained brown soils predominate. Here we would do well to omit soybean growing.

Effect of the Soybean on Soil Productivity

Growing a soybean crop leaves a train of effects on the soil. What are they; how intense their action; and how much is long-time productivity influenced?

Soybeans, as does any crop, consume phosphorus and potash. In each bushel of soybeans delivered from the premises, 1 pound of phosphoric acid leaves the farm, representing about 30 pounds an acre for a 30-bushel crop. That rate of removal is about one-third faster than in the instance of a corn crop, say a 60-bushel one; but about the same as taken by a good red clover hay crop.

On the count of potash uptake and removal from the farm, the soybean again outdoes corn, by one-fifth, and the "carry away" fraction in the marketed soybean virtually matches the poundage of this nutrient unreturned to the soil when an acre-crop of red clover is fed to livestock.

Being a legume, the soybean acquires nitrogen from the atmosphere as well as from the soil. The above-ground portion of a good soybean crop (27-bushels) and a 2¼-ton red clover crop contain identical poundages of nitrogen, 143 pounds an acre. Calculations point to a net gain to the soil of about 15 to 20 pounds of nitrogen when a 30-bushel crop of soybeans is marketed and the haulm put into the soil. Supporting this expectancy is an actual finding by Dr. O. H. Sears, University of Illinois, of a 16-pound gain in the instance of a crop yielding 20 bushels. To actually realize that gain, however, it is necessary to return to the land the haulm, containing in a good crop from 50 to 70 pounds of nitrogen per acre.

For each bushel of soybeans produced, the soil receives about 110 pounds of organic matter as haulm and plant remains. On an acre basis, this may amount to 3,000 or 4,000 pounds. Not all is gain, however, for some of the existing stock of organic matter in the plow layer is destroyed incident to growing the soybean crop. Normally, the input outruns the outgo leaving a net advantage.

Soybean roots measurably improve tilth of soil. Seemingly the physical good done is about half or two-thirds that from the root action of red clover. Although intense crumbing produces uniform and small aggregates, they are fragile. The betterment is confined largely to the upper portion of the plow layer.

To Soybean a Mild Debit

The collective effect of a soybean crop—nutrient uptake, plus nitrogen credit, plus organic matter economy, plus conditioning of tilth—would indicate a net drag on soil productivity. The rate* is –0.25 (debit) per acre with residue returned to soil; and –0.50 (debit) with residue removed. See Figure 8.

A Constant Threat: Erosion

Aside from and in addition to the above direct effect of the crop on the future capacity of the soil to produce, there is the hazard of erosion. Absence of canopy over the soil, before and after planting, exposes the soil body to churning action of the raindrops and consequent dislodgment of soil

* For full meaning of "soil productivity index" see Ohio Extension Bulletin No. 175, "Our Heritage, the Soil."

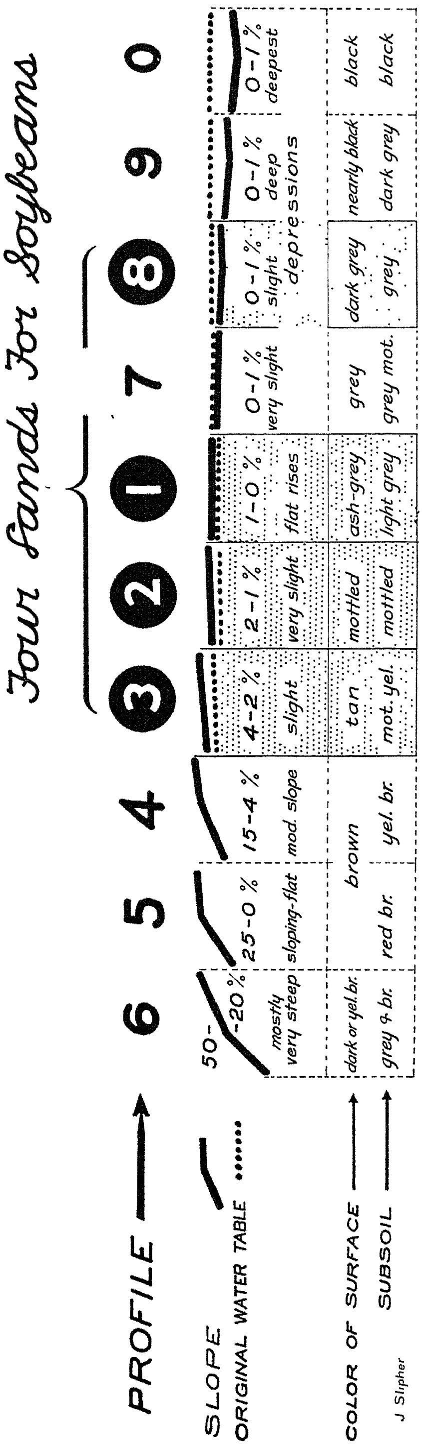


Fig. 6.—Of the 10 great soils of Ohio, four moisture-retentive ones are best adapted to soybean growing. They are: (1 above) ashy gray flats (beech tree land), (2) mottled gray rises, (3) tan gray and (8) dark gray (elm tree land). Their slope ranges from 4 per cent to 0.

particles. Downslope movement of rainwater may carry away the loosened soil. Unsplashed soil suffers little erosion. Therefore, if the crop were drilled solid, the spread of top intercepts and breaks the impact of raindrops. Thus, protected, the soil surface tends to retain its crumbs unshattered and remain open and adsorptive to quieted rainwater. Intake mounts, runoff lessens, erosion abates. The burden of erosion may be held to a tolerable level by planting solid to afford a canopy against impact of raindrop, and/or ribbed cultivation of contour-planted crop, and/or appearance less often in the rotation.

After Harvest—What?

Dare protection cease with the growing of the crop? After harvest the ground is especially vulnerable. Action by the growing crop roots have brought the upper plow layer into a high degree of crumbiness. Its fluffiness and openness invite intake of rain water. But hazard lurks in the fragile nature of the crumbs. By blanketing them with the crop's haulm, one can prolong their stability and reduce volume of run-off. The use of an accessory cutter-head on the rear of the combine would fractionate the material and, thereby facilitate evenness and completeness of coverage. A covering of residue does almost as well as a grazed sod in checking erosion.

The Soybean in Rotation Patterns

soybean	oats	wheat	clover seed		
$-\frac{1}{2}$ debit	-1 debit	-1 debit	+2.75 credit	=	+0.75 credit

CROP EFFECT

$+\frac{1}{4}$	$+\frac{1}{4}$	$+\frac{1}{4}$	=	+0.75 credit

RESIDUE

600 lb./rotation(+0.15 ¢ 200 lb.) = +0.45 credit

FERTILIZER

TOTAL CREDITS +1.45

EROSION BURDEN

On "Soil Profile 1"-------------0.40 debit
(flat to 0 or 1% sloping grey soil)

On "Soil Profile 2"-------------0.80 debit
(1% to 4% sloping grey soil)

If Terracing and Contour Tillage-0.53 debit
are Practiced on Profile 2

THE SCORE

Since the combined credits (+1.45) outrun the debits arising from erosion hazard in each situation cited above, the net effect is a favorable SOIL PRODUCTIVITY BALANCE

in each instance, namely +0.26 of 1% / +0.16 / +o.23 of 1%

Soil's yearly GAIN in producing ability

FIG. 7.—In example, only seed of clover crop removed from field, all top growth of the year remaining on land and earns a credit of +2.7 points or +0.7 greater than customary +2.0 allowance for hay only.

