IPM-3

Kentucky Integrated Crop Management Manual for Field Crops

"SOYBEANS"

Section 2
Pages 33 - 60

Agriculture and Natural Resources • Family and Consumer Sciences • 4-H Youth Development • Community and Economic Development

Kentucky Integrated Crop Management Manual for Soybeans

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For additional and current information please consult the following web sites:

For more IPM information and links to many pest and crop management sites view the IPM web page at: http://www.uky.edu/Ag/IPM/

For the most current information on pests view the **Kentucky Pest News** at:
http://www2.ca.uky.edu/agcollege/plantpathology/extension/kpnindex.htm

For up-to-date weather, and crop and pest models view Ag-weather at:
http://wwwagwx.ca.uky.edu/Gisproducts.html

Revised January 2015
This manual is provided by the Kentucky Integrated Pest Management Program

Acknowledgements

The following individuals have provided information, expertise and/or revised portions of this manual:
Paul R. Bachi, University of Ky., Plant Pathology
Monroe Rasnake, University of Ky., Department of Agronomy
Charles R. Tutt, University of Ky., Department of Agronomy

Preface

Agriculture is the world's most important industry. This level of importance will continue due to rapidly expanding populations that demand increased amounts of food and fiber. Crop protection problems associated with this increased production have become more complex. A simplistic approach to pest control leads to serious environmental complications. A truly successful pest management program must take a multi-disciplinary, multi-crop approach in order to supply the farmer with reliable pest control information. An approach to crop production based on sound economic, ecological, technical and social considerations is required to assist the farmer to achieve needed production levels, while maintaining food safety and environmental quality.

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Don Hershman. University of Kentucky. Pod and stem blight and anthracnose, pg. 35; Pod and stem blight and Anthracnose on pods, pg. 35; Late season brown spot, pg. 35; Cercospora leaf spot, pg. 36; Charcoal rot, pg. 36; Downey mildew, pg. 37; Frogeye leaf spot, pg. 37; Pytophthora root and Stem rot, pg. 38; Pod and stem blight and anthracnose on pods, pg. 38; Soybean cyst nematode cysts on soybean roots, SCN cysts and SCN field damage, pg. 39; Close-up of soybean rust on underside of leaf, pg. 40; Severe soybean rust on upper side of leaf, pg. 40; Northern stem canker, Southern stem canker and Rhizoctonia stem canker, pg. 41; Sudden death syndrome stem discoloration, pg. 41; Sudden death syndrome field spot, pg. 42; Range of sudden death syndrome foliar symptoms, Early virus like symptoms of sudden death syndrome, pg. 42; Bean pod mottle virus foliar symptoms, pg. 43.

Lloyd Murdock. University of Kentucky. Nitrogen deficiency, Manganese deficiency, pg. 49.

Darren Mueller. Iowa State University. Pod and stem blight, pg. 38. Bugwood.org.

Potash and Phosphate Institute . CD- Nutrient Deficiency Symptoms. Potassium deficiency, pg. 49

University of Kentucky Plant Disease Diagnostic Lab, Princeton, KY. Charcoal rot stem streaks, pg. 36

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Scouting Procedures for Diseases in Soybeans

Donald E. Hershman

The main reasons for scouting soybean fields for diseases include: 1) assessing potential stand losses (caused by diseases) that may require replanting; 2) determine the identity, incidence, and severity of active diseases, at key growth stages (to facilitate making fungicide use decisions); 3) develop historical disease data base for your farm; 4) help identify fields that may require early harvest and/or are not worth harvesting due to extreme disease; and 4) crop yield potential assessment.

When scouting for diseases in any crop, proper disease identification is essential. Once you are familiar with common diseases that occur in Kentucky, you will find they are not very difficult to identify. This guide will help, but the best teacher is experience. You are encouraged to attempt to identify diseases yourself, and then send a sample to one of the University of Kentucky's two Plant Disease Diagnostic Laboratories for confirmation. This service is available, at no cost, through your local county Extension office.

Initially, the thought of scouting for crop diseases can seem daunting. However, you will soon learn that the number of diseases you are likely to encounter is not that large. In addition, they tend to occur at specific times (and plant stages) during the season. They will **not** occur at the same time! The below chart will give you some idea of when specific diseases are most likely to be observed in your crop. When scouting, make notes about disease incidence in each spot you scout. In these notes, include the percent of plants with visible symptoms, and where in the canopy symptoms are most prevalent (lower, mid, upper canopy). Notes on disease severity, are also in order. You might find it helpful to use a 1-3 disease severity rating scale, where 1 is light severity and 3 is severe. Make management decisions based on the average disease situation in the field.

Observation Times for Soybean Diseases

	Pre-emergence	Seedling	Vegetative	Bloom	Beginning Pod	Pod Fill	Maturity
Seedling Blight		************					
Brown Spot				**			
Soybean Cyst Nematode			***				
Downey mildew			**				
Virus Diseases			*********************************				
Phytophthora root & stem rot			***				
Anthracnose					*******************************		
Soybean Rust				**			
Northern & Southern Stem Cancker					********************************		
Sudden Death Syndrome					********************************		
Cercospora Leaf Blight				***			
Charcoal Rot					********************************		
Frogeye Leaf Spot			***				
Pod & Stem Blight						*********************	

Description of Soybean Diseases

Anthracnose

Pod and stem blight and anthracnose

Examination Period: Every two weeks from beginning pod fill to harvest maturity. Examine two rows of plants 10 feet in length.

Symptoms: Symptoms appear most frequently on stems and pods as irregularly- shaped brown areas. In advanced stages, affected tissues are covered with black fruiting bodies that resemble tiny pin cushions, thickly covered with black spines. These structures can be seen with the use of a 10x hand lens. There is no definite arrangement of these fruiting structures on the stems or petioles as in the case of pod and stem blight. Seeds from infected pods may be shriveled or moldy and may have dark spots on the seed coat.

Occurrence: Prolonged periods of wet, humid, warm weather favor the disease, which occurs late in the season. Early maturing varieties are frequently more likely to become infected. Fields that have been in soybeans the previous year are more likely to have anthracnose problems.

Pod and stem blight and anthracnose on pods

Brown Spot

Examination Period: Every four weeks from flowering until physiological maturity. Observe two rows of plants 10 feet in length at various spots throughout the field.

Late season brown Spot

Symptoms: Irregular, dark brown spots from small specks to 1/6" develop on upper and lower leaf surface. Some spots may coalesce. Affected leaves often turn yellow and drop. Generally, lower leaves are first affected, and the disease then moves throughout the canopy, conditions permitting. All soybean varieties are susceptible to brown spot, but some varieties appear to be more susceptible than others.

Occurrence: Brown spot is present in nearly all young soybean fields each year to one extent or another. Symptoms usually disappear with the advent of hot, dry weather stops disease development. Warm, moist weather is favorable to the fungus. The disease can be worse where soybeans are following no-till soybeans and/or if early-maturing varieties are planted, since they tend to mature when conditions favor disease. River bottom fields or fields subject to fog or morning shade are usually the most impacted.

