THE SOYBEAN PROJECT

4-H-209-W

Purdue University Cooperative Extension Service • West Lafayette, IN 47907

Contents

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The Soybean Project

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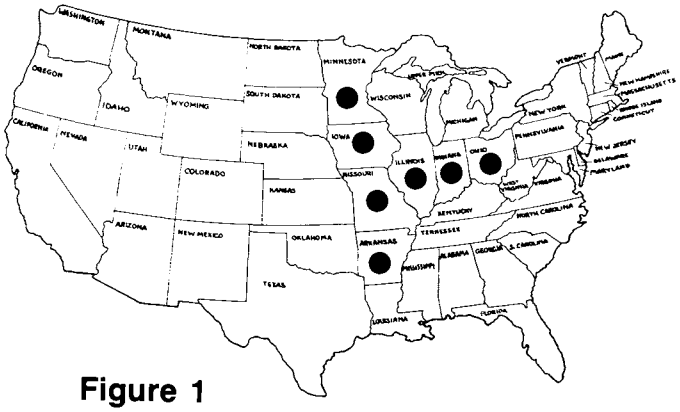


Figure 1

Soybeans came to the United States at the beginning of this century from eastern Asia. For several thousand years before that the soybean had been one of the five sacred grains of China. Orientals still prepare soybean seeds in hundreds of ways for human food.

About 1930 the soybean began to be important economically in this country. Its first use was as a forage crop. It was preserved as hay or silage or used as pasture for hogs and sheep. It was also plowed under as a green manure crop to enrich the soil.

When the many uses of the plant's high quality protein and oil were discovered, the soybean quickly became a "wonder bean." In fact, the growth of the soybean industry has been without equal in the history of U.S. agriculture. Since World War II soybean acreage in the cornbelt has been steadily increasing. Figure 1 shows the states that produce large acreages of this crop.

Indiana farmers grow soybeans on close to 4.5 million acres each year. They are often the state's number one cash crop. Figure 2 shows where most of the soybeans are grown in Indiana.

Indiana farmers have increased their acreage of soybeans for several reasons. First, demand for soybeans has increased each year. Buyers keep on bidding up the price of soybeans even though farmers are raising more acres. Second, most land that grows corn also grows good soybeans.

Today, only a few places in the world can grow soybeans. With soybeans playing an increasingly important role in feeding the people of a hungry world, U.S. farmers are exporting every other row of their soybeans to other countries.

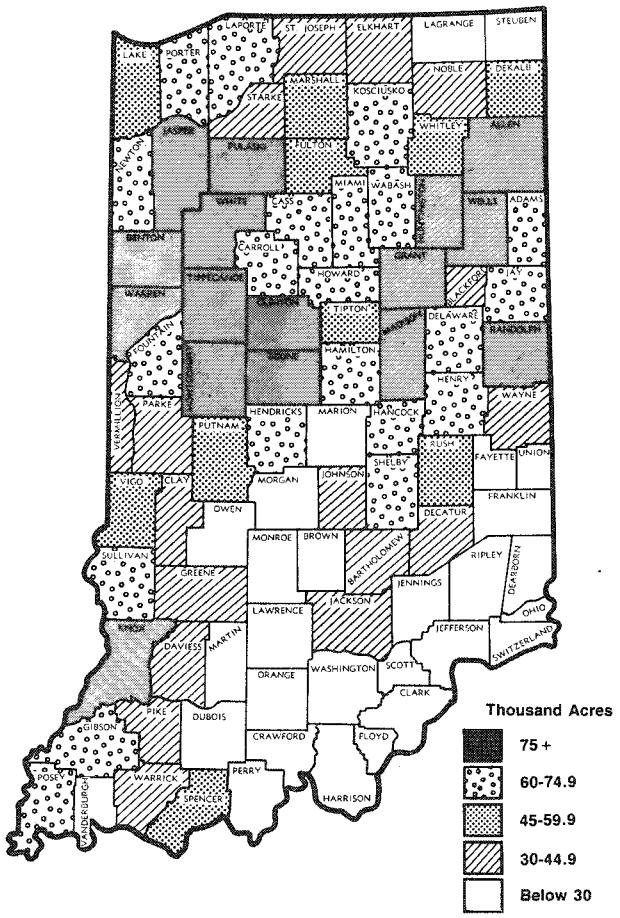


Figure 2

The Soybean Described

The soybean is a member of the legume family. Other common plants in this family are alfalfa, clover, peanuts, peas, and field beans. Plants in the legume family have a number of things in common:

- The seeds are always formed in pods.
- The plants have the ability to use nitrogen from the air. A special kind of bacteria produces lumps (nodules) on plant roots and make its home inside. This bacteria furnishes nitrogen to the plant. Farmers can buy this special bacteria and place it on or near the seed at planting time to encourage nodulation as roots develop. therefore, there is no need to buy nitrogen fertilizer for soybeans.
- Many legumes are high in protein. This is part of the reason why soybeans have become such an important crop.

The Seed

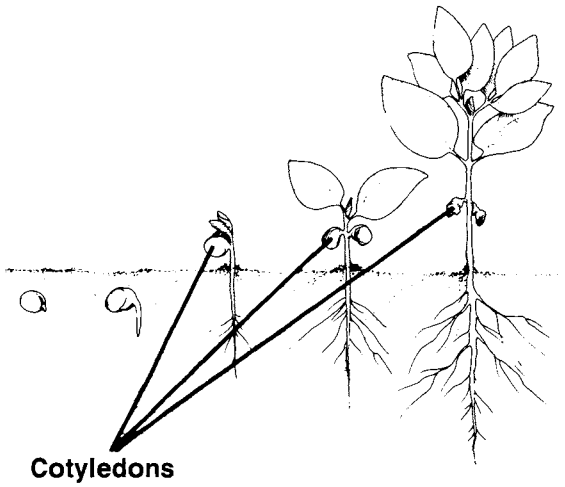
Two or three soybean seeds are usually found in each pod, and there may be several hundred pods on each plant. Each soybean seed is made up of two halves called cotyledons (cot-i-le-duns). This is why the soybean is called a dicotyledonous (di-cot-i-lead-on-us) plant. Between the soybean cotyledons—and attached to them—is a small embryo plant with tiny leaves and root. The two cotyledons contain stored food which the young plant uses when the seed is placed in the right surroundings and germinates. See Figure 3.

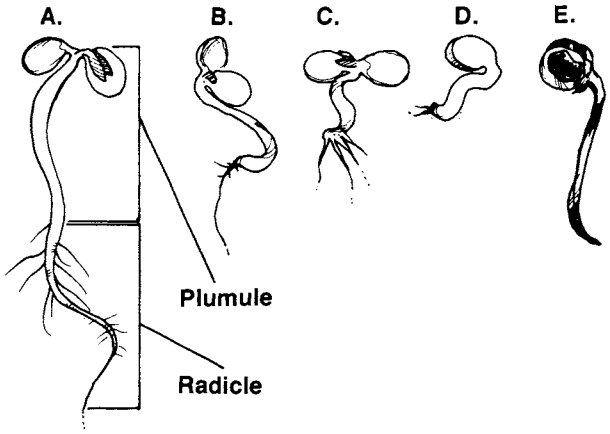
Most soybean seeds in Indiana are a yellowish color and have a black, brown, or colorless eye. The eye is named the hilum (hi-lum). Some farmers coat the seeds with a material to protect the seedling from disease. These seeds are stained a red, purple, green, or yellowish color to show that they have been treated with a fungicide.

Some soybean seeds do not produce a strong seedling when they germinate. The weak seedling is likely to die. If enough of the seed planted is of this type, a poor stand develops, and yield per acre is reduced.

When he analyzes the seed to be planted for germination, the seed analyst does not count weaker seedlings among those that germinated. Figure 4 shows the difference between healthy and weak seedlings.

Figure 3





A. Normal Sprouts
B. Rudimentary Plumules
C. Stunted Radicles (Plumule Development O.K.)
D. Broken and Stunted
E. Rotted Plumules

Figure 4

The Seedling

The first true leaves to appear above the cotyledons are the two unifoliolate (single) leaves. These leaves have a single leaflet per petiole (leaf stem). Unifoliolate leaves and cotyledons grow opposite each other.

All the other soybean leaves that develop later have three leaflets. They are called trifoliolate leaves. One of these leaves develops each node or stem joint. Trifoliolate leaves do not grow opposite each other, but alternately on the stem. See Figure 5.

The junction of the main stem and a leaf is called an axil. In each axil is an axillary bud. This bud may develop into a branch, form a flower cluster, or remain dormant. Buds are also present where the cotyledons attach to the main stem. These remain dormant unless the plant is cut-off above the cotyledons.

The Root

Soybeans have a tap root that grows down into the soil about 2 feet. The soybean also develops a dense fibrous root system which fills the area between rows. Parts of the branched root system are as close as 2 to 4 inches from the surface of the soil.

The Mature Plant

Northern corn belt soybean varieties continue to develop new leaves and stems after flowering begins. Botanists call this kind of flowering habit "indeterminate." So you will find flowers developing in leaf axils lower on the plant while it is still producing new leaves as its top.

The soybean plant flowers over a period of 3 to 5 weeks. During this time you may find pods, flowers, and buds on the same plant. Soybean flowers are very small and are either purple or white depending on the variety.