The soybean needs social standing. It needs a rotation with respectability. Sandwiching it in between two or three other more soil degrading crops (common practice) accounts for an unsavory reputation. Soil productivity suffers chiefly due to the heavily degrading crops, not because of ill effect from the soybean, as commonly supposed. When scored for productivity effect, the rotations shown in Figure 9 are found sadly wanting, although the soybean member itself is only a mild contributor to the total delinquency.

Deep delinquency, as above, can not be erased by manure or fertilizer or the two jointly, except with uncommonly large applications. Few farms can marshal enough fertilizer plus manure plus crop residue to cancel the heavy debit inherent in these crop rotations. Dropping out the soybean member does not correct the ill effect of these cropping systems upon soil productivity. Satisfactory cropping schemes for soil upkeep, and that includes the soybean crop, are set forth in Figure 10.

Yield Potential

Although 20 bushels marks the normal Ohio yield, vastly greater performance can be had. An expectancy of 1½ to 2 times the current yield is indicated in uplifts to be had from technological soil and crop practices now available to growers. If these were adopted and applied in the degree dictated by the delinquency of the land, the grower could obtain what may properly be regarded as full or "par" production.

What yields constitute "par"or attainable performance on the part of specified soybean lands appear in Figure 11.

From an 11.5 acre-yield in 1926, Ohio's performance has risen to one of 24 bushels in 1949. This—a rise of 109 per cent in 23 years—signals promise of great strides in the future as well. No less than other farm crops, the soybean responds: to timeliness of planting, to moisture conservation, to soil tilth of a high order, to nutrient input, and to varietal adaptation. When all are working simultaneously on the same acre there results in practice a combined uplift in yield greater than the arithmetic sum of their separate benefits. Already, yields of 40 to 55 bushels from an acre are being attained in the Soybean Belt.

What practices bring these yield levels, and how to tailor them to crop and land needs, are set forth in the remainder of this bulletin. An upsurge of yield awaits the grower who puts these to work in a collective program. Only full effort will produce full results. Also, see Figure 12.

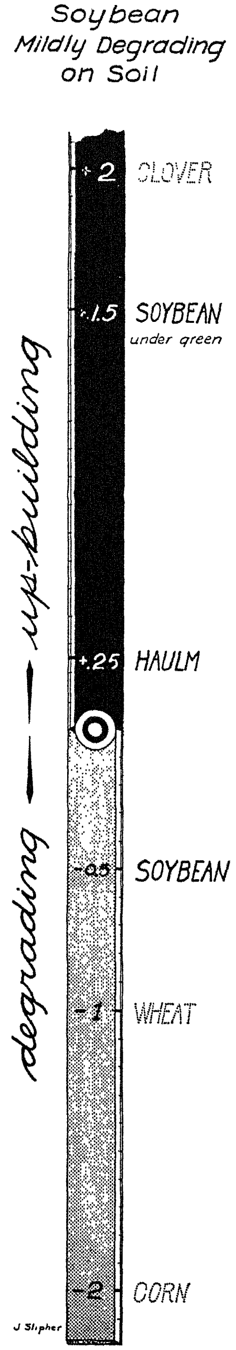


FIG. 8.—A yardstick to gauge crop effect.

Liming—To Supply Nutrient Lime

Uptake of lime nutrient from the soil by the soybean crop is four-fifths as great as that consumed by red clover. For each bushel of soybeans produced, 4 pounds of lime (in terms of lime carbonate) must be had from the soil. Being a rugged feeder, the soybean plant can wrest its needed quota from the soil with more ease than do other heavy lime-consuming legumes (Figure 14). However, some soils do not contain enough to meet the demand. Shortage handicaps normal growth and curtails yield. By supplying the missing fraction, liming assures normal growth and more promising yield.

Moreover, acidity of soil, commonly (though not always), co-existing with scarcity of food lime, further distresses the plant. Findings demonstrate that acidity renders inoculation more hazardous. Relief is had from liming, which furnishes lime for nutrient purpose as well as neutralizing the acid and substituting a medium favorable to both the plant and the nodule organism. (Refer to page 20). Extent and intensity of need for lime varying as between soil groups is set forth in the table following.

What Soil		Need For Lime
By Legend (In Soil Cons. Dist.)	By Description	
Profiles 1, 2	Gray	Heavy and wide spread
Profile 3	Brown	Medium; 50% of group
Profile 8	Dark	Light; less than 25% for group

An exact need for available lime may be found by laboratory test. Soybeans and red clover require identical rates of liming.

Generous responses of soybeans are had from liming needy soil; little or none from treating those naturally rich in lime, as demonstrated below:

7.3 bushels of soybeans on gray soil (Profile 1) in Indiana
6.2 bushels of soybeans on brown soil (Profiles 3, 4) in Ohio
3.4 bushels of soybeans on dark soil (Profile 8) in Ross Co., Ohio
0 bushels of soybeans on dark soil (Profile 8) in Indiana

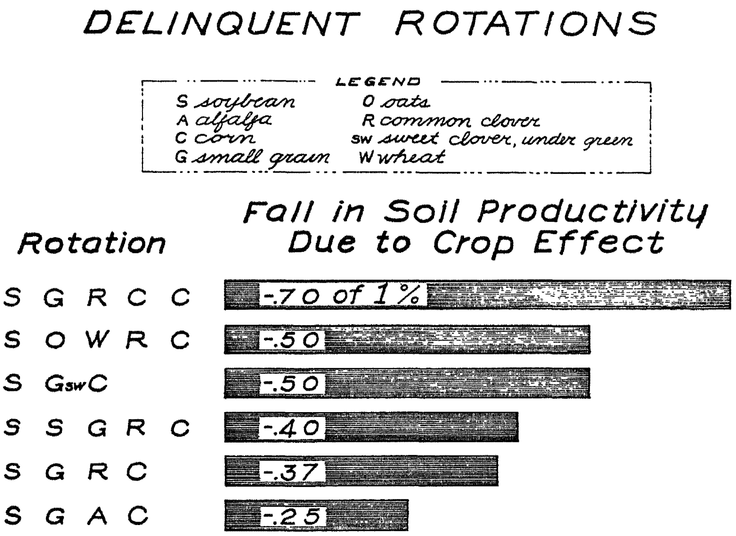


Fig. 9.—Values in this chart are based solely on direct effect of crop and do not include allowance for crop residue (straw, stalk, haulm.)