Cercospora Leaf Blight


Cercospora leaf spot

Examination Period: Every four weeks from flowering until physiological maturity. Observe two rows of plants 10 feet in length at various spots throughout the field.

Symptoms: Affected leaves, mostly in the upper canopy, will develop a bronze-purple stippling, usually concentrated between the veins on the upper leaf surface of upper canopy leaves. Close inspection will reveal that the stippling is the result of numerous pinpoint spots. Veins as seen on the leaf undersides may be darkened. Eventually, affected tissue becomes necrotic (brown) and starts to roll and deteriorate. Under severe disease conditions considerable upper canopy defoliation can occur. Seed harvested from affected pods often have a purplish color known as purple seed stain.

Occurrence: Cercospora leaf blight is typically a late season disease and tends to be most severe when warm, wet conditions coincide with grain fill. The disease can be worse where soybeans are following no-till soybeans and/or if early-maturing varieties are planted, since they tend to mature when conditions favor disease. River bottom fields and fields subject to morning fog and/or shade tend to be the most commonly affected. Varieties show minimal differences in susceptibility.

Charcoal Rot


Charcoal rot

Examination Period: Every four weeks from beginning pod fill until harvest. Examine two rows of plants 20 feet in length and keep your eye open for any suspected areas of the field.

Symptoms: Root systems are extensively rotted and have superficial and imbedded, pinpoint, black structures in roots and lower stems that resemble small flecks of charcoal (hence the name). The imbedded black bodies will appear as black streaks when the wood is scraped longitudinally with a knife. The sub epidermal black bodies are easily seen by peeling the "skin" off the roots and lower stems. Premature wilting and death of the plant may result and often occur as groups of plants in varying size areas.


Charcoal rot stem streaks

Occurrence: Charcoal rot is most severe when conditions are wet during the vegetative growth stages followed by plants come under severe moisture stress during the reproductive stages. Dry, high temperature soils favor the expression of charcoal rot late in the season. Problems may be worse where soybeans were grown the previous year. One-hundred percent of the plants in a field can be infected because of the widespread occurrence of the causal fungus in all agricultural soils.

Downy Mildew

Downey mildew

Examination Period: Every four weeks from V2 stage to physiological maturity. Observe two rows of plants 10 feet in length at various spots throughout the field.

Symptoms: Small, cream to yellow, irregular lesions can occur on any leaf, but they are most frequently observed in the upper 1/3 of the canopy. The underside of lesions will have a downy appearance, hence the name, downy mildew.

Occurrence: Seems to occur under any conditions that favor soybean growth, but the most severe infections are associated with hot, humid weather. The disease rarely impacts yield.

Frogeye Leaf Spot

Frogeye leaf spot

Examination Period: Every four weeks from vegetative stage until maturity. Observe two rows of plants 10 feet in length.

Symptoms: Spots can occur on leaves in the lower, middle, or upper canopy. Spots are roughly circular, often if a faint yellow-green halo when young. Older spots have an ashen center and a purplish border (i.e., a “frog’s eye”). Severely diseased leaves frequently have a tattered appearance as affected tissue falls away from weathering. Soybean varieties can differ significantly in their susceptibility to frogeye leaf spot.

Occurrence: Generally develops in the late vegetative through pod fill stages. Leaves are only susceptible to infection while they are still expanding and at physiological maturity. Most severe symptoms are found in fields planted to susceptible varieties and in fields prone to fog or subject to morning shade. River bottom fields are frequently the most severely impacted, although frogeye can usually be found at very low levels in almost every field, every year.

Phytophthora Root and Stem Rot

Examination Period: Every four weeks from V2 stage to physiological maturity. Observe two rows of plants 10 feet in length at various spots throughout the field.

Symptoms: Plants of any age may wilt and die. On plants with at least a few visible nodes, the base of affected plants will have a distinct dark brown canker that encircles the stem, beginning at the plant base, extending up the stem 6 -8 in. or more. Leaves dry up on the plant and remain attached.

Occurrence: This is not a common disease in Kentucky even though the pathogen is commonly present in soils. Typically, soil conditions are not favorable for infection and disease development. The disease is favored by cool, wet soils, especially those with high organic matter content. However, there are certain fields in the Commonwealth that do have a istory of recurring Phytophthora root and stem rot. Early-planted fields are at greatest risk. The disease is rarely seen in doublecrop soybean do to the warmer, dryer soil conditions in late-June – early July when doublecrop soybean is planted.

Pytophthora root and stem rot

Pod and Stem Blight

Examination Period: Every two weeks from beginning pod fill to harvest maturity. Examine two rows of plants 10 feet in length.

Symptoms: Pod and stem blight is generally first observed occurring on fallen petioles near the base of attachment and on stems just above petiole attachment. Small, black, pimple-size structures (pycnidia) can be observed to align themselves in linear rows. Pycnidia, are also commonly distributed on the pod surface.

Occurrence: Warm, humid weather favors the disease which occurs late in the season. Planted early maturing varieties are generally more likely to become infected. Fields that have been in soybeans the previous year are more likely to be affected. Similarly, fields subject to delayed harvest are frequently affected. Pod and stem blight is the primary biological cause of reduced soybean seed quality in Kentucky.

Pod and stem blight

Seedling Blight

Examination Period: Every two weeks from planting until V2 stage. Look for dead or dying seedlings two rows of plants 10 feet in length at various spots through the field

Symptoms: Generally only scattered individual plants or small groups of plants are killed. Several fungi can cause seedling blight and the symptoms observed may vary according to the fungi involved. Infected seedlings may contain small, black, dry, sunken lesions on the cotyledons. Infected stem tissue may be translucent to brown or orange-brown in color. A soft, water rot is often produced. Dry

Pod and stem blight and anthracnose on pods

weather may cause infected plants to become dry and shredded. Outermost tissues of larger roots may slough off. Smaller roots may be decayed and break away from plants when pulled from the soil.

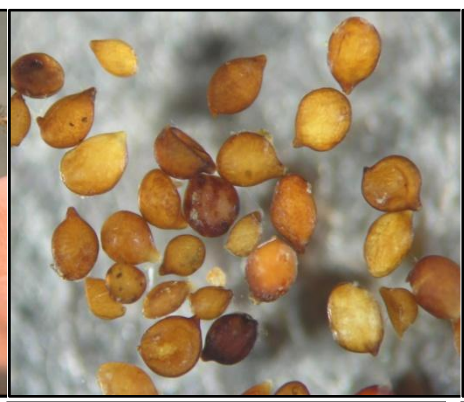
Occurrence: Low soil temperatures from 50F to 60F and high soil moisture are favorable to disease development. Low, wet and compacted areas of the field are likely to show the first symptoms of the disease. No-till fields may be more prone to seedling blights due to the tendency for fields to be somewhat cooler and wetter compared with their tilled counterpart. Disease is also favored if seed planted is of marginal quality, especially if no seed fungicide was used.

Soybean Cyst Nematode

Examination Period: Every four weeks from V2 until harvest. Observe all areas of the field with and without suspected symptoms.

