

**D**rainage and tillage take aim on a target to provide a season-long root zone that will produce outstanding soybean yields. Weather, good and bad, has a major influence on how near one gets to the bull's-eye – **maximum yield**. There are a number of fields that have unique drainage and tillage needs which require creative solutions beyond the limited comments below.

Proper tillage choices (including no-till planting) can enhance rapid, extensive root growth and improve water infiltration. This reduces oxygen depletion in flat Delta soils after rains and can expand the moisture reservoir in droughty upland soils. In a productive soil, soybean roots expand and the taproot extends deep enough to access nutrients for maximum yield. Effective tillage practices complement seeding to obtain vigorous, properly spaced seedlings. Effective tillage also provides the soybean roots the best environment to reach moisture and plant nutrients at critical stages in plant development.

Adequate drainage is essential to soybean production whether dryland or irrigated. Poor drainage hampers field operations from field preparation through harvest and limits the effectiveness of irrigation. Eliminating poorly drained areas preserves natural soil productivity by reducing field rutting that requires additional tillage operations to correct. Poorly drained areas reduce yields and often require the most tillage. Water infiltration is also reduced if a soil is tilled when it is too wet. Good field drainage complements all crop production practices.



## Management Tip

Direct drainage improvement efforts toward having minimal standing water on a field 24 hours after a rainfall or an irrigation.

## Improving Surface Drainage

Soybeans need good surface drainage. Field surface smoothing and forming can improve the surface drainage of a field and should be done whenever possible. Use land planes to smooth out the high spots and fill in the low areas so that the field has a more uniform slope toward a drainage outlet. Low areas that are larger than 100 feet across or that need more than 6 inches of fill require more soil moving and compaction than a plane provides. These areas should be overfilled and compacted with equipment tires before being planed.

Another option for improved drainage is to plant on raised rows or beds if this fits the production plans for a field. Raised rows are not common in soybean production but may be necessary on some fields that are not adequately drained using other efforts.

Drain furrows are commonly used to improve a field's surface drainage. Furrows are shallow and narrow and can be constructed with several different types of equipment. Concentrate the furrows on the low areas in a field rather than putting them in randomly. Drain furrows should generally run with or at a slight angle to the natural slope of the field but not across the direction of the slope.

Make an effort to accurately determine a field's drainage flow pattern. Some limited surveying of field elevations can be very helpful in determining where to place a furrow to drain a low spot. Deciding where water will drain by simply looking at the field is not easy. The furrow should have continuous positive grade to assure that the water will be directed off the field. When surveying isn't possible, someone who knows the drainage flow pattern of the field should oversee the drain furrow installation. A drain furrow will not be successful unless the water can drain into it freely. If a berm remains on the



Figure 6.1. A PTO power ditcher is one tool that is used to construct drain furrows for improved surface drainage.

upgrade side of the furrow drain after it is constructed, water movement into the furrow will be restricted. If the berm is unavoidable, then it should always remain on the downgrade side of the furrow. Furrow or ditching equipment that spreads the soil evenly on both sides of the furrow helps avoid this problem. A drain furrow is not complete until it is connected to a ditch or pipe that carries excess water away from a field.

Precision grading of a field provides a positive method of improving surface drainage. It is limited to fields with relatively flat (less than 1 percent) slopes, or the cost can be prohibitive. If a field is being considered for precision grading, the soil should be evaluated to determine what problems might occur if deep cuts are made in some areas. These cut areas may expose soil with reduced production capability. County soil survey reports, published by the Natural Resources Conservation Service (formerly SCS), can help identify soils with unproductive subsoils. Poultry litter application may improve the productivity of cut soils. An Extension publication, *Soil and Fertilizer Information Article 2-90, Poultry Litter as an Amendment for Precision Graded Soils*, reports on results of litter applications.

The finished slopes of graded fields should range from 0.1 to 0.5 percent (0.1 to 0.5 ft. per 100 ft.) if possible. This range provides good surface drainage without increasing erosion potential. Grading for slopes of less than 0.1 percent should be limited and restricted to smaller fields with slope lengths of a

quarter mile or less. These flatter slopes are more difficult to construct with precision, and they tend to develop more low areas and reverse grades. An elevation survey of the field is required before any design work can be done. Survey information can be entered into a computer program that evaluates possible drainage options for a field and determines the required dirt work. Most dirt-moving contractors offer the computer program design, and it is also available through Natural Resources Conservation Service offices. Precision grading is usually expensive and is a long-term investment for increasing the production potential and market value of the land.