To Fertilize Or Not To Fertilize

Like other legumes, the soybean is a greedy consumer of potash and phosphorus. Unless usable supply in the soil equals plant needs, the crop performs poorly. By fertilizing an ashy gray soil with liberal (but not excessive) amounts of these two nutrients, investigator Mulvey, Purdue

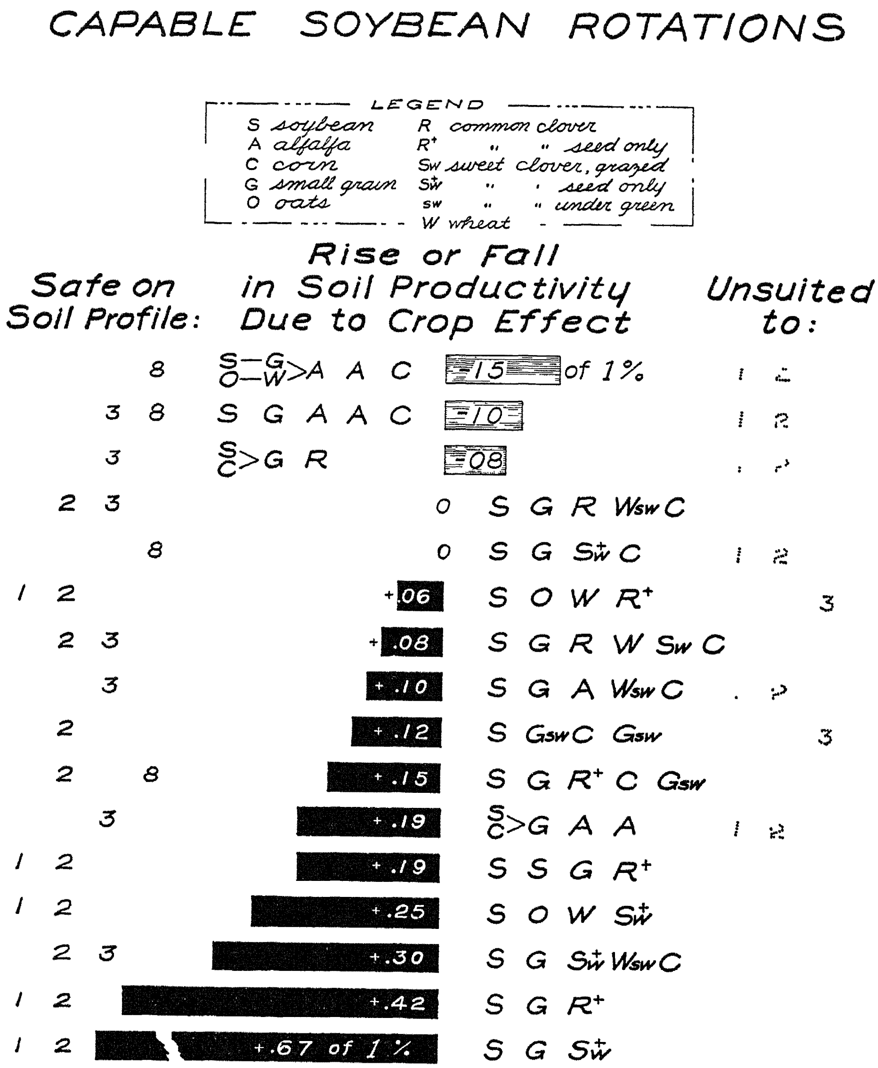


FIG. 10—Values in this chart are based solely on direct effect of crop and do not include allowance for crop residue (straw, stalk, haulm.)

University, upped yield 11 bushels an acre and substantially reduced the moisture content at harvest time. Fruiting was improved, there being twice the ratio of 3-bean pods and correspondingly less of 2-bean and 1-bean pods.

Comparison In Uptake

For each bushel of soybeans produced, the plant draws 2.2 pounds of potash from the soil; for corn, the uptake is 1.1 pounds. At this ratio of 2 to 1, a 30-bushel bean crop and a 60-bushel corn crop will take identical amounts of potash from an acre (See Figure 15). It follows too, that growing

PAR OR ATTAINABLE YIELDS

If a proper bracket of practices are in operation on each Soil Profile:

on Profile 1	30 bu.
on Profile 2	35 bu.
on Profile 3	40 bu.
on Profile 8	45 bu.

FIG 11—Consult land distribution (Fig 13) and profile description Fig 6).

a 40-bushel yield puts double (88 pounds) the burden on the stock of potash as does the average (20 bushels) Ohio soybean crop. To be correspondingly damaging, a corn crop would need to yield 120 bushels.

Of phosphoric acid, the soybean plant requires 1.4 pounds per bushel of crop; while corn gets along on 0.6 pounds for each bushel. Accordingly, a 30-bushel soybean crop and a 60-bushel corn crop will need 42 and 38 pounds of phosphoric acid respectively.

ABLE FEEDER

Few crop plants possess the strong feeding power characteristic of the soybean. It can forage ably. Nutrients, seemingly unavailable to wheat or corn, or to many other crops, are extracted with apparent ease by the soybean. Although a virtue, this trait has been cited in condemnation of the crop. Being weak feeders, wheat and, to a lesser degree, corn, grown immediately following the soybean, may and frequently do find themselves in difficulty—feeding at the "second table." On the contrary, soybean crops have demonstrated about as good response to residual or hold-over fertilizer as from direct application.

YIELD LEANS ON FERTILIZER BAG

Feeding power, however great, has a limit. A meager stock of usable nutrients possessed by the soil imposes a low ceiling on yield. Even a good soil, while offering much, may provide too little for a large yield. To raise the ceiling on any soil one better dip into the fertilizer bag. It's simply good business. In fact, stepping from a 20-bushel (state average) to a 40-bushel crop commits one to an enlarged fertilizer input. If one aspires to making this crop a major enterprise and not a mere sporadic "fill-in," then fertilizer must become a regular part of the management program.