Symptoms: **It is very common for SCN to damage crops without there being any obvious disease symptoms**. However, in some fields, under certain conditions, disease symptoms will be evident. Look for stunted yellow plants in roughly circular to oval areas of the field. Randomly dig (*do not pull*) up 20 plants (healthy and suspect) and examine the roots with hand lens for small, white, yellow, or dark brown lemon shaped cysts. Do not confuse cysts with nitrogen fixing nodules which will be 100 -1000x larger than cysts. Cysts are small, but once you know what you are looking for, they can often be seen by the unaided eye. If you see cysts, this means there will likely be significant yield loss in the field. But whether or not you see cysts, if your recent crop yields are not up to par, collect soil samples from suspect fields immediately after harvest and have a SCN analysis done. Sampling instructions can be obtained at you county extension office and on-line:
http://www.ca.uky.edu/agcollege/plantpathology/ext_files/SCNsamplingInstructions.pdf

Soybean cyst nematode cysts on soybean roots

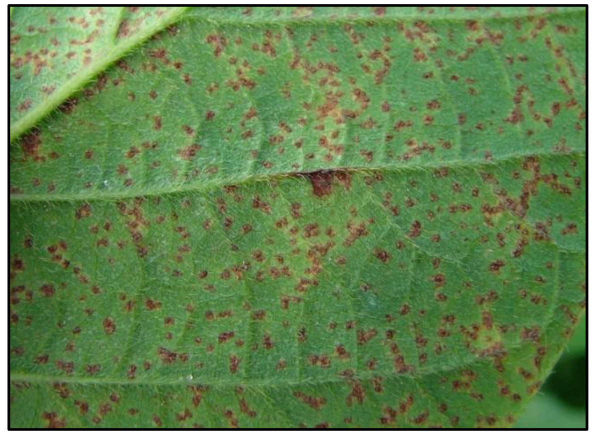


SCN cysts

SCN field damage

Occurrence: When symptoms do occur, they will be especially pronounced where soil fertility is inadequate, soil is sandy, and/or under moisture stress conditions. However, do not count on symptoms as a means of verifying the presence or absence of SCN. Damage is most likely to occur in fields which have SCN-susceptible or moderately susceptible varieties as part of a fields crop sequence. **Note:** recent surveys have found that most SCN populations in Kentucky can now reproduce to at least some extent on most SCN-resistant varieties marketed in Kentucky. Some varieties marketed as being resistant, in fact, are nearly fully susceptible. In other words, it is imprudent to assume you are doing a good job of managing SCN even where no symptoms are seen, where proper crop rotation is practiced and where SCN-resistant varieties have been routinely planted. If yields are not up to par, have an SCN soil analysis done for each problem field.

Soybean Rust



Close-up of soybean rust on underside of leaf

Examination Period: Weekly from flowering stage until maturity.

Symptoms: It is almost impossible to find extremely low levels of soybean rust in the field. Instead, samples must be incubated for 24-48 hrs and then observed at high magnification by a trained diagnostician. However, soybean rust is fairly easy to detect in the field once incidence has reached 5-10% (i.e., 5-10 leaves/100 observed) or more. Small brown lesions, with pustules, form on both leaf surfaces, but primarily on the undersides of leaves. Lesions are commonly first seen in small groupings along leaf veins or on leaf margins. This has to do with how water has flowed across and dried on the leaf surface. Observe lesions with a 20-30x hand lens. Look for very small brown raised structures that have the appearance of an "egg over easy" when young and a miniature volcano when old. When conditions are favorable (e.g., moist), look for clusters of clear spores coming from pustules. If initial field observations are unsuccessful, collect 100 suspect leaves, incubate them in a plastic bag for 24 hrs, and then observe them. Incubation frequently induces pustules to produce spores which are necessary to visually confirm the presence of soybean rust. Early stages of soybean rust are easily confused with other fungal and bacterial diseases, even thrip injury. When in doubt, collect leaves and submit them to one of UK's two plant disease diagnostic laboratories for observation.

Severe soybean rust on upper side of leaf

Occurrence: The soybean rust fungus does not overwinter in Kentucky. Rather, the causal fungus overwinters in the deep South and then blows north as the season progresses. Portions of fields that are subject to morning shade or fog are often the first to show symptoms. Lesions with pustules first develop in the lower canopy, usually after the crop begins to flower and especially during pod fill. The disease then moves into the upper canopy, provided conditions remain favorable for disease development. Hot and dry weather can stifle disease progress. Soybean rust is favored by moisture and moderate temperatures. Once disease severity reaches 20% or more, defoliation will usually occur within the next 6-8 weeks. During extremely hot and dry weather, disease progress frequently comes to a standstill until more favorable conditions return. All commercially available soybean varieties are highly susceptible to soybean rust.

Stem Canker

Examination Period: Every two weeks from beginning pod fill to harvest maturity. Examine two rows of plants 10 feet in length for initial signs and symptoms, but be observant over a much wider area for advanced symptoms of plant decline and death.

Symptoms: Look for dark, red-brown to tan, girdling cankers in the vicinity of stem nodes, often at the 4th or 5th node. Faint concentric rings may be visible within the canker. Diagnostic symptoms include healthy green stem tissue above and below the canker, diseased stems mixed in with healthy stems, leaves that die on the plant, but remain attached, and wilting terminals of affected plants during the heat of the day.

Northern stem canker

Southern stem canker

Rhizoctonia stem canker

Occurrence: The disease is more prominent in fields under continuous soybean production and is favored by moderate temperatures and moisture as well as early planting dates. Plants are infected in the early vegetative stages, but symptoms do not appear until the pod fill stages. Diseased plants may be widely scattered throughout a field or confined to groups. In severe cases, entire fields may be affected. Varieties differ in susceptibility to stem canker.

Sudden Death Syndrome (SDS)

Sudden death syndrome stem discoloration

Examination Period: Every two weeks from beginning pod fill until maturity. Examine two rows of plants 20 feet in length and keep an eye out for any suspicious areas within the field. SDS can be detected from a considerable distance, but confirmation requires close inspection of affected plants.

Symptoms: Initially, leaves show numerous, irregularly-shaped bright yellow blotches between the veins, which later become brown, while the main veins remain green. Occasionally, early disease symptoms mimic virus infections; the toxin that causes leaf symptoms can induce the appearance of leaf mottling and crinkling symptoms characteristic of virus infections. Leaflets may fall off the plants, leaving the petioles attached, thus, resembling feeding damage by grasshoppers. Pods of affected plants may shrivel and fall off the plant if foliar symptoms are evident by early pod development. If infections occur late, foliar symptoms may look severe, but yield may be little impacted. The fungus that causes SDS causes a root rot and also produces one or more plant toxins that result in aboveground symptoms. In the later stages of disease development, roots will be completely deteriorated and stems will have a milky brown interior when cut length-wise with a knife. At advanced disease stages, it is common to see signs of the causal fungus sporulating on severely diseased roots. Look for cobalt blue masses, especially on diseased primary and secondary roots.