An important component of field drainage is the ditch system that receives the excess water and carries it away from the field. Flow restrictions in these ditches can cause excess water to remain on a field. Maintain drainage ditches and routinely clean them out to effectively handle the drainage water from a field. Ditch outlets and drainage structures should also be routinely checked to assure that they are functioning properly and are not becoming restricted. Beavers often cause problems by damming ditches, culverts and drainage pipes. A Beaver Pond Leveler pipe has potential to reduce these problems in certain situations. This device is described in Extension publication FSA 9068, *Flood Water Management With a Beaver Pond Leveler*.

Drainage problems related to ditches may involve other property owners. It may be necessary to work with neighboring farms to correct common drainage problems. Planned drainage improvements could impact areas that may be classified as wetlands. If this is a possibility, contact the local Natural Resources Conservation Service. Their staff can visit the site and determine if there are drainage restrictions related to wetlands preservation laws.



### Management Tip

Include both short- and long-term goals for improving drainage in every farm improvement plan.

## Improving Internal Drainage

Most Arkansas soils have limited or restricted internal drainage. Internal drainage may be improved on a short-term basis when soybeans are rotated with crops such as corn or grain sorghum. The rooting pattern and root residue of these grass crops improve the soil's internal structure and the movement of water through the soil. Soybeans grown behind rice often produce higher yields, partially due to crop residue that improves infiltration and water-holding capacity of the soil. Some clean-tilled silty soils tend to seal over or crust after rainfall or irrigation. This restricts the infiltration and the internal drainage of the soil. Maintaining some crop residue on the soil surface reduces surface sealing so that the water can move into the soil profile more freely.

Naturally occurring restrictive soil layers and those formed by tillage equipment restrict internal drainage. This is desirable when growing rice, but restrictive layers reduce the root and water reservoir available for soybeans. The shattering of these layers prior to planting a soybean crop can improve both internal drainage and plant root extension.

## Compaction

Subsoiling increases non-irrigated soybean yields in some droughty, shallow soils. Dig up several complete root systems to evaluate taproot length and branching. Use a soil probe, shovel or backhoe to determine whether tight soils are limiting moisture infiltration or root penetration and to check the depth and thickness of any compacted zone. Limited research available indicates that only loamy sands have consistently produced greater yields from subsoiling. Subsoil other soils only when they have a compacted zone and are dry enough to shatter. Wetter, silty and clayey soils are not consistently responsive to subsoiling. Fall subsoiling assures time to store winter rains and allows some natural crumbling of the large soil aggregates. Subsoiled fields may remain soft longer in the spring, delaying early field operations, because the soil strength is inadequate to support traffic.

The most effective subsoiling depth is just below the bottom of the restrictive layer. If the restrictive layer begins at 8 inches and is only 2 to 3 inches thick, then the tillage shank must penetrate to 10 to 12 inches deep. The key is that the deep tillage implement extends just below the restrictive layer so that the layer is effectively lifted and shattered. Surface tillage, especially disking, reforms restrictive layers very quickly and should be avoided, if possible, or at least limited.

Use practical techniques to reduce soil recompaction before seeding. Maintain the shattered soil zone as an additional moisture reservoir to promote rooting into a greater soil volume. Recompaction from tractor tires in the immediate vicinity of the taproot is typically less likely after soybeans emerge. Larger diameter tires, minimum tire inflations and reduced axle loads are several of the best options to limit tire forces that may affect soil to depths of 20 to 24 inches.

Disks and highly inflated tires compress soil in the upper 10 inches. Heavy cutting disks may apply more than 200 pounds of force downward onto the soil below each blade. This, together with fine clay particles that sift down to the tilled depth in sandy soil, tends to form a hard layer that retards moisture infiltration. Axle loads greater than 7 tons exert forces with long-term soil effects below a foot that typically reduce the soil voids available for air, water and root growth. Subsoil no deeper than the compacted zone to avoid extra power and fuel consumption that increases the cost of subsoiling. "In-row" subsoilers that penetrate through the "hardpan" are more effective than random subsoiling paths due to recompaction from subsequent trips. High-residue subsoilers or ripper-hippers are suggested for maintaining the same row location year after year.