Parts of a Young Soybean Plant

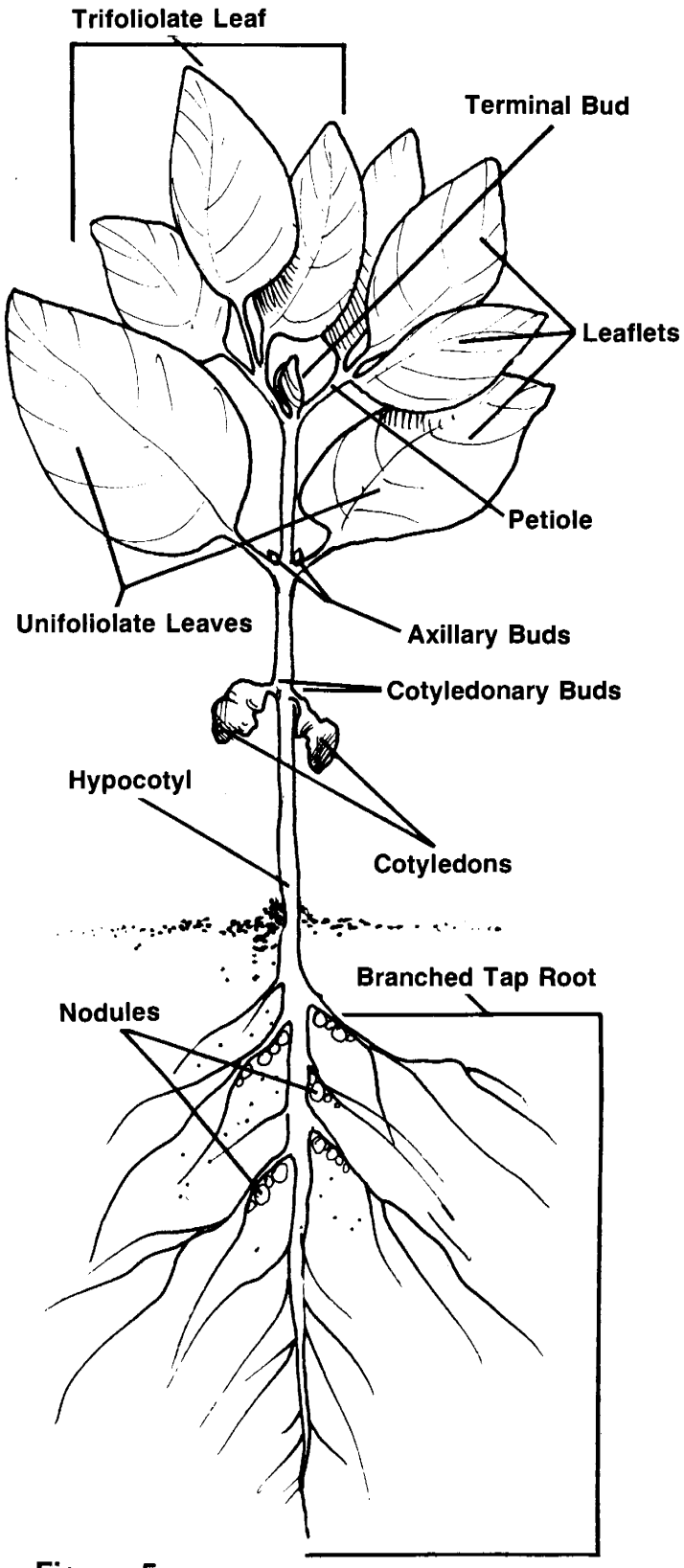


Figure 5

Activity No. 1

Do a soybean seed germination test.

1. The soybean's life begins when the seed germinates. Break a soybean seed into its two halves. Look inside at the small embryo plant waiting to develop when the seed is placed in the right surroundings.

2. Place two paper towels together and sprinkle water on them lightly. The towels should not be too wet. See Figure 6.

3. Get a sample of seeds to be tested. What color is the seed?

Are the seeds stained with a colored material that shows they have been treated with a fungicide?

Are the seeds covered with small black speckles showing that they have been inoculated?

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4. Put 25 soybean seeds on the moist towels. Do not let the seeds touch each other.

5. Moisten two more towels and place them on top of the seeds.

6. Roll the towels and seeds loosely and put a rubber band around each end of the roll. Place the roll on end in a small container.

7. Sprinkle the towels each day with enough water to keep the roll damp.

8. Store the roll in a warm place for 5 days. Unroll the towels and count the number of seeds that have germinated. Germinated seeds will have roots that are at least one inch long. Compare these seedlings with those in Figure 4. How many seeds germinated?

Throw away the seeds that have germinated.

9. Roll the remaining seeds in the paper towels again. Keep the roll moist at all times and store for 7 more days.

10. Remove the seeds. How many more seeds germinated?

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11. Add the number of seeds that germinated in Step 8 and 10.

Total = _____
Divide the answer in Step 11 by 25.

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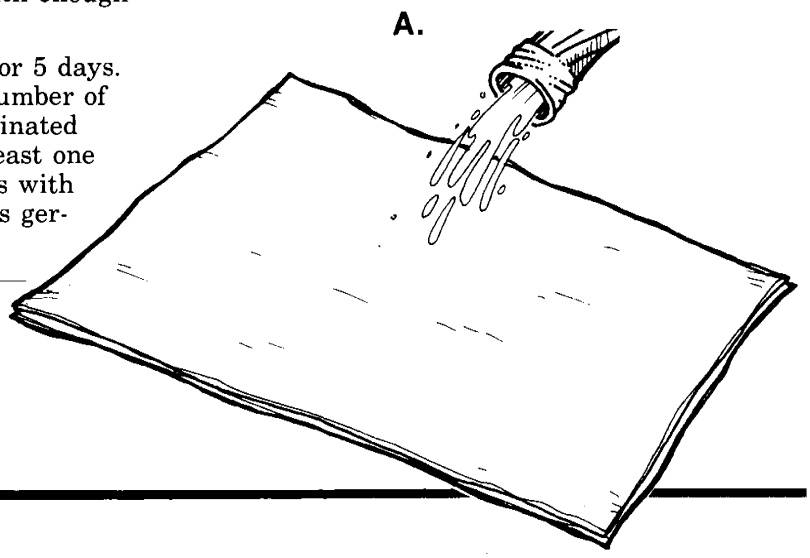
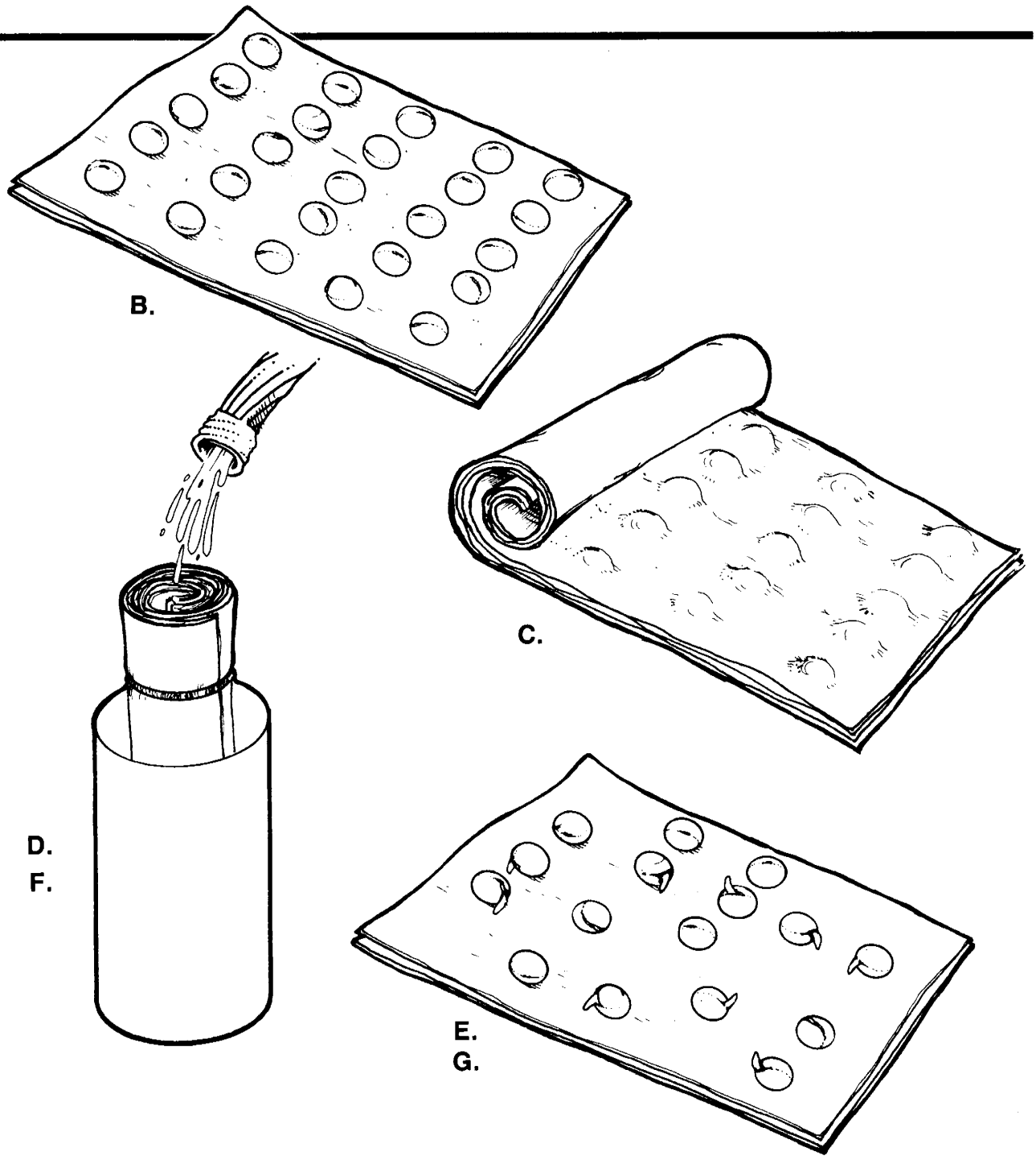
12. **Example:**
Step 8 = 12 seeds
Step 10 = 8 seeds
Total = 20 seeds
Divide 20 by 25 = 0.80
Multiply 0.80 by 100 = 80

Answer: 80 percent of the seed in this example germinated.

Note: Soybean seed should have a germination rate of at least 80 percent for satisfactory performance in the field.





A. Sprinkle towels with water.
B. Arrange soybean seeds.
C. Cover Seeds and roll towels
D. Sprinkle with water.
E. After 5 days remove germinated seeds.
F. Reroll towels and keep moist for 7 more days.
G. Remove germinated seeds.