Sudden death syndrome field spot

Occurrence: SDS usually develops in "hot spots" or streaks in fields. Affected plants most commonly first show foliar symptoms about the mid pod fill stage of development. However, root rotting is often evident weeks before, during the vegetative stages. Symptoms often get progressively worse until the plants die, but plants and fields have also been known to recover from light, early disease. SDS is most common in fields with high soil fertility, poor field drainage characteristics, soil compaction and/or soybean cyst nematode infestations, especially when planted early. Foliar symptoms can be confused with stem canker, but no visible canker forms in SDS-affected plants. SDS rarely develops in late-planted or doublecrop soybean because of higher soil temperatures. Varieties differ significantly in susceptibility to SDS.

Range of sudden death syndrome foliar symptoms

Early virus like symptoms of sudden death syndrome

Virus Diseases

Examination Period: Every two weeks from V2 stage until R6 (full pod stage). Observe two rows of plants 10 feet in length.

Symptoms: Plants infected early in the season are stunted. Leaves are stunted, misshapen, puckered and occasionally with dark green areas along the veins. A yellow mottling in the form of spots may develop on young leaves of infected plants. Later season symptoms may include a browning of yellow spots and a brown discoloration of the veins. When more than one virus is present, plants may become severely stunted and deformed with puckered leaves. Positive identification of soybean virus diseases cannot be done in the field. Samples must be submitted to a qualified plant disease diagnostic laboratory for proper identification.

Occurrence: Temperatures between 65ºF and 78ºF are most favorable for virus symptom expression. Higher temperatures may mask symptoms. Aphids and bean leaf beetles transmit soybean viruses. The former commonly transmits soybean mosaic virus, bean yellow mosaic virus, and alfalfa mosaic virus in Kentucky. Bean leaf beetles transmit bean pod mottle virus. Soybean mosaic virus is also seed transmitted and, thus, is often seen when farmer saved seed has been planted. The earlier symptoms are observed, the greater the potential yield damage caused by the virus.

Bean pod mottle virus foliar symptoms (severe strain)

SOIL SAMPLING AND SOIL TESTING

Lloyd Murdock

The most important factor of soil testing and fertility recommendations is obtaining a good soil sample. There is more room for error in this step than any other in getting reliable soil test results and recommendations.

Method:

The proper procedures for obtaining a good soil sample are well-established. Publication AGR-16 (Appendix I) contains a complete explanation of these procedures.

Time of Sampling:

Soil samples for alfalfa, small grains and soybeans can be taken anytime in the fall, winter or spring as long as it is at least six weeks after the last fertilizer application.
Recent fertilizer applications can distort the soil test results and fertilizer recommendations.

The best time to sample is in the late winter or spring for that year's fertilization. This gives all the nutrients in the soil and those released by the plant a chance to equilibrate. Fall sampling is also good but needs attention paid to sampling location to ensure a more representative sample in row crops. An equal number of samples should be taken from the row middle and from next to the row.

Early season scouting notes should be recorded and areas needing special attention should be outlined on the field map and soil sampled, if needed, to help determine the cause of the problem. The best overall suggestion when special notes are lacking is to wait at least six weeks after the fertilizer application but sample while the general crop condition and field are still visible.

Soil Sampling Depth:

Crop	Depth of Sample
No-till soybeans	4"
Conventional soybeans	6-8"

Identifying Compacted Soil

Lloyd Murdock

Most compaction results from the use of machinery on soil which is too wet to work well, or from overworking soil and destroying its natural structure. Pressure from tires and tillage tools compress more soil into a given volume. In the process, the natural soil aggregates are broken down and large pores become smaller. This increases the density of the soil and makes it more difficult for roots to penetrate the soil and decreases plant available water.

There are several ways to help determine if the soil is compacted sufficiently to cause problems. A soil penetrometer, tiling rod or a three foot length of 3/8-inch diameter steel rod sharpened on one end and having a handle welded to the other end are easy tools to use in identifying compacted layers. Such tools should be marked in six inch increments and should uniformly be pushed into the **soil when the moisture content is too wet for** tillage. Under these conditions, compacted layers can be "felt" due to resistance in pushing the rod through the soil, and depth to and thickness of the compacted zone can be identified.

The best method for identifying soil compaction is with a soil penetrometer. This is similar to a tiling rod but has a gauge that measures the amount of pressure required to push the rod into the soil. An Annual Field Compaction Record Sheet is on page 55 and gives instructions on how to use the penetrometer and how to make a field recording.

Regardless of the method used, a number of sites in each field should be checked (similar to a soil test) and if severe compaction is found it needs to be confirmed. The penetrometer will also give high readings for a dry soil and heavy clay layer. Therefore, if severe compaction is suspected in a field by the use of a penetrometer then a soil probe or shovel needs to be used to look at the layer and confirm that high readings were not due to a clay or dry layer.

End rows and areas of high traffic may need to be sampled and treated separately.

ANNUAL FIELD COMPACTION RECORD

University of Kentucky
Department of Agronomy

FARM ________________ FIELD ____________ ACRES____________

MAJOR SOIL TYPE ______________________________ YEAR______________________

Site	Reading	Depth of Highest Reading
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Site	Reading	Depth of Highest Reading
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		

<u>SUMMARY</u>

% of reading 200 or less _________

% of reading 300 or more _________

Most common depth
of readings 300 or more _______

METHOD

Push penetrometer into the soil slowly (do not surge). Note the highest psi reading and the depth at which it occurs. Continue to push until the resistance drops and note the depth where this happens.

Always use the penetrometer when the soil is too wet for proper tillage and when it is not saturated with water.

Avoid or test separately field entrances and turn row areas that have excessive traffic and do not represent the field. Readings should be taken in a random manner over the rest of the field.

INTERPRETATION

With readings of 300 psi or above, the compaction is considered severe. If 1/3 of the readings are 300 or more, a corrective action and change in tillage practices should be considered. When 1/2 of the field readings are 300 or more, then changes definitely need to be made. If severe compaction is identified in only a portion of the field, then corrective action should only be considered in that portion.

EXAMPLE RECORD

Site	Reading	Depth of Highest Reading
1	175	6-12
2	200	9-15
3	300	9-15
4	175	6-12
5	300+	9-15
6	225	9-15
7	200	6-12
8	300+	6-15
9	150	3-18
10	250	9-15

SUMMARY

% of readings 200 or less 50

Most common depth of readings 300 or more 9-15

% of readings 300 or more 30

Recognizing Deficiency Symptoms In Soybeans

Lloyd Murdock

Symptoms of a nutrient deficiency can be confused with those of a plant disease or other problems. Nutrient deficiency symptoms under unfavorable growing conditions such as drought or wet weather do not necessarily indicate a shortage of fertilizer. Information on previous soil treatments and a soil test are needed to identify a deficiency. Your local County Extension Office can provide you with the equipment and instructions needed to have your soil tested. The following are descriptions of nutrient deficiency symptoms in soybeans:

Nitrogen (N)

Nitrogen deficiency in soybeans are rare. Young plants will appear pale green and the number of root nodules will be decreased or nonexistent. Sometimes the root nodules can be present but inactive due to excessive water or extreme drought. Active nodules will be "beef steak" red in the center of the nodule. Occasionally, nitrogen deficiency symptoms are caused by soybean cyst nematode or a microorganism causing root rot.