### Management Tip

To profit, subsoiling must provide a yield increase ranging from 2 to 3 bushels per acre.



Figure 6.2. Less surface soil disturbance occurs when a high-residue subsoiler is used. This type of subsoiler can be used in no-tillage fields and requires less subsequent tillage in other production systems to adequately prepare the field for seeding.

## Tillage Principles

Appropriate tillage to aid infiltration and to reduce the effect of too little or too much rain often contributes to increased soybean yield. Emphasis should focus on tilling the soil properly to promote adequate root expansion as much or more than on weed control. Regardless of the tillage system used, the goal is to obtain the most profitable production and best root environment. Tillage generally accelerates organic residue deterioration, destroys soil structure and leaves it vulnerable to soil erosion. The forces of tractor tires and disks downward into the soil may cause compaction that is worse at higher soil moisture contents. Greater tractor axle loads transfer force deeper into the soil and cause compaction below 6 inches in the soil that persists longer. If less tillage is profitable compared to clean-tilled (conventional) systems, long-term soil improvements are beneficial to both the farm manager and the landowner.

Some reasons for tillage are to:

- Provide loose soil for soybean seeding and root growth.
- Aid drainage, infiltration or retard evaporation from the soil.
- Shape the soil surface and/or reduce the soil aggregate size to provide better soil aeration, soil-seed contact and moisture for germination

and root growth. Soybean seeds need water equal to 50 percent of their weight to activate enzymes for germination.

- Mix herbicide uniformly and/or destroy weeds to limit competition for nutrients.
- Warm and dry soil faster to help early-seeded soybeans.
- Suppress some diseases or insects by mixing plant residues into the soil.

Concern for a proper rootbed and soybean production cost are “juggled” by a grower to produce soybeans profitably.



### Management Tip

If the field is not rutted, stale seedbed or no-till approaches may be profitable options.

## No-Tillage

Good surface drainage and the proper use of herbicides and heavy-duty no-till seeding equipment are keys for consistent no-till success. Exercise care to get a uniform stand, and time herbicide applications to avoid no-tillage “messes.” Growers who accurately diagnose field weed species early and spray effectively make this option look simpler than it is. No-tillage fits situations where good weed control is possible for equal or less herbicide and application costs than the projected tillage cost. Some strengths of this option are:

- Heavy clays can be seeded without tillage that makes hard chunks of soil and without exposing soil surfaces that contribute to losing moisture needed for germination/emergence.
- Silt loams can be planted with greater assurance of obtaining a stand because the potential for soil crusting is substantially less with residue remaining on the surface.
- Rapid soybean emergence reduces the risk of partial germination and “skippy” soybean stands due to moisture leaving the topsoil from mixed or sandy soil.



- Soybeans double-cropped with wheat can be seeded in the same field during harvest completion, providing more timely planting and potentially greater yield than other options.
- Less soil is lost from the field due to erosion during intense rainfall.

Plant only when the soil is dry enough to close the furrow well and soil moisture is available for rapid seedling growth. Cut completely through surface residue to assure adequate soil contact with seed. Adjust seeding depth and covering devices to assure that seed is placed into moist soil. Refer to Extension publication FSA 1015, *Planting Reduced-Tillage Soybeans*. Although furrow irrigation is generally not feasible in no-till production, other irrigation methods are possible.



Figure 6.3. Aggressive closing wheels on a planter or soybean drill prevent soil cracking in the furrow before the soybeans sprout.

## Soybeans Following Wheat

Timely planting is vital to minimize yield reductions that typically occur when soybeans are seeded after June 15. Research indicates that yield potential decreases at least one-half bushel each day for seeding after June 15. Row or drill spacings narrower than 30 inches are preferred.

The John Deere 750 is an excellent no-till drill for seeding soybeans in late June or July when a 15-inch or narrower row spacing is recommended. Since late-planted soybeans are especially vulnerable to drought stress in July and August, use tillage practices that conserve soil moisture to obtain a quicker stand.

Before seeding wheat in the fall, plan to provide excellent drainage for both crops – the wheat and the no-till soybeans following the wheat. Phosphorous and potash, and in some cases lime, (meeting both wheat and soybean requirements) are best applied in the fall. If the chaff discharged behind a combine is over an inch deep (typical with combine headers over 20 feet wide and wheat yields above 50 bushels per acre), use a chaff spreader attachment on the combine to eliminate most wheat residue problems. Plant directly into wheat stubble. Avoid burning wheat fields because even temporary additions of organic matter improve soil tilth and water-infiltration rates.