Figure 6

Activity No. 2

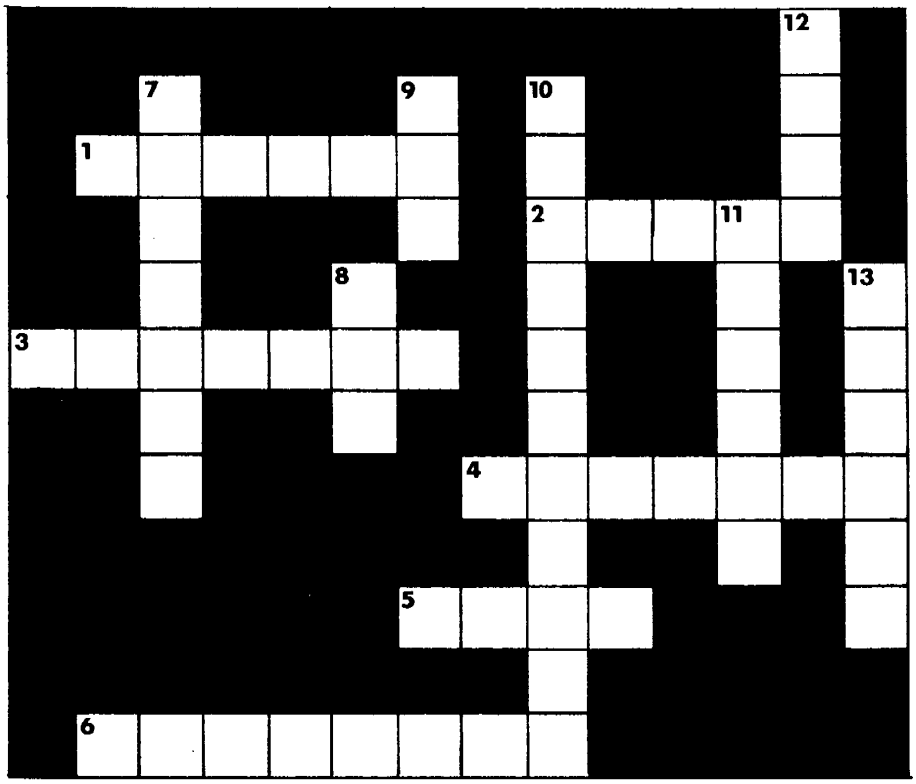
Do a soybean crossword puzzle.

Across:

1. Plant family to which soybeans belong
2. Soybeans grown here thousands of years ago
3. Soybeans have a high content of this
4. A legume used as hay
5. Stem joint
6. Supplied by the bacteria living in nodules on soybean root

Down:

7. Leaf stem
8. Extracted from soybean seed
9. Member of legume family
10. Refers to each half of soybean seed
11. Lump on soybean root where bacteria live
12. Contenent from which soybeans probably came
13. Early use of soybeans in America



Answers:

1. legume, 2. China, 3. protein, 4. alfalfa, 5. node, 6. nitrogen, 7. petiole, 8. oil, 9. pea, 10. dicotyledon, 11. nodule, 12. Asia, 13. forage

Selecting a Soybean Variety

Soybean plants come in many sizes and shapes. Each different kind is called a variety. Some varieties produce seeds within 75 days after they are planted. Others need 200 days to mature. Varieties range in height from 1 to 6 feet. Some varieties grow erect. Others creep along the ground. Some varieties can be grown successfully in Indiana. Others cannot.

How New Varieties are Developed

Thousands of soybean varieties have been brought to the United States from Asia. From these, plant breeders have developed new varieties which will grow and produce high yields in Indiana soils and climate. They do this by "crossing" one variety or strain with another.

The development of a new variety takes time. The first step occurs when the plant breeder places pollen from one plant onto the flower parts of a plant from a different variety. Seeds harvested from this cross are called the "first generation."

It takes four to six generations to develop a new strain. Then it takes three to four years of field testing to see if the new strain is better than older strains.

If a new strain is better, it is then named as a new variety. Farmers begin to grow these new and better varieties. Eventually the older varieties are no longer grown.

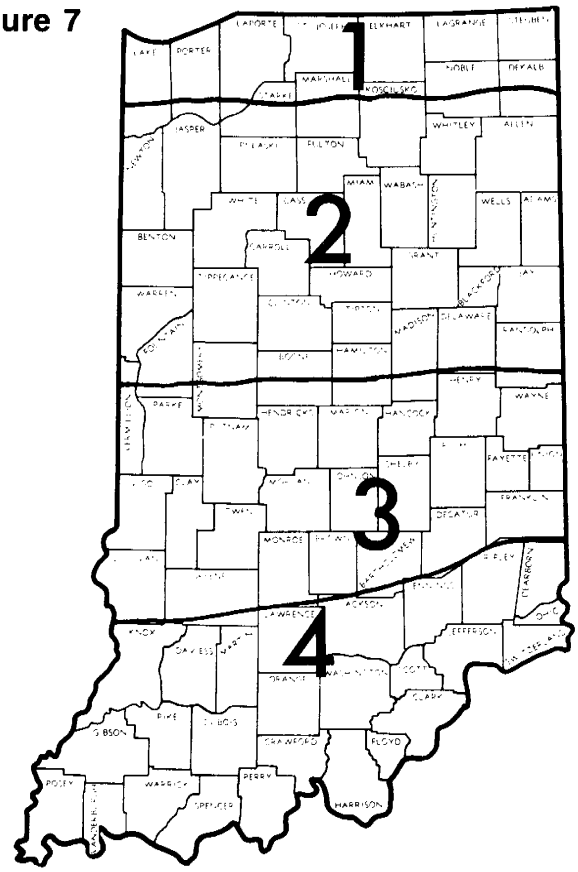
Soybean Traits

When you are selecting a soybean variety to plant, think about these traits:

- High grain yield
- Right maturity—soybean group see Figure 7
- Insect and disease resistance
- Lodging resistance—ability to remain upright
- Good seeding vigor
- Improved grain quality (The seed may have a higher protein or oil content.)

Growth habit (Is the variety a bushy or upright type?)

Figure 7



Maturity Groups Commonly Grown In Indiana

Certified soybean seed guarantees that the seed is true to variety. This means the seeds will produce plants as described by the company or person that developed the variety. For this reason, certified seed is a good investment.

Now certified seed may be sold by brand name or number with variety not stated. In this case, you will not know the genetic identity of the soybeans planted.

The analysis tag on a bag of certified seed lists:

- Crop purity
- Weed seed contamination
- Germination percentage
- Foreign material
- Date tested
- Variety name

Variety Adaptability Belts

You cannot grow all varieties of soybeans in all locations. This is because soybeans must produce mature seeds before frost. The length of day and night controls soybean flowering and maturity. Latitude—the distance north or south of the equator—determines the length of day and night.

The same soybean varieties will grow in long belts east and west. But you can move them only short distances north and south. This means that you might possibly grow a soybean variety and adapted to southern Iowa here in Indiana. But you could not grow this same variety in Arkansas because day length is different there. Even in Indiana some varieties that are grown in the northern counties are not recommended for growing in the southern parts of the state. See Figure 7.

To find out which varieties are adapted to your area, get the current Purdue Soybean Variety Performance Bulletin from your County Extension Office.

Effect of Day Length

Soybean plants remain vegetative (do not flower) when days are long and nights are short. This is the way it is in Indiana in June. In July when days start to shorten and nights begin to lengthen, flowers appear on the plants and seeds begin to develop in the pods. Regardless of when you plant them, most soybean varieties grown in Indiana begin flowering in early July. However, beans you plant earlier grow larger than beans you plant later. This permits larger yields.

You can demonstrate the effect of day length on soybean flowering by covering some vegetative plants in order to reduce the number of daylight hours they receive. These plants will flower sooner than the plants you do not cover artificially. (The same thing happens when a soybean variety is moved south from its adapted latitude because summer days are shorter in the south than in the north.)

Activity No. 3 Select a soybean variety.

Visit with a seed dealer, farmer or County Extension Agent. Find out which soybean varieties are being grown where you live. What are the advantages and disadvantages of each of the several varieties?

Soybean Variety	Advantages	Disadvantages

Activity No. 4 Demonstrate the effect of day length (light and darkness) on flowering.

1. Plant a row of soybeans 5 feet long in fertile soil in a sunny place. In Indiana, do this any time between May 10 and June 1. Place the seeds 2 inches apart. Cover the seeds with 1 to 1½ inches of soil.

2. Water the plants as necessary to keep them growing.

3. Grow the plant until their first two leaves are fully expanded and green. This will be about 2 weeks after the seedling emerges from the soil.

4. Construct a light-tight box large enough to cover about a foot of the soybean row. Construct the box so that there can be an adequate exchange of air between the inside and the outside. One good way is to make a frame of wood and cover it with at least two layers of black sateen cloth. Make the frame 12 to 18 inches long, 12 inches wide and 10 inches high.

5. Select and mark the place in the row where you are going to use the frame to increase the length of night the plants receive.

6. When you are ready to start the demonstrations, cover the plant with the black sateen box frame so the plants receive at least 13 hours of darkness. For example, place the frame over the row at 7 o'clock in the evening and remove it in the morning at 8 o'clock. Cover the same plants each day. Continue this treatment for 14 days. (For the surest results, keep covering the plants each evening until the first flowers appear.) Look carefully for the flowers each day. They are small and sometimes difficult to see.

7. Be sure no light is allowed to interrupt the dark period. Do not forget to cover the plants every evening. Push soil around the bottom of the frame so that no light reaches the plants.

8. Observe the plants receiving the normal light-dark period in the row next to the plants you are covering. Record these observations:

Soybean variety _____

Date planted _____

Date dark period began _____

Plant height at start of experiment _____

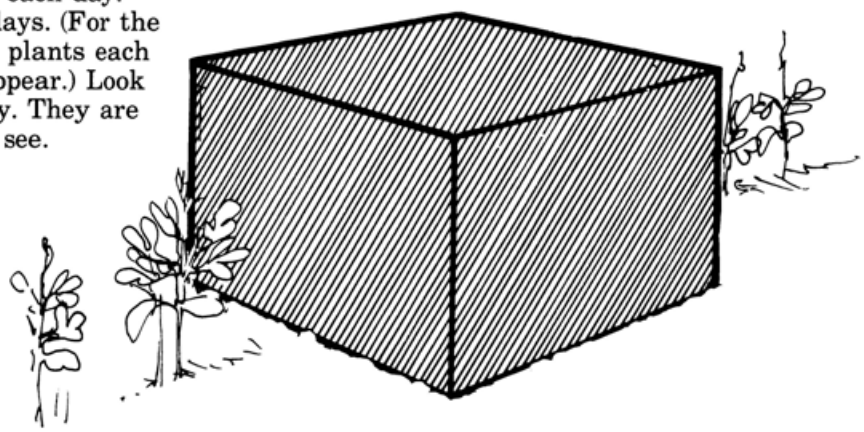
Evening hour soybeans were covered _____

Morning hour soybeans were covered _____

Date first flower was seen:

On artificially covered plants _____

On naturally grown plants _____



Activity No. 5

Find Out about differences in flowering among soybean varieties.

1. Get seeds of one early, one medium and one late maturing soybean variety. For example: Maturity Group II, III and IV in Figure 7.

2. Plant seeds in separate rows or in separate sections of the same row. Plant each variety the same day—sometime between May 10 and June 1. Mark the place where you plant each variety.