Potassium (K)

Symptoms will sometimes but not always appear first and be the most severe on older leaves. The first indication of a deficiency will be yellow mottling on the edges of leaflets. This will form an irregular but continuous border on the leaf. This area will eventually turn brown and die. Potassium deficiency will delay branching, reduce the number of pods set and reduce the number of beans per pod. Low Potassium soil test levels, Soybean Cyst Nematodes and soil compaction are some of the causes of Potassium deficiency symptoms.

Manganese (Mn)

Plants with a manganese deficiency will be stunted and have short, thin stems. Their foliage will be pale green to yellow. However, the veins of the leaves will stay green. The faded area of the leaves will next develop small brown lesions. The new leaves will change colors first. Old leaves will remain green and appear healthy. High soil pH and poorly drained soils are the main causes of this symptom.

Nutrient Deficiency Symptoms in Soybeans

Nitrogen Deficiency

Potassium (K) Deficiency

Manganese (Mn) Deficiency

Photos provided by Dr. Lloyd Murdock, University of Kentucky Department of Agronomy.
*Photos used with permission from the CD- Nutrient Deficiency Symptoms prepared by the Potash & Phosphate Institute.

SOYBEAN GROWTH STAGES

Jim Herbek

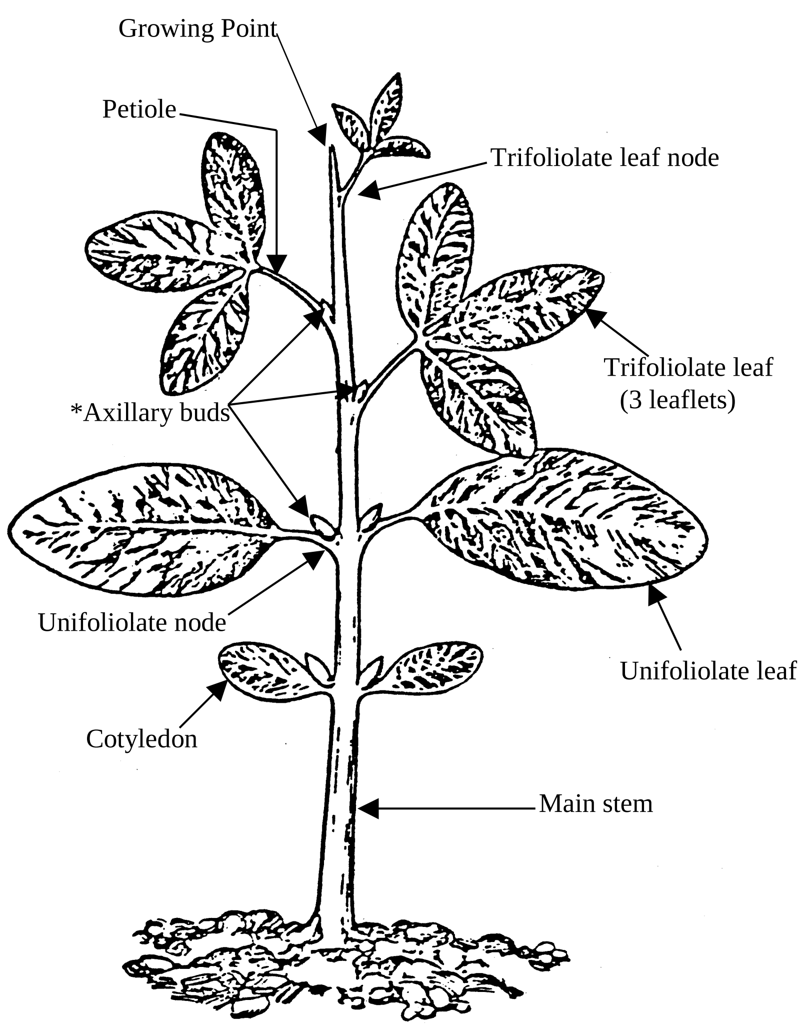
GROWTH STAGE		DESCRIPTION
Vegetative (V) Stages:		Begins with emergence (VE) and ends with Vn (last V stage prior to bloom).
Emergence	(VE)	Cotyledons above the soil surface.
Cotyledon	(VC)	Unifoliolate (single leaflet) leaves unrolled sufficiently so the leaf edges are not touching. The unifoliolate leaf node is the first node.
First-trifoliolate	(V1)	One fully developed trifoliolate (three leaflets) leaf. Is the first trifoliolate leaf node above the unifoliolate node.
Second-trifoliolate	(V2)	Two fully developed trifoliolate leaves. The first two trifoliolate leaf nodes above the unifoliolate node have fully developed leaves.
Third-trifoliolate	(V3)	Three trifoliolate leaf nodes on the main stem have fully developed trifoliolate leaves beginning with the first trifoliolate leaf node above the unifoliolate node.
nth-trifoliolate	(Vn)	The last V stage is designated V(n), where (n) represents the number for the last fully developed trifoliolate leaf on the main stem prior to beginning bloom (R1). (n) can be any number beginning with 1 for V1. The (n) for the the last V stage prior to beginning bloom (R1) will fluctuate with variety and environmental conditions. Varieties with an indeterminate growth habit (most varieties in maturity groups 00 to IV) will have a lower V(n) because they bloom earlier than varieties with a determinate growth habit (varieties in maturity groups V to IX). The V stages (node stages) following VC are defined and numbered according to the uppermost fully developed trifoliolate leaf node on the main stem. ***Determination of a fully developed leaf:*** A leaf is considered fully developed (leaf node is counted) when it has unrolled or unfolded leaflets (i.e. the two edges of each leaflet have separated (unrolled) and the two edges are no longer touching each other). For example, the V4 stage is defined when the leaflets on each of the first four trifoliolate leaf nodes are unrolled (i.e. four trifoliolate leaves are

		fully developed). The unifoliolate leaf node is unique because the unifoliolate (single leaflet) leaves are produced from it on directly opposite sides of the stem. The unifoliolate node is technically two separate nodes, but they are counted as one because they occur at the same position on the main stem. All other true leaves are trifoliolate (three leaflets) leaves, and are produced singularly (from different nodes) and alternate (from side to side) on the stem. The cotyledons (modified leaf storage organs) also arise opposite on the stem just below the unifoliolate leaf node. When the unifoliolate leaves (or the first few trifoliolate leaves) are lost (through injury or natural aging), the position of the unifoliolate node can still be determined by locating the two leaf scars (slight indentations) on the lower stem where the leaf petioles were attached that permanently mark where the unifoliolate leaves had grown. These unifoliolate leaf scars are located just above the two opposite scars, which mark the cotyledonary node position. Any leaf scars above the opposite unifoliolate leaf scars appear singularly and alternately on the stem, and mark node positions where trifoliolate leaves had grown.
Reproductive (R) Stages:		(Begins with bloom (flowering) and ends with maturity).
Bloom:		
Beginning bloom	(R1)	One open flower at any node on the main stem.
Full bloom	(R2)	Open flower at one of the two uppermost nodes on the main stem with a fully developed trifoliolate leaf.
Pod-Fill:		
Beginning Pod	(R3)	Pod 5 mm (3/16 inch) long at one of the four uppermost nodes on the main stem with a fully developed trifoliolate leaf.
Full pod	(R4)	Pod 2 cm (3/4 inch) long at one of the four uppermost nodes on the main stem with a fully developed trifoliolate leaf.
Seed-Fill:		
Beginning seed	(R5)	Seed 3 mm (1/8 inch) long in a pod at one of the four uppermost nodes on the main stem with a fully developed trifoliolate leaf.
Full seed	(R6)	Pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed trifoliolate leaf.