Untilled soils with sufficient moisture for emergence typically provide a seed environment that is equal to, or better than, one made with the best selection of tillage tools. Typically, herbicide incorporation leaves the top few inches of soil too loose for rapid seed development, especially on lighter-textured soils. The soil below the top 4 inches may suffer excessive compaction from tractor tires, disks, land planes and other implements.

Tillage is the best alternative for rutted fields or dry soil. If the field is too dry for reliable soybean germination, either wait for rain before seeding or irrigate (flush) the field. Growers with sprinkler irrigation have the option to seed or “dust in” soybeans 1/2 to 1 inch deep and water to promote emergence.

## Reduced Tillage

Covering previous soybean, wheat or rice residue before seeding soybeans is not essential. Pulling a small land plane over the places where last season’s levees were may possibly help eliminate ridges or furrows. Good field drainage permits timely planting and aids seedling growth. Today’s modern no-till planters and certain drills cut through residue from a previous bumper crop. One seedbed criteria is a surface smooth enough for accurate seed placement. If an incorporated herbicide is needed, schedule planting soon after tillage for good soil-seed contact before soil moisture escapes. Planting quickly after soil preparation allows seeds to absorb soil moisture before it evaporates and avoids possible rain delays. Rains foster surface crusting and weed germination in

newly tilled soils. Including some early-season soybeans (Group IVs) that can be planted in either April or early May could enable planting more fields immediately after seedbed preparation.

Limit seedbed preparation to a minimum number of tillage passes. Usually this is two or three passes (possibly a chisel or disk and a field cultivator or a combination finishing tool that may incorporate a herbicide). Few growers exceed four preplant tillage passes if rains don't interrupt seeding.



### Management Tip

Produce optimum yields with as few tillage operations as necessary for profit and soil preservation.

## Herbicide Incorporation

Two passes, the second at an angle to the first, provide excellent incorporation with a field cultivator operated 2 to 3 inches deep. The best soil mixing occurs when sweeps are used and the field cultivator is pulled at least 5 to 7 mph. Always operate the front row of shanks at least as deep or slightly deeper than the rear row. In lighter-textured soil, a drag harrow or board mounted behind the field cultivator improves herbicide distribution within 1 inch of the surface.



Figure 6.4. Herbicide effectiveness is enhanced by a thorough mixing to the depth recommended for the target weed species.

Combination incorporation implements provide the best herbicide uniformity with one pass. Implements such as a Triple K, with a spiral "basket," incorporate herbicides well into light- and medium-textured soils. Those implements with field cultivator teeth, a ground-driven reel and a drag harrow similar to a DoAll provide adequate one-pass incorporation. Newer conservation incorporation tools are equally effective at mixing herbicides.

### Precautions for red rice and johnsongrass control:

- For red rice control, use two passes of a conservation incorporator, DoAll, Triple K or similar implement.
- For rhizome johnsongrass control, the proper herbicide needs to be placed 4 inches deep. Consult the herbicide label to avoid excess soybean injury.

Tandem disks invert the soil and mix herbicides deeper than the implements designed for incorporation. A single disk pass leaves soil areas with low herbicide concentrations where weeds can often survive. The second pass of a disk improves the uniformity of herbicide concentration. As far as herbicide uniformity is concerned, the direction or angle of the second pass relative to the first makes little difference. A disk is better for rhizome johnsongrass control than for other herbicide-mixing tasks.

Disks with 7-inch blade spacings provide the best herbicide uniformity; 9-inch spacings must operate deeper and, even so, incorporate poorly. Disks with 11-inch spacings tend to cause the greatest soil compaction below the operating depth and are unacceptable for incorporating herbicides.

## Stale Seedbed

“Stale seedbed” refers to fields where the soil has consolidated since the last tillage (rainfall, freezing, thawing, etc.). This term describes fields where the last preplant tillage occurred at least a month prior to planting. The stale seedbed approach shifts preplant tillage from the spring rush immediately before planting to an “off-peak” time for labor. Completing tillage when soil tilth is excellent eliminates any further need for “freshening.” Green vegetation must be eliminated by an early spring “burndown” herbicide (possibly two sprays).