3. Record your results:

Date planted _____

Early maturing variety _____

Date first flower was seen _____

Plant height when first flowers seen _____

Medium maturing variety _____

Date first flower was seen _____

Plant height when first flowers seen _____

Late maturing variety _____

Date first flower was seen _____

Plant height when first flowers seen _____

Planting The Soybean

Date of Planting

Soybean yields do not drop off quite so soon as corn yields when the crops are planted in late May or June. Good bean yields can be obtained from varieties that mature slightly ahead of corn. Therefore, when you grow both corn and soybeans on the same farm, you can extend the planting season and the harvest season over a longer period of time.

On Indiana farms, corn is usually planted first, then soybeans. This is usually the correct order. Corn seedlings can recover from hard freezes because their growing point is protected below the ground until the plant is about 15 inches tall. Soybeans can tolerate cold weather. However, their growing point is exposed. A freeze can kill them.

If you plant soybeans too early, cool soil delays seed germination. Poor stands may result. Weeds may get ahead of soybean seedlings.

However, you need to plant soybeans as early as you safely can. Earlier planted beans will grow taller. They will have a larger plant on which to produce soybean pods. More of the sun's energy will be used to produce beans.

In Indiana, you should generally plant soybeans between May 10 and May 25 for highest yields. Each week you delay planting after about mid-May reduces yield per acre by 2 bushels.

Row Width

In the past, row crops were planted in 40-inch rows. However, you can usually increase soybean yields in Indiana 10 to 20 percent when you narrow your rows to 20 or 30-inch spacings. Yields may increase another 5 to 10 percent by planting in 7 to 10-inch row spacings.

Match row spacing with the soybean variety growth type. Some varieties usually yield better in 20 or 30-inch rows. Other varieties are bushy type beans called "fat-line" varieties. These may spread out and cover even 40-inch row spacings.

Narrow rows aid weed control. The area between rows is covered faster by the soybean plants, and weeds are shaded more quickly. Chemicals do not give perfect weed control so you may want to plant in row spacings which are wide enough for cultivation equipment. Post-emergency (see page 20) chemicals can be sprayed on soybeans planted in narrow row spacings to control weeds.

Seeding Rate

Seeding rate recommendations are often quoted in pounds per acre. This is not always a reliable guide because the number of seeds per pound varies with the soybean variety. Some varieties have small seeds; other varieties, larger seeds. So the best guide for figuring the planting rate is the number of seeds per foot of row.

Suggested rates of seeding for a different row spacings are given in Figure 8.

Do not "overplant" soybean seeds. If you do, plants will have thinner stems. Lodging plants fallen over onto the soil will result. Harvest losses will be higher. Yields will probably not increase with higher seeding rates than those recommended because there will be fewer seeds produced on each plant.

Suggested Rates of Seeding

Row spacing	Number of seeds per foot of row	Pounds per acre (average size seed)
7″	2-3	80
20″	5-6	60
30″	6-8	55
40″	9-10	45

Figure 8

Seed Inoculation

Some bacteria are beneficial to legumes such as soybeans and alfalfa. Bacteria enter the legume roots and cause the plant to produce nodules. See Figure 5. The bacteria in the nodules take nitrogen out of the soil air and fix it into a form that the soybean can use as plant food. Each kind of legume plant must have its own special kind of bacteria in order to produce nitrogen.

The special strains of bacteria are prepared commercially on several carriers, such as humus, peat or vermiculite. You can purchase these soybean "inoculants" at seed stores. Then you can add the bacteria to the soil or put it on the seed by an inoculation process.

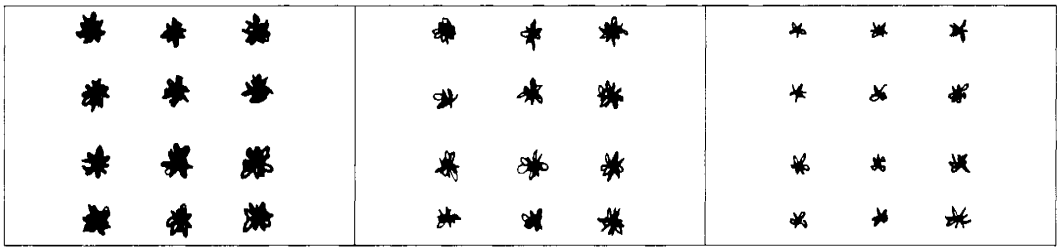
To inoculate soybean seeds, moisten the seeds with water. Then pour the right amount of the inoculant over the seeds and mix thoroughly. The seeds are now ready to plant. Plant them soon after you treat them with the inoculant.

If soybeans have been grown recently (within 3-5 years) in the area you are planting, the proper bacteria may already be in the soil. Then seed inoculation is not necessary. If the field has not been in soybeans for 3-5 years it is a good idea to use inoculum at planting time.

Activity No. 6 Find out how the planting date affects yield.

1. Get seeds of an adapted soybean variety.
2. Plant seeds on three different dates, each about 15 days apart. For example:
   Plant seeds on May 15, June 1, and June 15. See Figure 9.

ONE SOYBEAN VARIETY PLANTED AT THREE DATES



3. Record the following information.

Variety Used: _____

Date of planting	Date when 5% of plants are flowering	Number of days from planting to flowering	Average number of pods per plant on Sept. 1 (count on 10 plants)
1.			
2.			
3.			

4. The numbers in the third column should get smaller from the first to the last date of planting. Flowering will be delayed about 1 day for every 2 days of delay in planting. Why? _____

5. Based on the number of pods, which date of planting do you think will yield the most soybeans?

"Food" for the Soybean

Sixteen chemical elements are necessary for soybeans to grow. Carbon, hydrogen, oxygen, and nitrogen come from the air. Some of the nitrogen and the other 12 elements come from minerals in the soil. These elements have been classified into three categories—major nutrients, secondary nutrients and micronutrients-depending on the amount the plant uses for proper growth.

Study Figure 10. See where the soybean gets its "food." Notice the percentage of each nutrient group taken from the soil. This will help you understand why more attention is given to providing some elements than to others in a soybean fertility program. Notice that the sun provides energy to make the nutrients interact properly.

How well the soybean plant grows depends on how well it is fed. Soybean grain yield will not be higher than the limitation of any one growth factor.

Soil tests help to locate deficiencies by measuring the plant nutrients available in the soil. From a soil test, a recommendation can be made for adding any plant food which is lacking. Your County Extension Agent can tell you how to take and where to send a soil sample for testing.

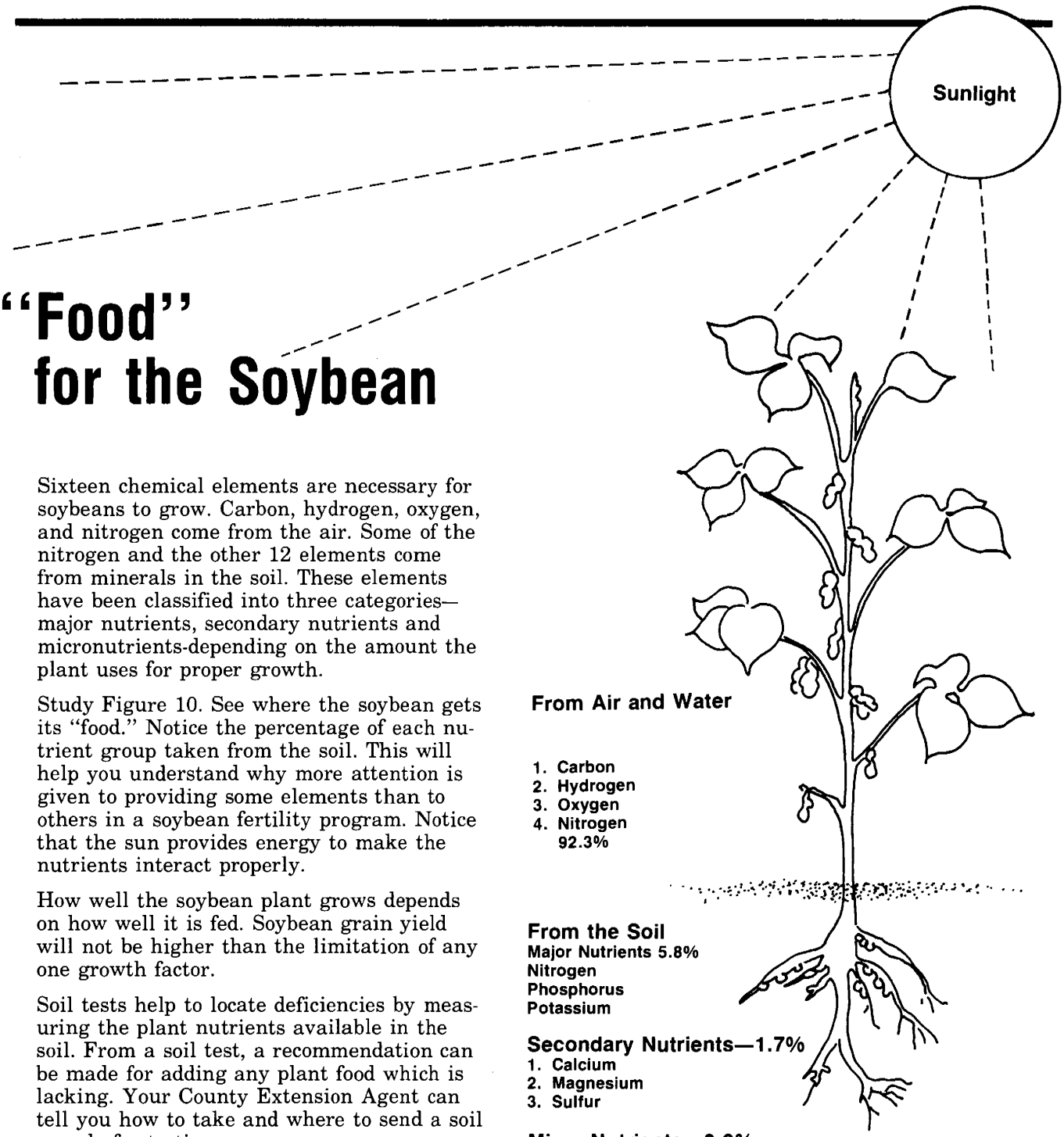


Figure 10

Major Nutrients

Nitrogen

The soybean seed contains more than 40 percent protein. Nitrogen is a component of all protein. Nitrogen is normally supplied by the nitrogen-fixing bacteria and the existing nitrogen in the soil.

The bacteria may not be able to make enough nitrogen available from the air to meet all the needs of a high yielding soybean crop. Therefore, it is best to grow soybeans from previous years. One reason for this is that if you add nitrogen fertilizer directly to the soybean crop, the bacteria slow down or stop their work. Consequently, in a corn-soybean rotation system, it is usually best to apply the nitrogen for both crops the year you plant the corn.