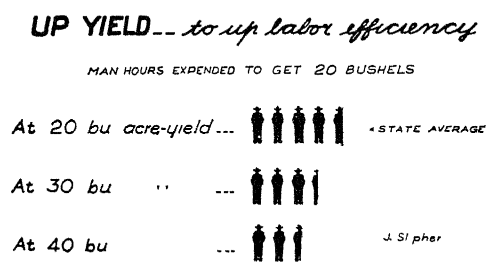
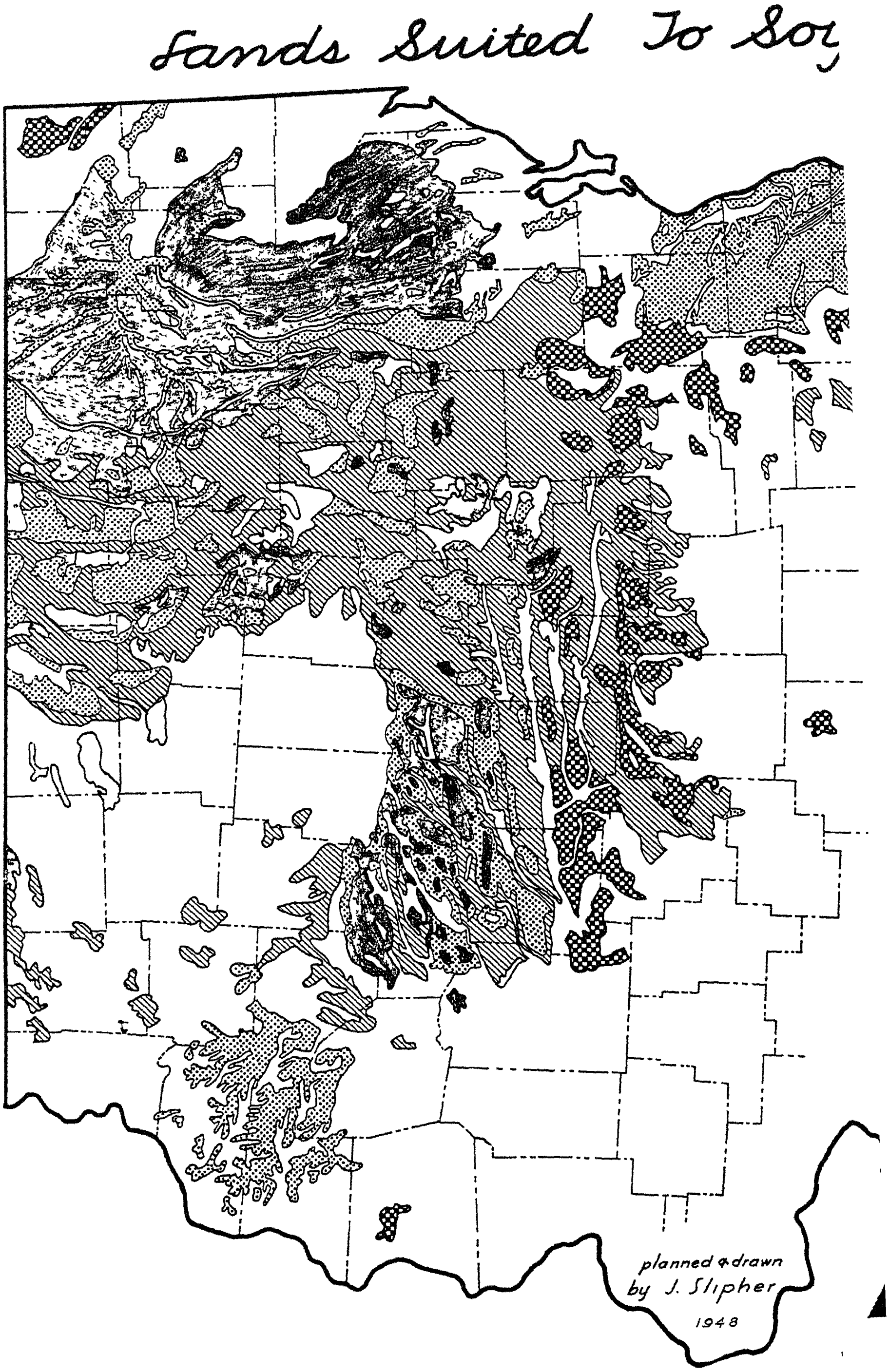
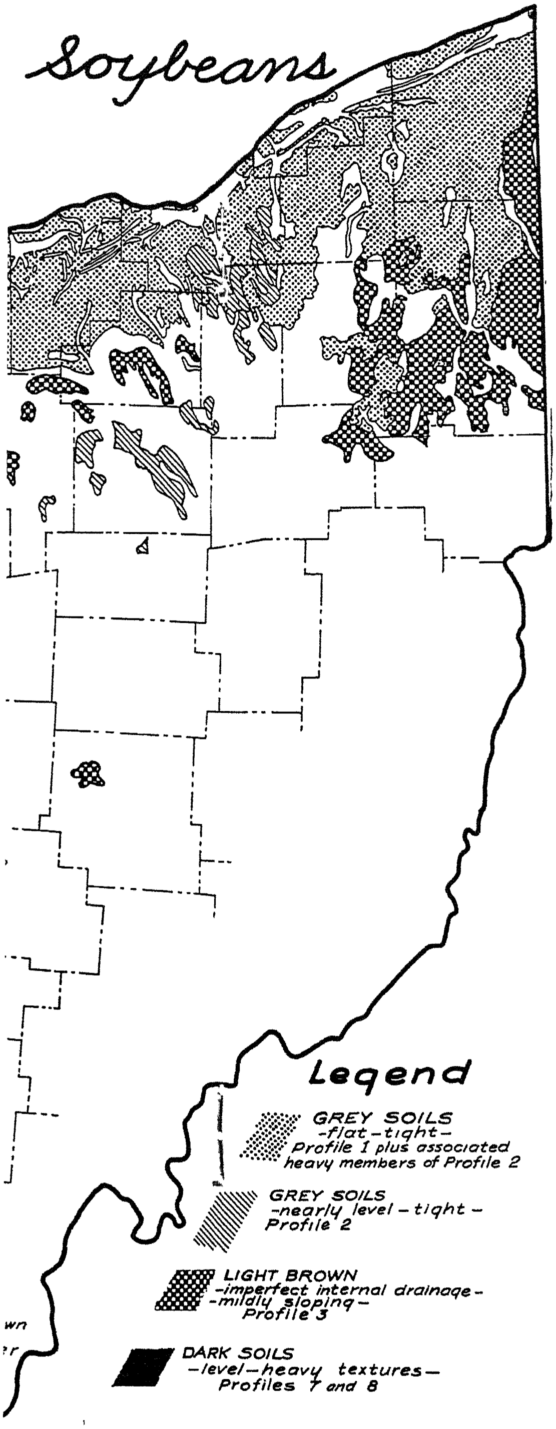


FIG 12.


Sands Suited To So
planned & drawn
by J. Slipher
1948



A Fertilizer Schedule

In Figure 16 is set forth a scheme of fertilizing soybeans on each of the three soil groups. The prescribed analysis and indicated rate are in keeping with the known weaknesses of the soils, experience of growers, and findings from experiment station investigations.

Proof by Performance

A goodly release of potash and phosphorus by the dark soils of western Ohio, accounts in large part for the good yields experienced there. About half as much potash is had from the gray group, necessitating much from the fertilizer bag. Unless fortified by regular stuffing with crop residues and ma-

Table II, Kind of Soil and Response of Soybean to Fertilizing

Dark Soil	*Increase*
Profile 8 (Brookston Soil) Indiana	
400—0–12–12 direct	None
Profile 8 (Brookston soil) Ross Co., Ohio	
400—0–20–6 direct	5.3 bu.
Light Brown	
Profile 3 (limed Canfield soil) Ohio	
250—0–20–5 direct (4 yr. average)	5.0 bu.
500—0–10–20 direct (4 yr. average)	12.3 bu.
Profile 4 (Miami Soil) Germantown, Ohio	
250—0–20–10 direct	7.3 bu.
Gray Soil	
Profile 2 (Crosby soil) Indiana, residual 400—0–10–20 on plowsole for prior crop of corn	5.8 bu.
Profile 1 (Clermont soil) Indiana, residual Complete fertilizer on plowsole for prior crop of corn	7.5 bu.
Profile 1 (Clermont soil) Indiana, direct	
400—0–12–12	9.0 bu.
Profile 2 (Crosby soil) Indiana, direct	
400—0–10–20	11.0 bu.