On clay soil, soybean yields from stale seedbeds may exceed yields from fields that receive a full complement of spring tillage operations. Stale seedbed soybean production is successful on clay soil that often remains wet and forms clods when tilled. Several rains are necessary to mellow clods in the stale seedbed before planting. This approach works if all green vegetation is killed. When soil is mellow and plant residue is minimal, planting difficulties are rare. In other words, with ideal moisture and little residue, almost any well-maintained planter or drill can provide an excellent stand.

Stale seedbed has been successful on most soil types. Early soybean growth is vigorous because the soil moisture is frequently excellent just below the surface. Burndown herbicides may add \$9 to \$15 per acre cost, but the approach enables timely seeding. Thus, tillage during dry fall and early winter periods permits farming more soybean acres.

## Growing Soybeans on Beds

Bedded soybeans may increase yields if surface water movement from the field is slow, especially for fields that are nearly flat. After intense rains, these soybeans don’t stand in water as long, and the beds may also provide faster emergence because they are warmer.

The extra cost of planting systems using beds can be offset with an extra 2 to 3 bushels of soybeans per acre. Above-average yields often are essential, partly because many of these fields are so flat that they require annual land planing before bedding. Furrow irrigation complements this tillage

option. Where an impervious pan is near the surface of prairie silt loams, irrigation is essential for obtaining yields necessary for long-term economic enterprise survival. Bedded rows can also be useful on shallow soils. Limiting tire compaction to specific middles is helpful; thus, properly spacing tracks and selecting equipment widths enhance the root environment below most of the “outboard” rows.

Beds can be formed on centers as narrow as 30 inches, but this row spacing may be too wide for maximum yields on certain soils if foliage doesn’t lap the middles by the reproductive stage (R2). Middlebusters are an excellent way to form rows with less preliminary tillage. Corn stalks do not tend to snag on middlebusters, whereas preliminary tillage is almost always necessary after a corn crop before operating disk hippers. Clay soils may tend to “slab” more with middlebusters than with disk hippers.



### Management Tip

Bedded rows may salvage soybeans, especially during intense, early-season rainfalls, if water stays on a field more than one day.

## Managing Tillage

Developing an adequate seedbed is partly science and partly experience on many soils. Observing the seedbed condition is easy compared to judging what is appropriate tillage for the unseen soil. To achieve maximum yield, especially without irrigation, later-season root access to nutrition and moisture is critical. The effects of tillage on soil below the top 4 inches may persist a number of years. Mastering seedbed preparation is simple compared to improving the rooting zone.

The cost of conventional tillage practices for soybean production ranges from \$20 to \$35 per acre. Tillage operations on fields with high yield potential may provide profits that marginally productive fields won’t. Poor soils in fields where the best yield

potential ranges between 22 to 28 bushels per acre do not justify extra operations if nutritional or other limitations prevent significant yield boosts. For fields with projected yields below 28 bushels per acre, set goals of keeping preplant tillage costs below \$15 per acre. A selection of estimated tillage costs is listed in Table 6.1 and additional estimates are available in Extension publication FSA 21, *Estimating Farm Machinery Costs*, available from your county Extension office.

Proper tillage supports long-term soil productivity while reducing tillage costs related to the current crop. An effective, inexpensive weed control program is another aspect that must be coordinated with the production system. Enhance soybean profits by producing more soybeans with less tillage. Select tillage and complementary operations that have the potential to increase soybean yields and offset the cost of extra inputs.

**Table 6.1. Typical Costs of Tillage Operations When Implement Is Operated at Proper Depths, Speeds, Etc.**

<b>Operation</b>	<b>Estimated Cost Per Acre for One Pass</b>
Bed conditioner	\$2.00 - \$3.25
Chisel plow	\$4.00 - \$6.00
Combination incorporator	\$2.50 - \$3.25
Cutting disk	\$4.50 - \$6.00
Disk bedder	\$2.25 - \$3.25
Field cultivator	\$1.75 - \$2.75
Land plane	\$4.50 - \$6.00
Light disking	\$3.50 - \$5.00
Rotary hoe	\$1.50 - \$2.00
Row cultivator	\$3.50 - \$5.00
Subsoiler	\$7.00 - \$14.00