One reason why fertilizer costs less for soybeans than for corn is because corn has no nodules on its roots. Therefore, corn cannot take any of its nitrogen from the air the way soybeans can.

Phosphorus

Phosphorus, like nitrogen, is a major nutrient required for plant growth. Without phosphorus there can be no life. Phosphorus stimulates early root formation and growth. It is important to young plant seedlings. It is essential for flower and seed development, and it speeds up plant maturity.

High levels of phosphorus in the soil favor high soybean yields. Some Indiana soils are naturally low in phosphorus. Phosphorus fertility levels must be built up in these soils before they will produce top crop yields.

Potassium

Soybeans create a big drain on the supply of potassium in the soil. More than half of the potassium used by soybean plants is found in the grain. Since the grain is removed from the field, potassium needs to be replaced by the regular use of fertilizer.

Soils that test medium to high in available potash will produce good soybean yields. However, most Indiana soils need applications of potash fertilizer for top yields.

Secondary Nutrients and Micronutrients

Secondary nutrients and micronutrients are very important for good plant growth. Plants are not healthy without these elements. But plants use them in smaller amounts than they use nitrogen, phosphorus, and potassium.

A good liming program gives soybeans the calcium and magnesium they need. Sulfur shortages do not exist in soybeans in Indiana.

At the present time Indiana soils supply the micronutrient needs of soybeans, except for manganese in certain areas of the state. A fertilizer or foliar spray will supply manganese.

Check with your County Extension Agent if you notice plant leaves turning yellow early in the growing season. Secondary and micronutrients can be toxic or harmful to plant growth if they are present in above normal amounts. Therefore, you want to use micronutrient elements in a soybean fertilizer program only when you know deficiencies exist.

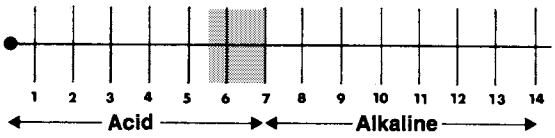


Figure 11.

Soil pH

Soil pH is a measure of the acidity or alkalinity of soil. It is measured on a scale of 1 to 14, with 7 being neutral. See Figure 11. Acid soils are sometimes called "sour." Alkaline soils are "sweet."

Soil pH is important for all crops. The ideal range for most is 5.5 to 7.0 Soil Ph in the ideal range is especially important for legume plants like soybeans. This is because the nitrogen-fixing bacteria prefer this pH.

Soils in Indiana usually fall within the pH range of 5.0 to 7.0 Rainfall has leached basic elements such as calcium and magnesium from the soil, leaving it acid in nature. Lime corrects this acid soil condition. It is also an economical source of calcium. Lime works with fertilizers to produce higher yields of better quality crops.

Activity No. 7

Test for deficiencies in plant nutrients

1. Collect some soil from a highway cut area. Get the soil about 4 to 5 feet down the slope from the surface.

2. Prepare two containers in which to grow the soybeans. You can use regular clay pots or three-pound coffee cans. The containers should have holes in the bottom to let excess water drain out. Covering the bottom of the containers with small chunks of cement block or gravel also helps excess water drain.

3. Fill one container with the poor soil you collected. Fill the other container with good soil from your garden. Plant several inoculated soybean seeds about 1 inch deep in each container. Water occasionally but do not waterlog the soil. Keep the containers outdoors in full sunshine.

4. Look for the following things when you compare the soybeans grown in each container:

- Yellow leaves—Lack of nitrogen or poor nodulation can cause leaves to have an unhealthy yellow appearance. Lower leaves usually turn yellow first when nitrogen is lacking. If margins of the upper leaves become yellow, potash is probably lacking. Deficiencies of other nutrients can also cause yellowing.
- Reddish purple leaf coloring—A phosphorus deficiency often causes young plants to develop a purplish color along leaf margins.
- Stunted growth—It is not easy to decide which nutrients are deficient, but plants grown in poor soil should appear stunted.
- Low grain yields—The grain yields of soybeans grown in poor soil should be low.

5. Record your observations on the plants grown in each container. (Count the number of nodules on each plant by following the procedure described in Activity 8.)

Plant Characteristics

	Leaf color	Plant height	Number of pods	Number of nodules per plant	Other observations
Fertile Soil					
Poor Soil					

Activity No. 8

Collect and preserve nitrogen fixing nodules from the roots of soybean plants.

1. Carefully dig up a soybean plant in late June or July. **Do not pull.** Let as much soil as possible cling to the roots.

2. Put the plant and soil in a container filled with water. Let it stand for one day.

3. Very carefully remove the soil that still clings to the root system.

4. Cut all nodules from the roots and place them in a small jar filled with alcohol.

5. Record the number of nodules you find.

_____

Cut open a few nodules. What color is the inside?

_____

How do nodules help the soybean plant grow?

_____

_____

Protecting the Soybean

The soybean plant has enemies—weeds, insects and diseases. It needs protection from these enemies. Soybean production practices are designed to provide this protection.

Weed Protection

Weeds are hard on soybean production. For every pound of giant foxtail that grows on an acre, you can expect to harvest 1 pound fewer of soybeans (beans and straw). Or when 1½ pounds of pigweed (dry matter basis) grows, you can expect a 1 pound loss of soybeans.

Weeds compete for plant nutrients, water, and sunlight. They often use more nutrients and water than the soybeans do. See Figure 12.

You may never eliminate weeds, but you can control them. Tillage, planting clean seed, and using herbicides are some of the ways to cut down weeds in your soybean fields.

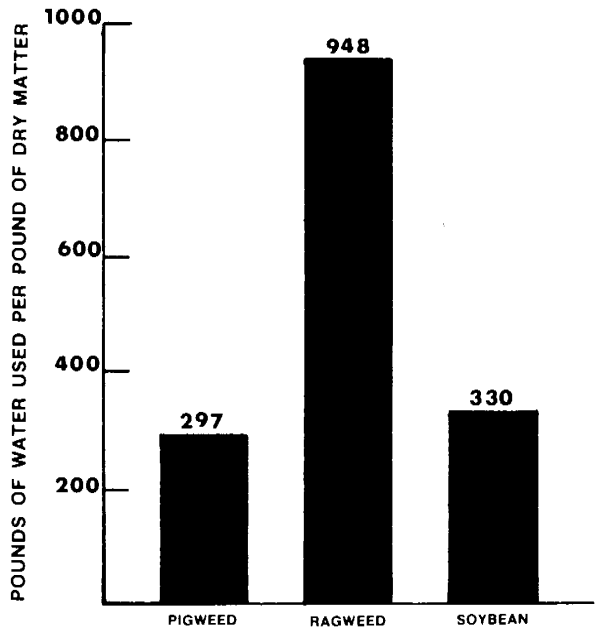


Figure 12

Clean Seed

Why plant a weed problem? Many farmers unintentionally plant weeds by using soybean seed that contains weed seed. One survey showed that 37% of the soybean seed planted contained weed seed. This meant there was an average of 150 weed seeds for every pound of soybeans. Weed-free soybean seed is a good investment if you want fewer weed problems.

Tillage

Two tillage tools—the rotary hoe and the row cultivator—are effective in soybean weed control. Most annual weed seedlings are very small and delicate. The soybean seed is rooted deeper than these annual weeds. Because of this, the rotary hoe can tear small weed seedlings loose from the soil without severely damaging the soybeans.

Begin rotary hoe operation when most weeds have germinated, but before they completely emerge from the soil. Farmers call this the "white" stage of growth for weeds. You can easily kill weeds in this stage. Operate the rotary hoe at 8 to 12 miles per hour for best results. One research study reported 6 more bushels of soybeans per acre as a result of rotary hoeing.

If soybeans are planted in rows, the row cultivator can be used once or twice each season. It destroys weeds between the rows. It can also push soil into the rows to cover young weeds. Shallow cultivation will guard against soybean root pruning. Avoid too much ridging of soil around the stems of soybean plants so the pods will be higher off the ground at harvest.

Chemicals

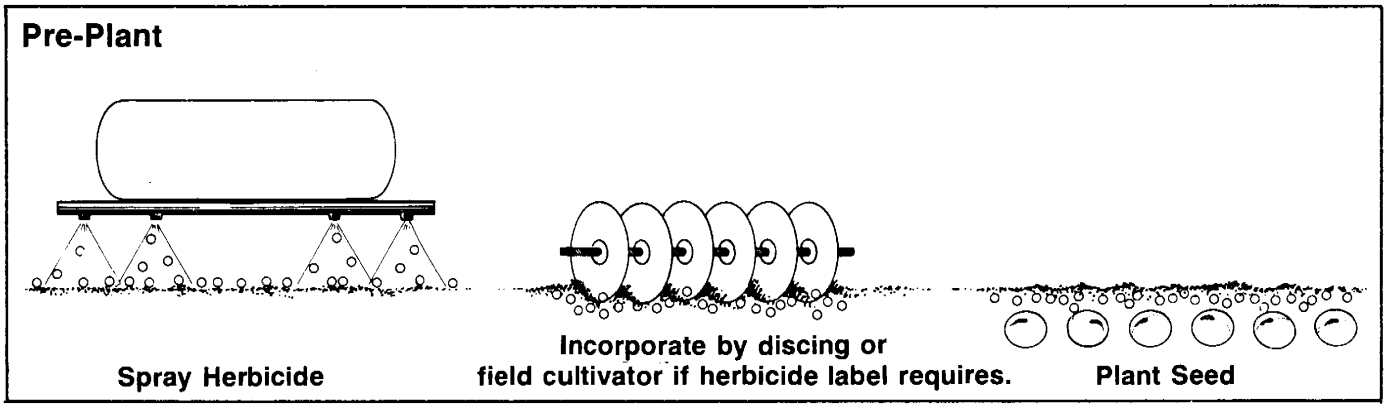
Weeding with chemicals (herbicides) is a newer method of controlling an old problem. See Figure 13. There are three types of soybean herbicides:

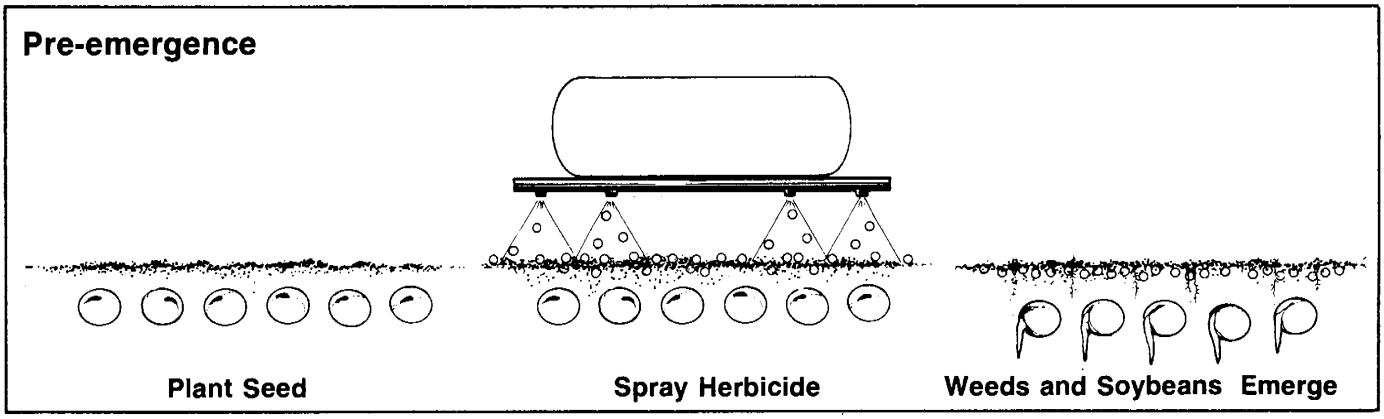
- **Pre-plant**—Apply a chemical onto the soil before you plant the crop. Work it into the soil if the chemical label requires incorporation.