← Fig. 13.—Gray Flat group is represented by Crosby silty clay loam in west-central, Trumbull silt loam and silty clay loam in northeastern, and Clermont silt loam in southwestern Ohio. Gray Sloping group: Crosby silt loam in western; Ravenna and Mahoning silt loams in northeastern Ohio. Light Brown group: Celina in western and Ellsworth in northeastern Ohio. Dark group: heavy Brookston and Paulding types.

nure, the gray group needs a double charge of fertilizer. That urgency has further support. Poor tilth and faulty ventilation handicap availability, suggesting need for an extra allowance.

Response of the soybean to fertilizer usage on different soil groups appear in Table II.

Soybean Varieties Adapted To Ohio

Three varieties of soybeans are best adapted to Ohio conditions. They are: Monroe, Hawkeye, and Lincoln. These have been chosen from extensive performance tests conducted not only in Ohio but throughout the soybean growing states having a similar growing season. These three varieties are now grown on 60 to 70 per cent of the Ohio soybean acreage. The remaining acreage is being devoted to varieties that should be replaced by the above three, or to later maturing varieties grown for hay.

Monroe—This is the earliest of the three varieties. It is especially adapted to northern Ohio where its earliness permits timely seeding of winter wheat. It is five days earlier and stands better than Earlyana, but is similar to Earlyana in other respects. Monroe matures about 10 days earlier than Hawkeye.

Earlyana and Richland, now being replaced by Monroe and Hawkeye, are no longer recommended. Sufficient seed of Monroe and Hawkeye will be available by 1950 or 1951 to replace the entire acreage devoted to Earlyana and Richland.

Hawkeye—This new variety is similar in maturity and standing ability to Richland. It is taller than Richland, however, and produces larger yields. It yields within a bushel to the acre as much as Lincoln

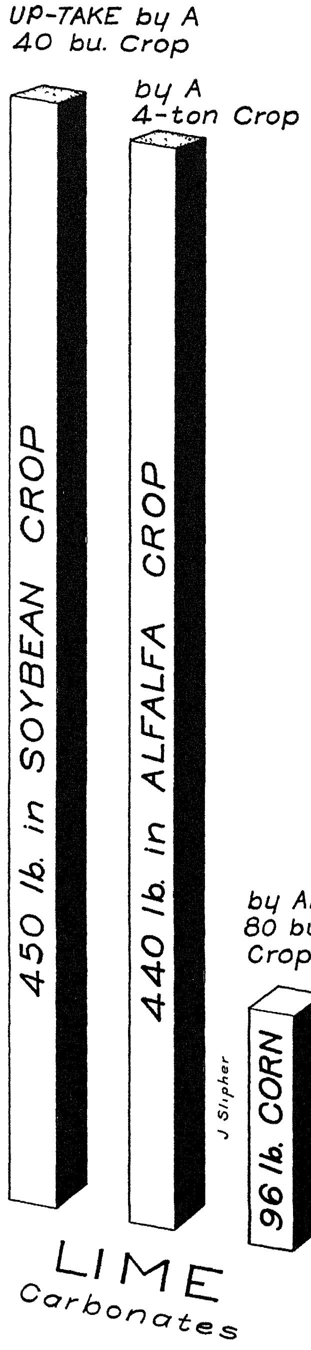


FIG. 14

and maturies five to six days earlier. It equals the Lincoln in oil content. As rapidly as seed becomes available, Hawkeye is expected to replace Richland and, under some conditions, Lincoln.

Lincoln—Having already replaced most of the Mingo, Scioto, Illini, Dunfield, and Manchu, the Lincoln soybean should replace all similar maturing varieties grown in Ohio. As an average of a large number of tests over several recent years, the Lincoln has outyielded these older varieties by four bushels an acre. Lincoln has outyielded every variety similar to it in maturity that has been adequately tested to date in Ohio. Though Lincoln has a good record of standing ability, it is not as stiff stemmed as Hawkeye.

Although Kingwa, Virginia, and other so-called hay varieties are still grown to some extent, there is no particular advantage in their favor. Grain varieties are equally well suited for hay production and will invariably be ready for cutting before poor hay curing weather arrives.

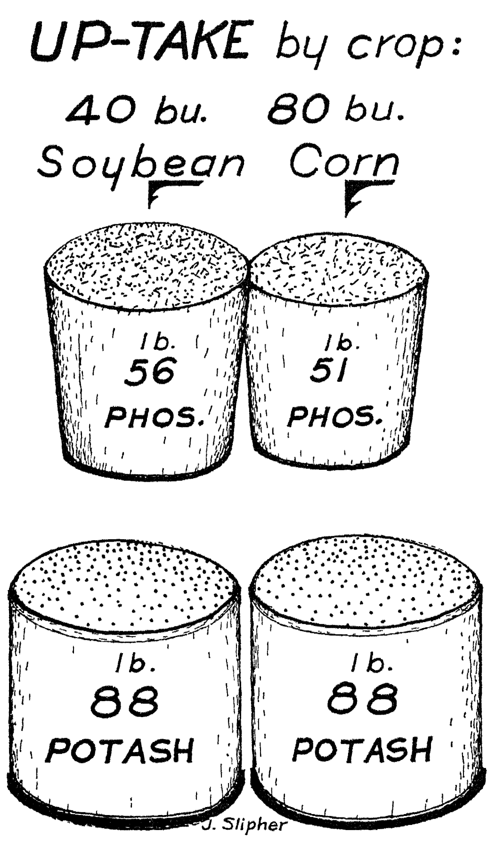


Fig. 15

The development of new and better varieties of soybeans is receiving major consideration from plant breeders, and varieties recommended today may be obsolete in the near future. For current variety recommendations refer to Ohio Extension Bulletin 225.

Inoculation To Tap Air-Nitrogen

By inoculating the soybean (or other legume) the farmer can farm the air for nitrogen. Nitrogen is the key material out of which the soybean plant fabricates its vast volume of protein. As much as two-thirds of the nitrogen for this purpose can come from the atmosphere, if full nodulation (Figure 17) is provided by inoculation. In the absence of nodulation, yield is set by the quantity of usable nitrogen contained in the soil. Few soils possess enough to turn out more than a modest crop. The better the nodulation the less the drain on the existing stock of soil nitrogen and the better the yield. In fact, to gain a plus nitrogen balance in the soil requires that one establish full nodulation on the crop.

Inoculation may be done simply by applying commercial inoculant to the seed preparatory to planting. The soybean inoculant is specific for that crop.

Is Microbe Missing?

What land requires it? Land being put to soybeans for the first time needs inoculation. Thereafter, repeat it on each crop—if the soil is acid. Succeeding crops on non-acid soil will need no hand inoculation—if the lapse between crops is no more than 3 or 4 years. Acidity and persistent wetness of soil shorten the longevity of the nodule organism and make uncertain its living over between successive soybean crops. To avoid chance of imperfect nodulation or of low vitality of existing organisms, it is good practice to hand inoculate every planting.

