Field Selection and Soil Preparation

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Field Site Selection

Ideally, sites for tobacco production should be chosen two to three years in advance of planting, which allows for observation of any problems, such as poor drainage, low fertility or soil pH, and specific types of weeds common in a field. Several factors need to be considered when selecting sites for tobacco, including soil properties, rotational requirements, conservation compliance requirements, potential herbicide carryover and proximity to curing facilities or irrigation.

The roots of a tobacco plant are very sensitive to the aeration conditions in the soil. In saturated soils, tobacco roots begin to die within six to eight hours, with significant root loss occurring in as little as 12 to 24 hours. This sensitivity to aeration conditions is why tobacco plants wilt or "flop" after heavy rainfall events. Tobacco grows best in soils with good internal drainage, which helps keep excess water away from the roots. Of course, tobacco also needs water to grow, and a soil with a good water holding capacity is an advantage during the short-term dry spells that are common during summers in the regions where

burley and dark tobacco are grown. The best soils for burley and dark tobacco production tend to be well-structured silt loam or silty clay loam soils.

Cover Crops

The benefits of using winter cover crops are well-documented. Winter cover crops protect the soil from erosion losses, scavenge leftover nutrients from the soil, and add organic matter to soil when they are plowed under or killed in the spring. Winter cereal grains, such as wheat and rye, are the most commonly used cover crops in tobacco production. These grains, when planted in September or October, make good growth by early winter to help reduce soil erosion and grow very rapidly in spring as the weather warms. Winter grains should be plowed under or killed in early spring no later than when they are heading. Waiting too long can result in nutrients being tied up by the cover crop, significant reductions in soil moisture during dry springs, and, in some cases, organic matter toxicity to the tobacco crop. Organic matter toxicity can occur when a heavy cover crop is plowed under just before transplanting. The breakdown of the cover crop reduces oxygen in the root zone and may result in the production of organic compounds and/or nitrite that are toxic to roots. Affected tobacco plants are yellowed and stunted but usually recover in two to three weeks.

Winter legumes, such as vetch or crimson clover, may also be used as cover crops, either alone or in combination with a winter cereal. Alone they do not produce as much growth in the fall compared to winter annual cereals when planted at typical cover crop planting times. However, legumes have the potential to fix nitrogen from the atmosphere and supply additional nitrogen to the crop that will follow them. In practice, the amount of nitrogen fixed by legume cover crops is limited due to the relatively short period of growth in the spring prior to termination.

Brassica cover crops including oilseed radishes, mustards, and turnips can also be used as cover crops for tobacco fields. There are several brassica species that have been developed specifically for cover crops and provide similar benefits to winter cereal grains. In addition to these benefits, limited data suggests that some of the brassica cover crops may help to reduce mild to moderate soil compaction. One limitation of brassica cover crops is that many species are prone to winter kill, so including a winter cereal with the brassica is recommended. Furthermore, like the legumes (vetch in particular), if certain brassicas are allowed to go to seed, they can become a nuisance weed in the following tobacco crop.

Crop Rotation

The benefit of crop rotation for reducing certain diseases is well known (see Disease Management on page 33); however, rotation also has significant agronomic benefits. A good rotation scheme is a key element to maintaining the long-term productivity of fields used for tobacco production. Continuous tillage and production of tobacco can result in losses of soil organic matter, weakened soil structure, and severe soil erosion. All of these factors lead to declining productivity over time. In some cases, rotation may be necessary for growers who are required to have a conservation compliance plan to remain eligible for government farm programs. Even though tobacco itself is no longer covered under any federal farm programs, a grower who is out of compliance with their conservation plan on any part of a covered farm risks losing benefits for all commodities.