- **Pre-emergence**—Make the treatment after planting the crop, but before the crop or weeds emerge from the soil.
- **Post-emergence**—Spray a chemical over the young soybean and weed seedlings that have emerged from the soil.

New herbicides are available each year. It is important to read the label on herbicide containers and follow the instructions. To find out about recommended rates and methods of application, get a copy of ID-1 "Weeding with Chemicals" from your County Extension Office.

Much progress has been made in chemical weed control. Some farmers now drill soybeans and control weeds entirely by means of herbicides and crop competition.





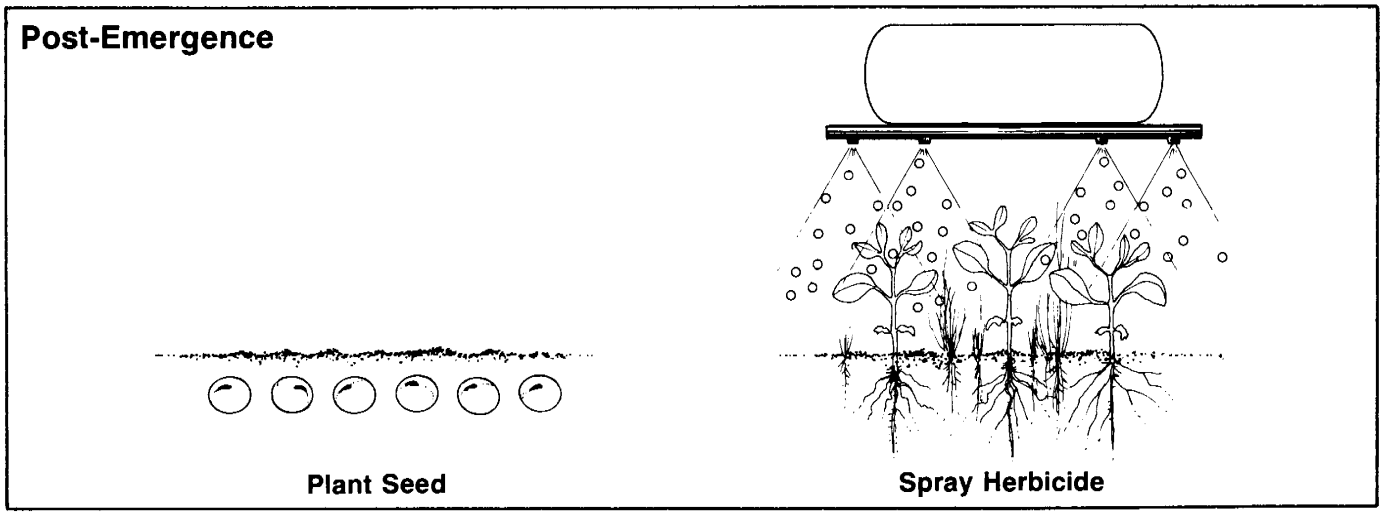


Figure 13

Disease Protection

Soybean diseases in America become more serious as soybean production increases. About 50 known diseases now attack soybeans. They cause an average reduction in soybean yields of 12 to 14% a year.

Good cultural practices help to control soybean diseases. Some of these are:

- Use of certified seed of disease-resistant varieties.
- Use of disease-free seed.
- Rotation of soybeans with unrelated crops.

Soybean diseases are caused by bacteria, fungi and viruses. Following are some of the more important common diseases.

Bacterial Diseases and Their Symptoms

- **Bacterial blight**—Large dead areas develop on the leaves. These dead areas shred and tear in wind and rain.
- **Bacterial pustule**—A warm weather disease that appears in July and August, it is most common on leaves but it can also affect pods.
- **Soybean cyst nematode**—Microscopic sized worms which live in soil and infect the soybean roots. Control by using resistant varieties or crop rotation.

Fungus Diseases and Their Symptoms

- **Brown stem row**—A brownish-red discoloration develops inside the root and lower-stem portion.
- **Phytophthora root rot**—Favored by wet, cold soils, it is more common in low spots in the field. The fungus kills seedlings before or after emergence from the soil. Stem base and roots are brown and rotted. Some soybean varieties are resistant to this disease.
- **Purple satin**—A purple discoloration on part or all of the seed coat, this may result in a lower grade when the crop is marketed.
- **Pod and stem blight**—A major cause of moldy beans and poor seed quality, this produces small black fruiting bodies the size of pencil points on stem and pods after the leaves drop.

Virus Diseases and Their Symptoms

- **Bud blight**—Plants infected at or after flowering produce small, undeveloped pods. Many pods drop to the ground. Infected plants remain green after healthy plants are mature.
- **Soybean mosaic**—Leaves of infected plants are distorted and narrow and their margins turn down.

Insect Protection

For years people thought soybeans were immune to insects. Now we know that more than 20 insects feed on soybeans. Insect control is helped by:

- Effective weed control in soybean fields
- Correct planting dates
- High germination seed
- Insecticides applied in the soil
- Insecticides applied to foliage

Insects that affect soybeans can be grouped in three categories:

- **Soil insects**—These attack seed and root. Examples are seed corn maggot, wire worms, and grape colapsis.
- **Foliage feeders**—These attack leaves. Examples are Japanese beetle, green cloverworm, striped blister beetle, bean leaf beetle, and Mexican bean beetle.
- **Pod feeders**—Examples are the stink bug and bean leaf beetle.

Chemicals for insect control (insecticides) change as new products are developed. They are very useful if you handle them carefully. By law you must follow the directions on the label. Many chemicals are effective for certain insects. Current insecticide recommendations are made by the Cooperative Extension Service and Agricultural Experiment Station. Ask your County Extension Agent for help with insect problems. In most cases, insects on soybeans do not cause enough economic damage to require insecticide application.

Activity No. 9 Do a soybean herbicide survey.

Visit with a dealer who handles herbicides or a farmer who uses them, or ask your County Extension Agent for a copy of ID-1 "Weeding with Chemicals." Learn the names of five herbicides used to control weeds in soybeans. Find out whether each chemical is a pre-plant, pre-emergence or post-emergence herbicide. List the weeds each herbicide controls most effectively.

	Herbicide	Type	Weeds controlled	Approx. cost per acre
1.				
2.				
3.				
4.				
5.				

Activity No. 10 Examine a field for insects.

Watch your plantings of soybeans for insect damage. Identify the insects you find. What part of the plant does the insect damage? (Get E-85 "Common Soybean Insects" at your County Extension Office. It has color pictures of common soybean insects.)

	Insect	Type of damage	Method of control
1.			
2.			
3.			
4.			
5.			

Activity No. 11 Check for soybean diseases.

Watch your soybean plants for disease damage. Identify the diseases you find. What part of the plant does the disease damage? (Get copies of BP-6-1 "Soybean Diseases in the Midwest" and BP-6-2 "Soybean Foliage Diseases" from your County Extension Office.)

	Disease	Type of damage	Method of control
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____

Harvesting the Soybean

From 10 to 50 percent of the soybean crop is lost each year—about three bushels an acre is the average loss. There are four main types of harvest loss: shatter loss, stalk loss, stubble loss, and machine loss. A good combine operator knows how to check and make corrections for each kind of harvest loss. As a rule of thumb, an average of four beans on each square foot of ground equals 1 bushel per acre harvest loss. The beans may be either loose on the ground or left in the pods.

Shatter Loss

Shatter loss is the loose beans or pods found on the ground. Some are knocked from the plant by the cutterbar or reel of the combine. Some soybean varieties shatter some of their beans naturally. Shatter loss is usually the largest kind of loss—about 40% of the total harvest loss. See Figure 14.

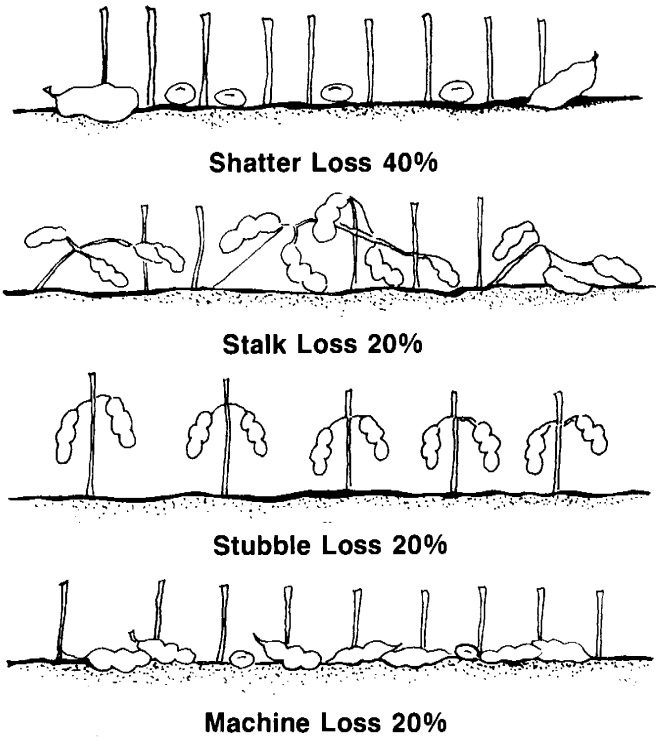


Figure 14

Stalk Loss

The cutterbar may not cut lodged soybean plants. Or the lodged stalks may be cut but not gathered into the machine. Stalk loss is about 20% of the total harvest loss. See Figure 14.