Maturity:

Beginning Maturity	(R7)	One normal pod on the main stem that has reached its mature pod color (normally brown or tan). Seed is yellow (has lost all green color).
Full maturity	(R8)	Ninety-five percent of the pods that have reached their mature pod color. Five to ten days of drying weather are required after R8 before the soybean has less than 15 percent moisture.

Young Soybean Plant



*The upper junction between the main stem and a leaf petiole is called an axil. In each axil there is an axillary bud. This bud usually developes a flower cluster, but may remain dormant, or may develop into a branch.

Plant Populations In Soybeans

Jim Herbek

Some producers prefer soybean stands reported as plants per foot of row (based on row spacing). Others prefer soybean stands reported as plants per acre. Stand/population determinations for each of these are explained below.

Stand Counts should be determined around the second week after emergence. A 10 foot piece of rope or measuring tape can be used for measuring the length of row. Place this rope between two rows and count the number of plants in both rows within a ten foot distance (for a total of 20 linear feet of row for each count). Repeat this process in five locations in the field for each 50 acres or portion thereof, thus giving a **total of 100 linear feet of row** for each 50 acres or less.

The exact 20 feet of distance for each count (total of 100 linear feet for 5 counts) **is important** due to the nature of the population formula, which is based on 100 feet of row (see table in next column)

Try to pick out representative rows for stand counts. If areas of the field are quite different in respect to stands, these areas should be counted and noted separately.

Stand (plants per foot of row)

Divide the total number of plants counted in 100 linear feet of row by 100 to determine the average number of plants per foot.

Examples of the number of stand/population determination needed for various field sizes.

39 acre field	=	One population determination (100 feet of row)
76 acre field	=	Two population determinations (100 feet of row each)
141 acre field	=	Three population determinations (100 feet of row each)
232 acre field	=	Five population determinations (100 feet of row each)

Example:

Number of plants in 100 feet = 620
620 ÷ 100 = 6.2 plants per foot of row.

Population (plants per acre)

Row width: Measure the distance between rows in several locations to determine the row spacing. Or, check with the producer to find out what row width was used in planting.
Population determination: Multiply the total number of plants counted in 100 feet of row by the "C" (conversion) factor for the appropriate row spacing (see following table for "C" factor).

Example:

Stand Count for 100 feet = 461
Row width = 15 inches
461 x 348.48 = 160,649 plants per acre.

Row Width	C Factor*
7”	746.78
8”	653.37
10”	522.74
15”	348.48
20”	261.35
30”	174.24

*To find the “C” (conversion) factor for other row spacings, divided 43,560 by the row spacing (in feet) and then divide that result by 100 (for 100 linear feet of row counted).

When more than 50 acres are involved in a field, determine the plant population for the whole field by averaging the plant populations that were obtained for each 50 acre portion. Also, draw a map of the field indicating the location of each 50 acres or portion thereof counted and the plant population obtained in each location.

Soybean plant stands may range from one plant per foot of row (narrow rows) to 12 plants per foot of row (wide rows) depending on row width. Soybean plant populations (plants per acre) may range from less than 100,000 to over 200,000 plants per acre, but will generally be in the range of 120,000 to 170,000 plants per acre.

Broadcast Soybeans

Plant populations for soybeans not planted in rows can be determined by making stand counts using two methods: a) counts on a square foot basis; or b) hula-hoop method:

a). Plants per square foot method: Use a four foot square area to make counts. Obtain a four foot square by marking a rope into two foot lengths and forming a square or use a fold-up wooden rule to form a 2 foot x 2 foot square. Count the number of plants contained in the four foot square area. Repeat this process in 10 locations in the field for each 50 acres or portion thereof, thus giving a total of 40 square feet for each 50 acres or less. Determine plant populations by dividing the total number of plants obtained in 40 square feet by 40 to determine the average number of plants per square foot. Multiply the average plants per square foot by 43,560 square feet per acre to obtain the population (plants per acre).

Example:
Total plants in 40 sq. ft. = 140
140 ÷ 40 sq. ft. = 3.5 plants per sq. ft.
3.5 x 43,560 = 152,400 plants per acre.

b). Hula-hoop method: Stand counts can be taken using a hula-hoop. Randomly toss the hoop and count the number of plants within the circle. Repeat this process in 10 locations in the field for each 50 acres or portion thereof, thus giving a total of 10 counts for each 50 acres or less. Determine plant populations by dividing the total number of plants obtained in 10 hoop counts by 10 to obtain the average number of plants counted per hoop. Plants per hoop can then be converted to plants per acre by multiplying the average number of plants counted per hoop by the factor (for the inside diameter of the hoop used) shown in the table below.

<u>Example</u>:
Total plants in 10 hoop counts = 156
156 ÷ 10 hoop counts = 15.6 plants per hoop
Inside diameter of hoop = 28 inches
15.6 x 10,000 = 156,000 plants per acre.

Inside Diameter of Hoop	26”	28”	30”	32”	34”	36”	38”
Multiplication Factor	11,800	10,000	8,900	7,800	6,900	6,200	5,500

Estimating Soybean Yield Prior to Harvest

Jim Herbek

The following are guidelines to get an estimated soybean seed yield while the crop is still standing in the field. Proceed with caution since variability in soybean stand, pods per plant, seeds per pod, and seed size can all drastically affect the final yield. These estimates become highly variable when conducted before seed fill is completed. Even with these attempts to get as representative a sampling as possible, there is still variability with the yield estimates because of assumptions about final pod number, seed number and seed size.

Estimates should be made in five to ten locations across the field to get a better estimate for yield. Obviously, the more locations you sample, the better the estimate. Each of the locations selected should represent those areas of the field.

Step 1. Determine size of area to be investigated.

Select 1/1,000th of an acre because the numbers are easy to calculate. The feet of row needed to equal 1/1,000th acre for various row widths are shown in the table below. The following steps are based on using 1/1,000th acre. If another size is selected, then adjust the calculations accordingly.

Row width and feet of row needed to equal 1/1,000th acre.