Rootbed Architecture

Rootbed satisfactory to the soybean consists of a plow layer fluffed up by tillage to contain 20 to 30 per cent more pore space than the undisturbed mass. From the seed level downward the crumb size needs to be small; upward, a graduation ranging from 1/16 to 1 inch, the large units resting on or

FERTILIZER USAGE FOR SOYBEANS

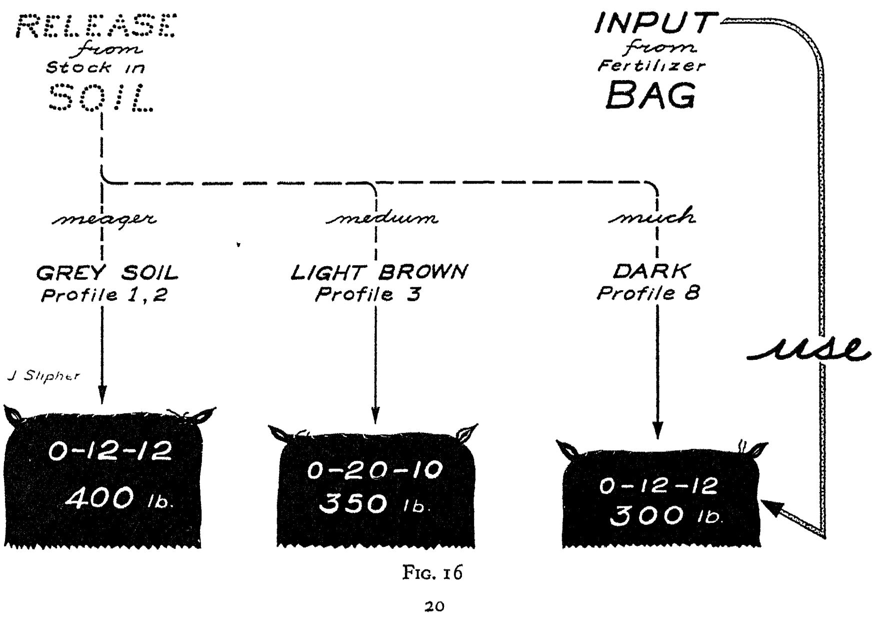


Fig. 16

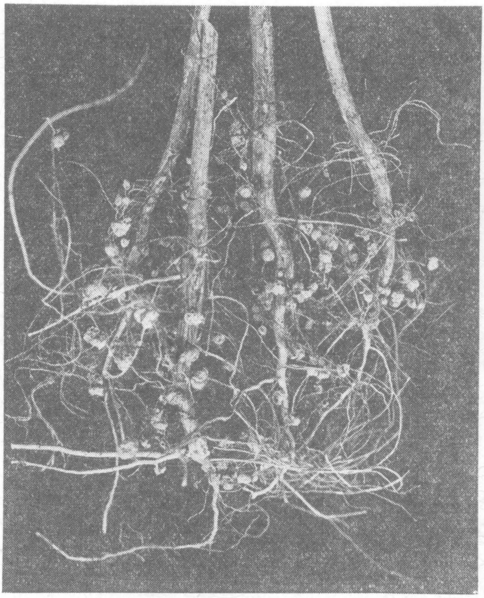


FIG. 17.—Soybean plant favored by excellent nodulation.

in the top. To produce a root-bed approaching those specifications will require that plowing be done at the moisture condition favorable to good granulation, and that supplemental tillage segregate coarser crumbs toward the surface and finer ones toward the seed level. The spring-tooth harrow accomplishes exactly that, by its lifting and sifting action. Coarseness of surface mitigates against crusting and eases emergence of seedling. Undue "fineing" of any soil leads to packing, to repelling of rainwater, and to erosion. Consolidation of fine particles stifles ventilation and becomes a threat

Sort of Soil		Performance			
By Description	By Legend (In Soil Cons. Districts)	Tilth quality of crumb	Air Ventilation	Internal Drainage	Moisture Retention
Gray	Soil Profiles No. 1, No. 2	fragile	sluggish	poor	weak
Light Brown	Soil Profile No. 3	medium	fair	imperfect	medium
Dark	Soil Profile No. 8	rugged	good	fair	strong

to normal respiration of crop roots, if the emerging seedlings have not already broken their necks in or under the soil crust.

Wetness of soil granule weakens it and permits it to collapse, if the soil were plowed when soggy. However, at the right moisture content the soil mass shatters into natural clumps, yielding favorable tilth. At

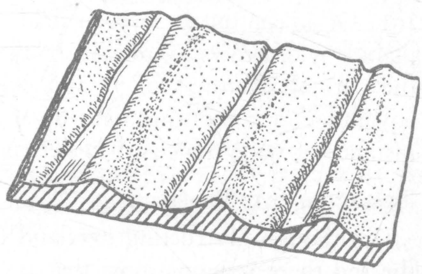


FIG. 18.—Water reservoirs in ribbons on contour of tillage-grooved slope.

FIG. 19.—Rainwater is trapped in grooves "on the land" made by tillage tools in contoured soybeans. Soil and nutrients stay in place; yield mounts. (Photo by courtesy SCS). Also, see FIG. 21.

best, to escape undue damage to tilth, gray soils (Profiles 1, 2) permit only mild tillage action. (Refer to Figure 6.) The more rugged crumb of dark soil (Profile 8) withstands and requires more vigorous processing. In intermediate position are the mottled light brown soils (Profile 3).

How to Plant on Sloping Land

Sloping land imposes two practices: seeding solid and doing it on the contour. Safeguarding the soil against erosion and the promise of full yield combine to make these two measures primary. Here other factors become of secondary weight.

For Safety—Plant Solid

In early season when the crop provides little or no canopy, the soil is vulnerable to erosion. The beating raindrops churn it and the down-slope movement of sheet water carries away the loosened soil. Positioning rows of plants and drill furrows on the contour set up barriers crosswise of the direction of water movement, arresting loss of water, fertilizer, and soil material. In later season, solid planting assures nearly continuous canopy and neglible dislodgment of soil particles by beating raindrops (See Figure 19). Of 39 contoured soybean fields studied in Missouri, 19 planted in corn planter width rows averaged 18.3 bushels an acre as against 29.8 bushels on the part of plantings in 7- and 8-inch drills on 15 fields. Moreover, the advantage of contouring over up-and-down planting was 7 per cent in the instance of wide rows and 12 per cent for close rows.

Terracing Fits Profile 2, 3

Although obstructing overland flow puts much water into the body of the soil there remains some that needs to leave over the surface. To drain away this excess, field terraces aid the crop and safeguard the soil on the longer slopes of 2 to 10 per cent grade. Terracing applies to Soil Profiles 2 and 3, the gray and light brown lands, suited to the soybean enterprice. (See page 7). Where terrace structures exist, the procedure of contouring is simplified because planting and other field operations parallel the terrace which serves as a guide.

Widespread proof of the conservation value of contouring has been furnished by experience on 150 fields of growers in Illinois, Iowa, and Missouri on which contouring out-performed up-and-down slope planting by 2½ bushels of soybeans an acre or 11 per cent (Figure 21).

On Level Land: Row or Drill?