Stubble Loss

If the harvest machine is operated too high from the ground, stubble loss occurs. This is the bean pods left attached to the stubble. Stubble loss is about 20%of the total harvest loss.

Machine Loss

Some beans remain unthreshed in pods as they pass through the cylinder of the combine. Some threshed beans are carried out with the straw. Machine loss is about 20% of the total harvest loss. Soybeans damaged by the combine are another source of loss to the grower. Broken and split beans can reduce the market grade. Germination is also lowered. See Figure 14.

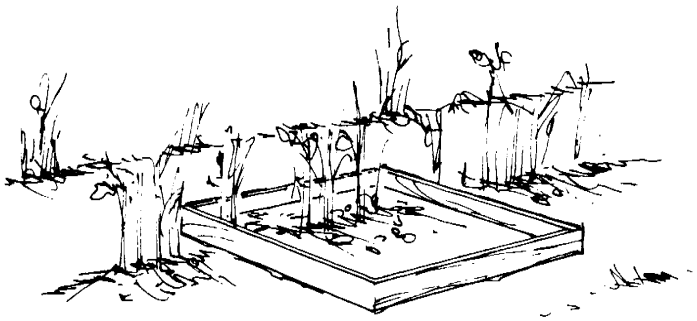
Activity No. 12 Determine soybean harvest losses.

1. Get permission from two or three farmers to check their harvested soybean fields for harvest loss.

2. Construct a frame 1 square foot in size (inside dimensions). Make the frame of wood lath. Or use posterboard or cardboard. If you use cardboard, measure out a square 14 x 14 inches. Then cut out the inside square foot of the cardboard.

3. Randomly select at least five locations spaced over the field. Drop the frame to the ground over the soybean row. Count the number of loose beans inside the frame. Also, shell out and count the number of beans in the pods left on the stubble or stalks inside the frame.

4. Average the losses together for the five check locations in one field. Record your results in the second column.



Soybean grower	Average number soybeans counted	Soybean bushel yield loss per acre (Col. 2 : 4)	Dollar loss per acre (Col. 3 x bushel value)
Example	**12**	**12 : 4 = 3**	**3 x $6.00 = $18.00**
1.			
2.			
3.			

Using the Soybean

Soybeans are high in protein and oil. Because of their nutrient value, some processed food or material made from soybeans is found in most American homes.

Soybean Oil

Nature produces many substances called oils. They are liquid at ordinary temperatures. Oils do not dissolve in water. Some, such as petroleum, are found ready formed in nature. Other oils come from the seeds of plants. Soybeans are only one of many seeds from which oil is drained. Others include cotton, sunflower, corn, safflower, flax, and peanut.

Through modern solvent processing operations, each bushel of soybeans produces about 11 pounds of soybean oil. Figure 15 shows how soybean oil is used.

Soybean Protein Meal

Soybeans are the richest in protein of all the common seeds. They are highly prized as a protein feed for livestock. Soybean oil meal is made by extracting the oil from crushed soybeans, "toasting" the meal and then grinding it or making it into pellets. About 97 percent of all soybean meal goes back to the farm in livestock feeds as a protein supplement.

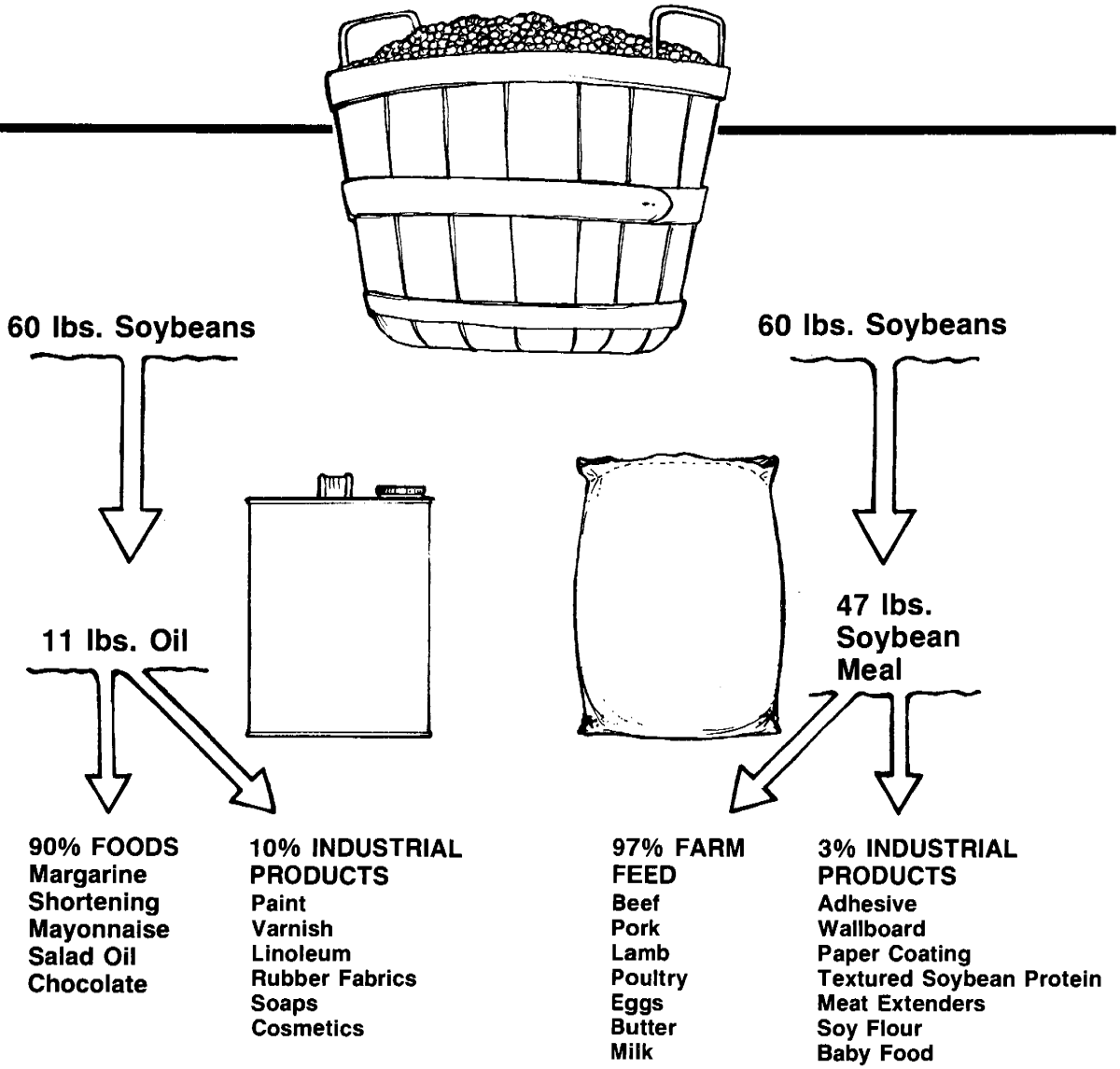


Figure 15

About 47 lbs. of soybean meal is produced from each bushel of processed soybean seed. Figure 15 shows how soybean meal is used.

Textured Protein Foods

Soybean meal is used as a protein feed for livestock. Animals change vegetable protein into meat protein. Meat is nutritious, and people like to eat it. But many of the world's people cannot afford the luxury of meat protein. So why not use the highly nutritious soybean protein directly for human food?

Soy flours and similar products can be used for human food. In the past, their use has been limited by a lack of desirable flavor and texture. Now, by a special process, soybean protein can be spun or extruded into rope-like protein fibers. Then, flavoring, coloring, and binders can be added to create textured protein foods. Textured protein can be shaped into granules, cubes, or slices. Meat flavors of beef, ham, bacon and chicken can be added. Textured protein, can also be combined with flavors that create nut-like and fruit-like products. Clearly, food uses for soybeans are rapidly increasing.

Textured protein foods are a new use for the soybean. They will probably be most successful as convenience foods in the United States. They take a short time to prepare in the kitchen. They can stay on the grocery shelf for a long time.

With this new use for textured protein, the importance of the soybean may be only just beginning. It may well be the most useful plant man has ever known.

Activity No. 13 Describe soybean uses.

List ten products you found in your home or barn that have soybean protein or oil in them. Name the soybean ingredient in each product.

Product	Soybean Ingredient

Activity No. 14 Prepare dry soybeans for use at home.

Harvest, shell and use soybeans left on the vine until mature and dry just like you would other dry beans. For cooking, the light colored soybean varieties are more attractive.

Soaking dry soybeans

- Remove debris from the hulled dry soybeans.
- Throw away any discolored, cracked or shriveled beans. Wash the beans. Cover dried beans with twice their volume of water. For example: 1 cup water for ½ cup beans.
- Soak 8 to 10 hours in the refrigerator. A ½ cup of dried beans will swell to almost 1 cup during soaking and cooking. A pound of dried soybeans (2¼ cups) will yield 6 to 7 cups after cooking.

Cooking the soaked soybeans

- Simmer or cook the beans in a pressure cooker. (If you are not going to use all the soaked soybeans, they freeze well for later cooking. Freezing reduces cooking time.)
- To simmer: Cook dried soybeans in soaking water, adding more water if necessary. Skim of husks and foam at the beginning of cooking. Simmer in a covered pan until tender—about 2-3 hours.
- In a pressure cooker: Put soaked soybeans in an uncovered pressure cooker. Do not fill the pressure saucepan more than⅓ full of soaked soybeans. Boil 5 minutes. Skim off the husks and foam. Add 1 tablespoon fat. Cook—with the lid on—at 15 pounds pressure for 30 minutes or at 10 pounds pressure for 35 minutes.

Spiced Soybean Milk

(1 serving)

1 cup soybean milk
1/8 teaspoon ginger
1/8 teaspoon nutmeg
2 teaspoons sugar
1/8 teaspoon salt

- Add dry ingredients to milk and mix well.
- Chill before serving.

Soybean Milk

- Wash 1 pound—2¼ cups of dry beans.
- Soak as described above.
- Drain.
- Using 3 quarts of water, grind the soaked beans in a blender. Place part of the beans and enough water to cover in the blender container.
- Grind until very fine
- about 2 minutes. Repeat until all beans have been ground and the 3 quarts of water have been used.
- Strain ground beans through two layers off cheesecloth into a large kettle. Wring as much liquid from the mash as possible.
- Boil the soy milk for 30 minutes, stirring occasionally to prevent scorching. Cook the milk thoroughly to destroy a substance in it which interferes with protein digestion.
- While milk is still warm, add 2 tablespoons of sugar and 1 teaspoon of salt. Stir until dissolved.
- Cover milk tightly and store in refrigerator.
- Strain milk before using.
- You can use soybean milk in most recipes calling for milk.