Row Width (inches)*	Feet of row needed to equal 1/1,000th acre
6	87 feet 1 inch
7	74 feet 8 inches
7.5	69 feet 8 inches
15	34 feet 10 inches
20	26 feet 2 inches
30	17 feet 5 inches

*To determine the length of row needed for other row widths, divide 43,560 by the row width (in feet) and then divide the result by 1000.

Step 2. Estimate plants per 1/1,000th acre.
Count the number of plants within the required length of row determined in Step 1. Make several counts and determine an average.

Step 3. Estimate plant population.
Multiply the average number of plants from Step 2 by 1,000 to estimate plants/acre.

Step 4. Estimate pods per plant.
Pick 10 plants in a row and count the pods on each plant. Determine the average number of pods per plant.

Step 5. Estimate pods per acre.
Multiply the pods per plant from Step 4 by the number of plants per acre determined in Step 3.

Step 6. Estimate seed number.
Healthy soybean plants will average about 2.5 seeds per pod. For healthy soybeans, multiply pods per acre from Step 5 by 2.5 seeds per pod to estimate seeds per acre. For soybeans under stress, the seeds per pod could drop to 2 or 1.5 or even less under highly stressful situations. You can actually evaluate the seeds per pod from the same soybean plants used in Step 4.

Step 7. Estimate seed weight.
The seed size (weight) estimate used in this calculation can make a large difference in yield estimations. Seed size is highly variable and can range from 2200 seeds per pound (large seed) to over 3500 seeds per pound (small seed) and is dependent on variety and also growing season conditions. Thus, it is difficult to know what seed size (seeds per pound) to use to obtain pounds per acre.

In Kentucky, about 2,800 seeds per pound is an average number. Divide the number from Step 6 by 2,800 to determine pounds of seed per acre. Under stressful conditions, the seed size may be smaller, meaning that more seeds per pound are needed. The original seed size from the seed bag may provide the best indication of soybean seed size.

Step 8. Estimate bushels/acre.
One bushel of soybeans typically weighs 60 pounds. Divide the number from Step 7 by 60 to estimate bushels per acre.

EXAMPLE

Step 1. Area size for 1/1000th acre
- Soybean row width = 15 inches.
- Make counts in 34’ 10” of row.

Step 2. Estimate plants per 1/1000th acre
- Average plant count from 10 locations = 140 plants.

Step 3. Estimate plant population
- 140 plants x 1000=140,000 plants/acre.

Step 4. Estimate pods per plant
- Average pod count from 10 or more plants = 30 pods/plant.

Step 5. Estimate pods per acre
- 30 pods/plant x 140,000 plants/acre = 4,200,000 pods/acre.

Step 6. Estimate seed number
- Healthy soybean plants. No stress.
- Assume 2.5 seeds/pod.
- Or, make actual counts (several plants).
- 2.5 seeds/pod x 4,200,000 pods/acre = 10,500,000 seeds/acre.

Step 7. Estimate seed weight (seed size)
- Estimate based on growth conditions

or use 2800 seeds/lb average.

- Or, from seed bag = 3000 seeds/lb.
- 10,500,000 seeds/acre ÷ 3000 seeds/lb = 3500 lbs/acre.

Step 8. Estimate bushels per acre

- 3500 lbs/acre ÷ 60 lbs/bushel = 58 bushels/acre (estimate).

APPENDIX

UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Taking Soil Test Samples

W.O. Thom, G.J. Schwab, L.W. Murdock, and F.J. Sikora

The most important part of making fertilizer recommendations is collecting a good, representative soil sample. Soil test results and fertilizer recommendations are based solely on the few ounces of soil submitted to the laboratory for analysis. These few ounces can represent several million pounds of soil in the field. If this sample does not reflect actual soil conditions, the results can be misleading and lead to costly over- or under-fertilization. It is necessary to make sure that the soil sample sent to the laboratory accurately represents the area sampled.

Sample Timing

Soil samples can be collected through much of the year, although fall (September to December) or spring (February to April) are the best times. Fall sampling will often result in a faster return of results and recommendations. Fall sampling will also allow the grower time to have the fertilizer applied well before planting the next crop. However, fall sampling results in lower pH and soil test K levels when conditions are dry. In either case, a field should always be sampled the same time of the year in order to make historical comparisons.

Most fields should be sampled every three to four years. High-value crops, such as tobacco, commercial horticultural crops, alfalfa, red clover, and corn silage, should be sampled annually so that plant nutrient levels can be monitored more closely. Application of manure can change soil test phosphorus, potassium, and zinc levels dramatically, so sampling manured fields each year is also recommended.

Tools You Need

A soil probe, auger, garden trowel, or a spade and knife are all the tools you need to take the individual cores that will make up the "field" sample (Figure 1). You will also need a clean, dry, plastic bucket to collect and mix the sample cores. Be sure not to use galvanized or rubber buckets because they will contaminate the sample with zinc. Soil sample boxes or bags and information forms for submitting samples are available at all county Extension offices.

Collecting Field Crop Samples

An individual sample should represent no more than 20 acres except when soils, past management, and cropping history are quite uniform. The most representative sample can be obtained from a large field by sampling smaller areas on the basis of soil type, cropping history, erosion, or past management practices (Figure 2). For example, a portion of a field may have a history of manure application or tobacco production while the other part does not. Phosphorus and potassium levels will likely be higher in these areas, causing the rest of the field to be under-fertilized if the field is sampled as one

Figure 1. A soil probe, auger, or spade and knife should be used in sampling soils. The spade sample must be trimmed as shown.

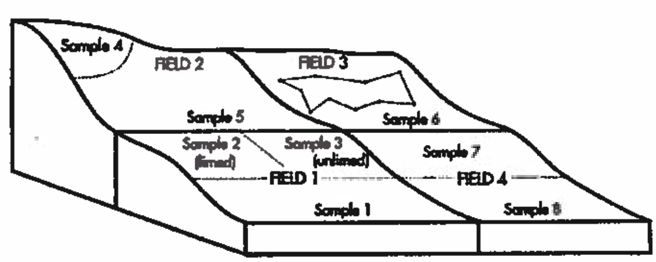


Figure 2. This shows how four fields might require the analysis of one to three composite samples for determining fertility needs. Each composite must contain 10 or more cores, as shown for Sample 6 in Field 3.

unit. It is much better to collect separate samples from these areas because their nutrient requirements are likely quite different from the rest of the field.

If a few years of yield maps are available, these can help identify areas of the field that should be sampled separately.

Soil sampling can also be used to "troubleshoot" areas of the field that are visually different or are consistently low yielding when compared to the rest of the field. Take a sample both from the poor growing area and adjacent areas of good growth. Keep good records indicating where each sample was taken.

Collect at least 10 soil cores for small areas and up to 30 cores for larger fields. Take the soil cores randomly throughout the sampling area and place them in the bucket. **Do not sample:**

- back furrows or dead furrows,
- old fencerows,
- areas used for manure or hay storage and livestock feeding, and
- areas where lime has been piled in the past.