Level land permits but does not argue for row planting. The supposed yield advantage of rowed planting versus solid drilling is not a settled issue. True, if one has an abnormally weedy site to deal with, then rowing the crop becomes a necessity in order to be able to uproot weeds and keep the crop clean. Putting the crop in rows of 21 inches, 24 inches, or 28 inches economizes on amount of seed required and reduces the hazard of lodging, but the grower may face the disvantage of loss by dribble at the cutter-bar when combining. A short-stemmed crop is especially troublesome in this respect.

Not a Closed Issue

Yield findings favoring solid planting have been and are yet being had in enough instances as to place the two methods on a par. Which, if either, would prove superior under situations of 35- or 40-bushel yield level, remains to be established. On the score of exposure of soil to damage by beating rains, certainly rowing offers the greater hazard. But plants in 7-inch or 8-inch drills soon grow enough top to shield the soil surface, prolonging good tilth once established and thereby lessening the need for its renewal by tillage. Too, under a continuous canopy substantially less dislodging and flotation of soil fragments takes place.

Time and Rate of Planting

There is a best time to plant soybeans and that is at corn planting time. May 7 to 15 has proven experimentally to be the optimum period. Each 10-day delay after that optimum has meant a sacrifice of about one bushel in yield, with the rate of loss increasing through June and July. At the Ohio Station, delaying planting three days has resulted in one-day later maturity.

Experience and experiment on rate of planting show the following guiding points:

For solid drilling: 1½ bushel is an optimum rate of seeding, provided the seed is of high germination and the tilth condition of soil is prime. If seed and tilth are inferior, or the seed above average in size, then 2 bushels are needed.

For row planting: 45 pounds of good seed is a proper rate in row-planting. The earlier maturing varieties, being short stemmed and usually non-branching, have limited space for pods, require more plants per acre to afford full yield. If rowed, Earlyana and Richland yield best at a 20-inch spacing. Their yield lessens as the rows widen. The Lincoln variety will do as well at 28-inch spacing as at 21-inch rowing, especially on highly productive land. Considerations governing the merits of solid and row plantings are treated on pages 22 and 23.

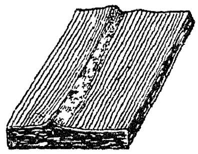


FIG. 20

Gauge Planting Depth by Soil

Depth of placing seed is normally 1 inch. Less depth may result in insufficient moisture to bring normal germination (Figure 23). Greater depth may prove too remote from surface heat to favor prompt germination and means undue resistance to emergence. Cool soils, the ashy gray ones, promise best performance, if planting is ½ to 1 inch deep. But a 1½-inch depth offers best germination on the warm soils, the dark ones.

Invitation to Air and Water: Cultivation

To admit air and rainwater into the soil, cultivation is needed. Crusting or consolidation after rains slows the respiration process of roots, restricts gaseous nitrogen reaching nodules, and repels intake of rainwater. To keep these three functions normal, tillage deep enough to reopen the consolidated layer is needed (see Figure 24). Need disappears when the top growth of the soybean becomes great enough to furnish a protecing canopy.

TILTH BY TILLAGE

Until there is a protecting canopy, repetition of tillage will be called for following rains and even after periods of high humidity and cloudiness. No rule-of-thumb guide fits. Unlike durability of tilth means unlike program for its renewal, namely:

Simplest—Possessing strong tendency to self granulate into rugged crumbs, dark colored soils (Profile 8) require least attention to cultivation. For them shallow as well as infrequent action suffices.

Greatest—At the other extreme stand the gray soils (Profiles 1, 2). The fragile crumb characterizing them is prone to slake apart, rendering tilth less

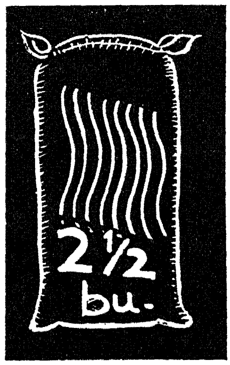


FIG. 21.—Summary of farm studies in Corn Belt and represents average returns on soybeans being had by farmers by contour planting.

enduring. More frequent and deeper rebuilding of tilth is required of cultivation.

Medium—The brown soils (Profile 3) exhibit a need for cultivation intermediate between the above two.

ACHILLES HEEL

The 1-inch or 2-inch surface is the critical layer. Vulnerability centers there. It is here that openness and coarseness must be sought. That condition can be achieved by the rotary hoe, spike-tooth harrow, or spring-tooth cultivator on the dark soils; by deep working shovel, or spring-tooth cultivator or rotary hoe on the gray or brown soils. Corrugation and great coarseness are proper on slopes; openess and looseness, or level sites.

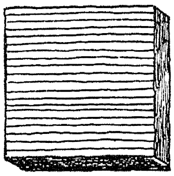


FIG. 22

Forethought and Technique in Harvesting

The combine is by far the most economical method of harvesting soybeans and has completely replaced all other methods in the important grain producing areas. Fewer soybeans are lost by this than any other method of harvesting.

Soybeans should not be harvested for direct storage until the moisture content is 14 per cent or less. If placed in large or deep bins, the moisture content dare not exceed 13 per cent.

ONE GUIDE: MOISTURE

Soybeans should be harvested promptly after they are first ready. Delaying harvest is unnecessary and may prove to be costly, if bad weather further delays harvesting until the soybeans have been damaged in the pod. If weather remains dry throughout the harvesting season, there is the danger of splitting in the harvesting operation. Splitting can be avoided if the combine cylinder is run at a reduced speed.

Prompt harvesting also permits timely seeding of winter wheat or rye after the soybean crop is harvested. The excellent tilth of the surface soil following soybeans often permits direct seeding with a disk drill without previous soil preparation. Since stiff-stemmed varieties feed evenly into and through the combine, the person who adopts them will experience less bunching of straw and troublesome interference with soil-working operations.

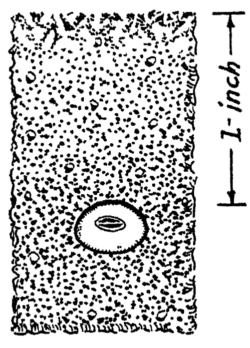


FIG. 23

Hay Not Excelled

Soybean hay is equal in feed value to any other high-quality legume forage (See Figure 25). It may fall short of that high value if during curing one permits loss of leaves or spoilage. August ought to be hay-time for soybeans, affording 7 per cent more daily sunshine and 11 per cent higher temperature than does September. By adopting the so-called grain varieties for hay purpose, one can take advantage of their earliness to shift hay-time from September to August. Then the better curing weather makes high quality attainable.

Haying Formula Peculiar to the Soybean

To obtain best quality hay and gain ease of curing needs to be done when the pod is yet green and the bean immature and swelling. True, deferring until the seeds are three-fourths fully formed will produce the maximum yield, but it is obtained, however, at the expense of quality because of loss of leaf and tardy curing of the large seed in pod.

Fig. 24.—Sealed surface reopened by lifting action of rotary hoe; Brookston soil.

Leaving the crop one to two days in the swath before putting into small windrows is good precedure.

Defoliation Advances Date of Harvest

Powdered cyanamid, previously sold as "AERO Defoliant" but now as "AERO" Cyanamid, Special Grade, has been used to a limited extent to induce leaf drop and advance the date of harvest.