Dry Roasted Soybeans

- Soak the soybeans as described above. During the last 3 hours add salt.
- Drain. Air dry. Spread in one layer in a shallow pan.
- Oven roast at 450 F for 20 to 30 minutes. Stir occasionally.

Soybean Chili

(6 to 8 servings)

3 cups cooked soybeans
1 pound ground beef or pork
1 small onion, chopped
2 cups tomatoes, canned or fresh
1 teaspoon salt
1 tablespoon chili powder
1 cup cooking water from soybeans

- Brown meat and onions in a skillet.
- Remove excess fat with large spoon. Add rest of ingredients.
- Heat to boiling. Then reduce heat and simmer uncovered for 45 minutes, stirring occasionally.

Cocoa

(2 servings)

1½ tablespoons cocoa
2 tablespoons sugar
1/8 teaspoon salt
2 cups soybean milk

- Mix cocoa, sugar and salt.
- Add small amounts of milk and boil mixture for 2 minutes.
- Add rest of milk. Heat to desired temperature.

Suggestions for Project Completion and Exhibits

Here are suggestions for completing each division of the 4-H Soybean project. Be sure to complete the record at the back of the manual. Check the check list in the manual. It is like the one the judges may be using when they look at your exhibit. Check with your 4-H adult leader about your own county's requirements.

Division I

Completion Suggestions for Division I

- Do three of the following activities:
  - Activity No. 1 on page 6
  - Activity No. 2 on page 8
  - Activity No. 3 on page 11
  - Activity No. 13 on page 27
- Do one of the suggested exhibits for Division I.
- Fill in the record sheet.

Exhibit Suggestion for Division I

Complete Activity No. 1 on page 6. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "Germination of the Soybean Seed" (This is the title of the experiment.)
- Photographs (approximately 4 x 5) of your experiment (Glue to the posterboard. Label each picture.)
- One dry rag doll (Mount near the bottom of the posterboard to show one item used in the test.)
- A sample of dry soybean seed to show the condition of the seed before the germination test was run.
- Seedlings from the germination study, if possible.
- Show your calculations.
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner.)

Another Exhibit Suggestion for Division I

Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "Using the Soybean" (This is the title of the experiment.)
- A Flow chart like the one on page 27, using real materials rather than a drawing (Examples are soybeans in a plastic container; soybean oil in a clear bottle; and labels from cans, bottles or boxes showing that soybean oil or protein is an ingredient.)
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner.)

Another Exhibit Suggestion for Division I

Exhibit one peck of soybeans at the county 4-H crops show.

Division II

Completion Suggestions for Division II

- Do two of the following activities:
  - Activity No. 4 on page 12
  - Activity No. 7 on page 18
  - Activity No. 14 on page 28
- Do one of the suggested exhibits for Division II.
- Fill in the record sheet.

Exhibit Suggestion for Division II

Complete Activity No. 4 on page 12. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "The Effect of Light and Darkness on Flowering" (This is the experiment title.)
- A brief description about the purpose of your experiment.
- Photographs (approximately 4 x 5) to illustrate your work and to describe the equipment, including a picture of plants that were covered and one of those that were not covered when each began to flower. (Before taking the pictures, label cardboard signs showing the date of first flower and plant height. Place the signs in the row and take your pictures.)
- Information about Step 8 in the activity.
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner).

Another Exhibit Suggestion for Division II

Complete Activity No. 7 on page 18. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "Soybean Plant Nutrient Deficiencies" (This is the title of the experiment.)
- A short story—50 to 100 words—explaining the purpose of your experiment.
- Photographs (approximately 4 x 5) of plants from each soil group (Include close-up pictures showing nutrient deficiency symptoms.)
- Observations of plants in your experiment (See Step 4.)
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner.)

Another Exhibit Suggestion for Division II

Complete Activity No. 14 on page 28. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "Preparing Soybeans for Home Use" (This is the title of the activity.)
- Photographs (approximately 4 x 5) showing how you prepared the roasted soybeans.
- The recipe you used.
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner).

Suggestion: Place a cup of roasted soybeans in a plastic bag or small jar to mount on your poster.

Another Exhibit Suggestion for Division II

Exhibit one peck of soybeans at the county 4-H crop show.

Division III

Completion Suggestions for Division III

- Do two of the following activities:
  - Activity No. 5 on page 13
  - Activity No. 6 on page 15
  - Activity No. 14 on page 28
- Do one of the suggested exhibits for Division III.
- Fill in the record sheet.

Exhibit Suggestion for Division III

Complete Activity No. 5 on page 13. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "Differences in Flowering among Soybean Varieties" (This is the title of the experiment.)
- A short description—50 to 100 words—about the purpose of your exhibit.
- Photographs (approximately 4 x 5) of the three soybean varieties taken when they began to flower (Before you take the pictures, label cardboard signs showing variety name, date of flowering and plant height. Place the signs near the plants and then take your pictures.)
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner.)

Another Exhibit Suggestion for Division III

Complete Activity No. 6 on page 15. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "How Planting Dates Affect Soybean Yields" (This is the title of the experiment.)
- A step-by-step story of how you conducted the experiment (Include the information asked for in Step 3 in the activity).
- Photographs or drawings (approximately 4 x 5) to illustrate what you did.
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner.)

Another Exhibit Suggestion for Division III

Complete Activity No. 14 on page 28. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- "Preparing Soybeans for Home Use" (This is the title of the activity.)
- The recipe you used for the products you prepared.
- Photographs (approximately 4 x 5) showing how you prepared the products.
- Your name, address, name of 4-H club to identify you poster (Put in lower right-hand corner.)

Suggestion: Prepare two or more edible products from soybeans. Seal them in sanitary containers so the products are visible. Display these products in front of your poster.

Another Exhibit Suggestion for Division III

Exhibit one peck of soybeans at the county 4-H crop show.

Division IV

Completion Suggestions for Division IV

- Do the following activities:
  - Activity No. 9 on page 22
  - Activity No. 10 on page 23
  - Activity No. 11 on page 23
  - Activity No. 12 on page 25
- Do one of the suggested exhibits for Division IV.
- Fill in the record sheet.

Exhibit Suggestions for Division IV

Complete Activity No. 9 on page 22, Activity 10 on page 23, or Activity No. 11 on page 23. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.

- Title of experiment—"Soybean Herbicide Survey" or "Soybean Insect Study" or "Soybean Disease Study."
- A short story—50 to 100 words—about the purpose of your experiment
- Photographs (approximately 4 x 5) or magazine pictures of weeds or insects or soybean diseases, depending on your experiment (Show what damage occurred and give suggestions for its control. Label each picture.)
- Line or mount specimens of insects, weeds or diseases (This is optional.)
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner.)

Another Exhibit Suggestion for Division IV

Complete Activity No. 12 on page 25. Plan to exhibit a 22 x 28-inch posterboard with the following information and materials. Display the posterboard horizontally.
"Measuring Soybean Harvest Losses" (This is the title of the experiment.)

- A step-by-step story of how you conducted your experiment.
- Photographs or drawings (approximately 4 x 5) to illustrate what you did.
- Information asked for in Step 4 of the experiment.
- The tool you used to determine the losses.
- Your name, address, name of 4-H club to identify your poster (Put in lower right-hand corner.)

Another Exhibit Suggestion for Division IV

Exhibit one peck of soybeans at your 4-H crops show.

Division V and Advanced

Grow at least five acres of soybeans each year, using cultural practices described in current AY (Agronomy) publications. These are available at your County Extension Office. Keep accurate records, using the 4-H Crops Record. Check with your 4-H leader about specific county exhibit requirements.

Indiana 4-H Club Record

4-H Soybean Project, Division I, II, III, or IV (Circle one.)

Name _____ Age _____ Year _____

Address _____ Zip Code _____

Name of Club _____ Year In 4-H Work _____

County _____

I have reviewed this record and believe it to be correct.

Signature of leader _____ Date _____

Which activities did you do?

Activity	Date Started	Date Completed

Which activity did you exhibit? _____

Which activity was the most interesting? _____ Why? _____

Which activity taught you the most? _____ Why? _____

Judges may use a check list like this one when they look at your exhibit.

Entry No. _____ Placing _____

Section _____ Exhibit Title _____

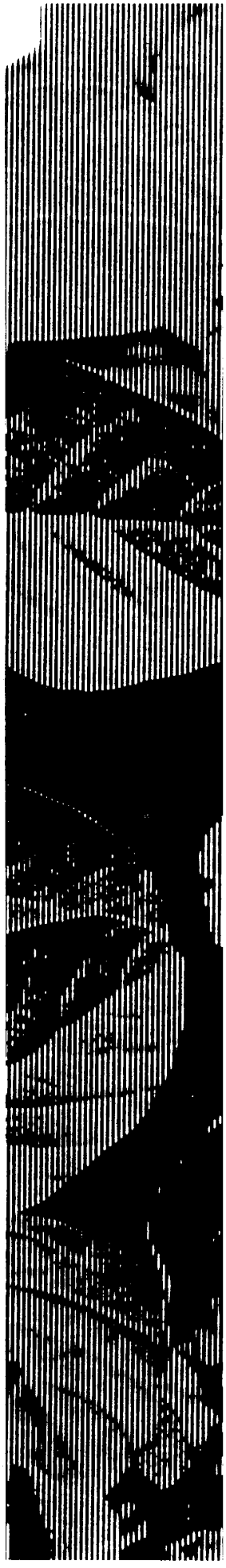
Class _____

Check List For Soybean Project

	Excellent	Good	Needs To Be Improved
Subject			
One main idea	_____	_____	_____
Important to the public (timely, practical)	_____	_____	_____
Simply expressed, in timely manner	_____	_____	_____
Accurate information	_____	_____	_____
Public Appeal			
Causes people to stop, look, listen	_____	_____	_____
Makes people keep on looking	_____	_____	_____
Idea shown in unusual way (motion, color, slogan, etc.)	_____	_____	_____
Stimulates action or decision	_____	_____	_____
Will be remembered and talked about	_____	_____	_____
Attractiveness and Originality			
Neat; simple	_____	_____	_____
Good arrangement	_____	_____	_____
Readable signs	_____	_____	_____
Fresh approach; fresh idea	_____	_____	_____

Judge's Comments:

NOTES:



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