Grid Soil Sampling

With new advances in agriculture and the availability of global positioning satellites, it is now possible to divide a field into smaller units or grid cells that can be sampled individually. Soil test results from each grid can be used to prepare nutrient availability maps of fields. Variable-rate fertilizer and lime applications are then based on these maps. Grid soil sampling and prescription fertilizer maps may result in more accurate recommendations and may lead to greater efficiency in fertilizer use.

Currently the industry standard grid size is 2.5 acres, but Kentucky research shows that variability within areas as small as one acre can be as great as the variability within the entire field. Because soil variability is so high, it is important to treat each grid cell as a field. At least 10 random samples should be collected across the entire grid cell, rather than a few cores from the center of the grid (Figure 3). Grid sampling can be a good way to identify old field boundaries or parts of fields that have had different management in the past if they are unknown to the current producer. This intensive sampling is costly, and limited Kentucky research has not shown a predictable economic benefit when it is compared to the current recommended method of sampling according to soil type, past history, or past management zones.

Sampling after Banded Fertilizer Applications

Care must be taken when sampling no-till fields that have had fertilizer applied in bands rather than broadcast. Phosphorus, potassium, and zinc are immobile in the soil and remain in the concentrated band for several years after application. If these bands are completely avoided during sampling, soil test results will be lower than "actual," leading to over-fertilization. If bands are included too often, soil test results will be higher than "actual," causing an underestimation of fertilizer needs for the crop.

When the location of the bands is known, it is best to sample in the band one time for every 20 cores taken. If the location of the band is unknown, it is best to take pairs of random samples. The first core is completely random, and the second core is taken one-half the band spacing distance in a direction perpendicular to the band direction. For example, if banded fertilizer was applied on 30-inch spacing, the first core would be randomly selected, and the second sample would be taken 15 inches away (perpendicular to the direction of the band). This process would be repeated at least 10 times in a small field and up to 30 times in a larger field. The more cores that are collected, the more closely the sample will represent "actual" field conditions.

Collecting Lawn or Garden Samples

Sample gardens, lawns, and landscaped areas separately. Collect cores randomly from each area. The area to sample for trees includes the soil below the width of the tree. For shrubs, flower beds, and gardens, sample just the soil where the plants are growing. You should sample problem areas and areas with shrubs, trees, or flower beds separately from other turf or lawn areas. **Do not sample:**

- compost areas,
- under the drip-line of trees, and
- close to driveways or streets.

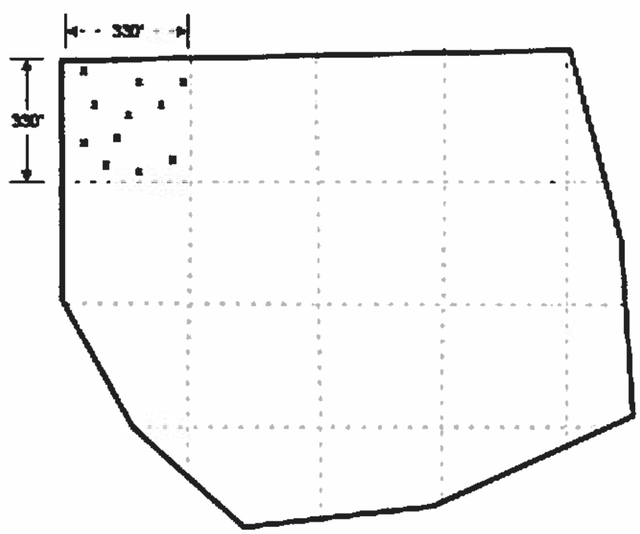


Figure 3. A field can be divided into 2.5-acre grid cells, as shown in the diagram above. Each cell should be treated as an individual field, and approximately 10 random cores should be taken from each cell.

Sample Depth

One commonly overlooked component of soil sampling is the depth of soil to be tested. Most plant nutrients accumulate at the soil surface. This nutrient stratification is a result of past broadcast fertilizer applications and decomposition of plant residue on the soil surface. Because there is a higher concentration of nutrients on the soil surface, soil test values usually go down as the sample depth is increased. To obtain accurate and consistent (between different years) results, samples must be taken to the following depths for these areas:

Tilled Areas—Take soil cores to the depth of the tillage operation (usually 6 to 8 inches).

Non- or Reduced-Tilled Areas—Take soil cores to a depth of 3 to 4 inches for pastures, no-till planting (where fertilizer or lime remains on the soil surface), and minimum-till planting (where fertilizer is incorporated only in the surface 1 to 2 inches).

Lawns and Turfgrasses—Collect soil cores to a depth of 3 to 4 inches.

Sample Preparation

After all cores for an individual sample are collected and placed in the bucket, crush the soil material and mix the sample thoroughly (Figure 4). Allow the sample to air dry in an open space free from contamination. **Do not dry the sample in an oven or at an abnormally high temperature.** When dry, fill the sample container with the soil (Figure 5).

Figure 4. Break up clods while a sample is moist, and spread out to air dry in a clean area.

Sampling and preparing the soil for submission is only half of the process. The other equally important part is filling out a sample information sheet so that the desired crop, tillage, and other information can be considered when making the fertilizer recommendation (Figure 5). The sample information sheet contains all the important information required to provide accurate lime and fertilizer recommendations. Sample information sheets for the University of Kentucky Soil Testing Laboratory can be found on the Web at <http://soils.rs.uky.edu/sample1.htm>. The types of forms available are the:

- agricultural form,
- home lawn and garden form, and
- commercial horticulture form.

Figure 5. Thoroughly mix the air-dried sample, fill the sample bag or box, mark with your sample designation, fill out the information sheet, and take the sample to your county Extension office.

Each form asks for primary and alternative crops, as well as other background information. The amount of background information needed depends on the crop to be grown. Table 1 is provided as a guide to the background information needed for major agricultural crops (a) and home lawn and garden plants (b). Help on filling out the forms can be provided by your county Extension office.

It is very important to complete the pertinent sections of the sample information form. This will assure that you receive the most accurate fertilizer recommendations possible. Soil samples should be taken to your county Extension office; from there they will be sent to the UK Soil Testing Laboratory. Results and recommendations will be e-mailed to the county office usually within one to two weeks of submission.

Table 1. List of required crop information for accurate lime and fertilizer recommendations.

A. Agricultural Soil Sample Form

	Primary Crop			
Required Information	**Corn**	**Soybeans**	**Tobacco**	**Forages**
Previous crop	yes[1]	no[2]	yes	no
Primary management	yes	no	no	yes
Previous management	yes	no	no	no
Primary use	yes	no	no	yes
Previous use	no	no	no	no
What was there 2 years ago?	no	no	yes	no
Soil drainage	yes	no	yes	no

B. Home Lawn and Garden Soil Sample Form

	Primary Crop		
Required Information	**Vegetables & Fruits**	**Turfgrass**	**Landscape Plants**
Turfgrass location	no[2]	yes[1]	no
General information	no	yes	no

[1] Yes = Information is needed for accurate recommendations.
[2] No = Information is not needed for accurate recommendations.

Revised 12-2003