When applied evenly on the ripening leaves of the soybean at the rate of 75 to 100 pounds to the acre, defoliant will hasten leaf drop and drying of the plants for ease of harvesting. However, if applied before the first leaves begin to yellow, foliage will be killed but the leaves will cling to the plants and interfere with good separation of the grain in the combine. Standing weeds also dry up faster after treatment with the defoliant.

The real worth of a defoliant in soybean farming is as yet undetermined. Fields in which the crop ripens unevenly can be harvested earlier after the judicious use of a defoliant. Applications made too far in advance of maturity seriously reduce soybean yields. Therefore, defoliation is no substitute for early maturing varieties.

On occasions, however, a small sacrifice in yield may be justified to permit timely seeding of wheat after soybean harvest. Incidentally and fortunately the nitrogen in the defoliant is recovered by the soil with benefit to future crops.

Land Management Following Soybeans

All too frequently the soybean haulm, left from combining the grain, is destroyed by burning in order to expedite the seeding of small grain, whether it be wheat in the fall or oats in the spring. The common complaint is that it is difficult to prepare the seedbed, either by disking or plowing, because the haulm is tough and not uniformly spread over the land.

Disposal of Haulm

The problem of obtaining uniform distribution of threshed haulm, as it is directly expelled from the moving combine, has not been entirely solved. The combines with straw spreader attachments and those with wide separators, carrying the straw directly through the machine, deposit the haulm more evenly and thinly on the ground surface. This is especially true with the shorter-stemmed varieties that feed through more evenly than a lodged crop. This insures a more even discharge of straw from the machine. Under these conditions there should be no difficulty in preparing the land for fall or spring-seeded crops.

Haulm—Fertilizing Value

The relative fertilizing values of soybean haulm and other crop residues, calculated on the basis of 1947 average prices of nitrogen, phosphate and potash in fertilizers, are set forth in Figure 26.

Fertilizing the Succeeding Crop

The relative damage or improvement a crop contributes to the soil is measured largely by the amount and kind of organic matter added or

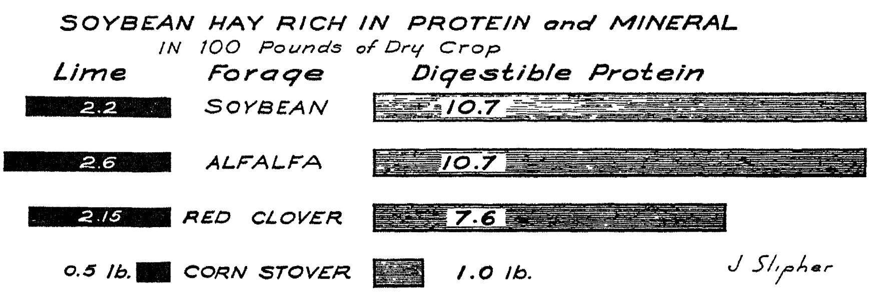


Fig. 25.—Well-made soybean hay is the equal of hays from perennial legumes in feeding value.

Residue	POUNDS NUTRIENTS IN 1 TON — Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Their Value Dollars
Soybean haulm 2	25	6	15	$4 29
Oats straw 1	13	4.5	31	$3 46
Corn 1	18	5.2	15.5	$3.37
Wheat straw 1	18	3.2	17.5	$3 34
Sugar beet tops 1	4.5	8.5	67.5	$4 64
Sweet clover haulm 3	31	2	36	$5.48

FIG 26.—Content of chart based on 1, "Feeds and Feeding" by F. B Morrison, 2, data by L. E Thatcher; and 3, data by C J Willard, Ohio Agricultural Experiment Station.

destroyed, the quantity of minerals removed, and the physical effects on the soil. Only about one-tenth of the weight of the soybean plant is in the roots, while with clovers and alfalfa the proportion is one fourth to nearly one-half. However, about two-fifths of the nitrogen of the soybean plant is contained in the leaves, straw, stubble and roots which usually remain on the land. The nitrogen contained in the residues plus the nitrogen fixed by independent organisms is sufficient to maintain the nitrogen supply in an average to good soil. Note Figure 26.

The soybean plant is a relatively heavy consumer of minerals. A 30-bushel soybean crop uses up as much phosphate and approximately one-third more potash and lime than a 60-bushel corn crop.

The problem, then, is one of replacing the plant nutrients consumed by the usually unfertilized soybean crop. This may be done by increasing the amount of fertilizer applied on the succeeding crop. It may respond favorably to direct applications of 325 to 400 pounds per acre rather than the usual of 250 to 300 pounds per acre. And, in order to maintain the proper mineral balance, the fertilizer grade should carry an amount of potash equal to that of phosphate.

Legume Seedings Following Soybeans

The occasional experiences on some farms have indicated that stands and yields of alfalfa and clovers have been adversely affected, when seeded in small grain following soybeans in the crop rotation. Legume seedings have also failed following other crops where formerly they were grown successfully. These failures may be attributed to a number of factors. Among them are: (a) increased soil acidity, (b) depletion of nutrients in the soil—phosphate and potash, (c) insufficient seedbed preparation, (d) competition of the companion crop, (e) the use of unadapted seed, (f) unfavorable weather conditions, and (g) disease and insect infestation.

The tests conducted by Willard and Thatcher, of the Ohio Agricultural

Experiment Station, over a period of three years (1944-46) show that hay fields were higher from seedings made in small grain following soybeans than after corn. These tests also revealed that the total number of alfalfa or clover plants for a given area was less following the soybeans, but the total weight of hay was greater after soybeans.

In other long-time experiments at the Ohio Station, when soybeans were introduced into the crop rotation, the hay yields were depressed by an average of 159 pounds per acre.

It appears from these tests that legume seedings are more likely to fail because all crops grown have brought about a depletion of mineral elements, lime and organic matter in the soil more rapidly than replacement has been made.

Market Grades of Soybeans

Grade requirements for Yellow Soybeans, Green Soybeans, Brown Soybeans, Black Soybeans and Mixed Soybeans.

Grade	Minimum test weight per bushel	Maximum limits of—			
		Moisture	Splits	Damaged kernels (soybeans and other grains)	Foreign material
	Pounds	*Percent*	*Percent*	*Percent*	*Percent*
No. 1[1]	56	13.0	10	2.0	2.0
No. 2[1]	54	14.0	20	3.0	3.0
No. 3[1]	52	16.0	30	5.0	4.0
No. 4[2]	49	18.0	40	8.0	6.0
Sample grade	Sample grade shall be soybeans which do not meet the requirements for any of the grades from No. 1 to No. 4, inclusive; or which are musty, or sour, or heating; or which have any commercially objectionable foreign odor; or which contain stones; or which are otherwise of distinctly low quality.				

[1] The soybeans in grade No. 1 of the class Yellow Soybeans may contain not more than 1.0 per cent, in grade No. 2 not more than 2.0 per cent, and in grade No. 3 not more than 5.0 per cent of Green, Black, Brown, or bicolored soybeans, either singly or in any combination.

[2] Soybeans which are materially weathered shall not be graded higher than No. 4.

Contents