A good long term rotation for maximum agronomic benefits would be one in which tobacco is grown on a specific site for no more than two years in a row, after which a sod or sod/legume crop is planted and maintained for at least four years before returning to tobacco production. The advantage of this rotation is that the long period in a sod crop helps restore the organic matter and soil structure lost during tobacco production. Unfortunately, many tobacco growers do not have sufficient land resources to maintain a rotation of this length. Shorter rotations away from tobacco are still very beneficial from a disease management standpoint and slow the degradation of soil structure compared to continuous tobacco production. Some rotation to a sod or hay crop, even if it is of short duration, is better than no rotation at all.

Herbicide carryover has become an increasing concern for tobacco in rotation with pasture/hay fields in recent years due to the use of pasture herbicides containing the active ingredients of picloram or aminopyralid. Brand names of these herbicides include Chaparral, Grazon, Surmount, Milestone, and Forefront. Sensitive broadleaf crops such as tobacco should not be planted for **at least 3 years** after aminopyralid has been applied and an adequately sensitive field bioassay shows that the level of aminopyralid present in the soil will not affect the crop. For picloram, the period of time needed before planting tobacco is not well-defined. Products containing picloram should never be applied to land that is intended to be a part of a tobacco rotation, and tobacco should not be planted in a field with any known history of picloram use until test plants have been grown in the soil for a few weeks and observed for injury symptoms. See the label for other restrictions and information.

Rotation to other row crops, such as corn or soybean, is also beneficial to tobacco, but less so than a rotation which includes sod crops. Rotations in which the rotational row crops are grown using conservation tillage practices are of the most benefit. Tobacco growers may also want to consider some form of conservation tillage for tobacco as well to help maintain long term soil productivity. In row crop rotations, precautions should be observed to minimize the potential carryover of herbicides and adhere to rotational guidelines on pesticide labels.

The proximity of tobacco fields to curing facilities is an obvious but often overlooked selection criterion. A large amount of time and money can be wasted transporting tobacco (and often crews) between the field and the curing barn. Consider placing new barns in an area that can be accessed from several tobacco production fields so that a good plan of rotation can be established.

Conventional Tillage

The typical tillage scenario for tobacco production usually involves moldboard plowing in late winter, often followed by smoothing with a heavy drag and two to four diskings prior to transplanting. Some growers may use a power tiller in place of the disk to break up clods and produce a smooth seedbed. After transplanting, many growers continue to till the soil with two or three cultivation operations. Compared to most other crops currently grown in the southeastern US, the level of tillage used for tobacco is intense. Tillage in tobacco production is useful to help control weeds, incorporate cover crops, reduce compaction, improve aeration, and incorporate fertilizers and chemicals.

However, excessive tillage or tillage under the wrong conditions can create compaction and lead to soil loss due to erosion.

All soils consist of the solid particles and the gaps or spaces, called pores, between the solids. In an un-compacted soil, the pores make up about 50% of the soil volume and are well distributed between small and large pores. Smaller pores are generally filled with water, while the large pores may fill with water during a rain event but quickly drain and are usually filled with air. This balance of air and water is beneficial for root growth. When a soil becomes compacted there is a significant reduction in pore volume and a loss of pore space, with the large pores being lost more readily than the small pores. Compaction creates a physical barrier that limits root growth and water drainage.

Intense tillage contributes to soil compaction in at least two ways. Tillage destroys soil organic matter and weakens soil structure, making the soil less able to resist the physical forces of compaction. The more intense the tillage or the longer tillage has been practiced, the weaker the soil structure will become. Tillage implements such as plows and disks exert tremendous pressures on the soil at points of contact. So even though tillage may seem to fluff up the soil at the surface, often compaction is taking place at the bottom of the tillage implement. Power tillers can exert tremendous pressure at the point where the tines contact the soil, resulting in compaction. The use of these implements to increase drying of wet soils before transplanting tends to compound the problem and may lead to poor plant performance throughout the season. Power tillers may do more damage to soil structure in one pass than several diskings. Tillage-induced compaction generally occurs from four to eight inches below the surface, depending upon the tillage implement used. Silt loam soils are most susceptible to tillage-induced compaction when tilled at soil moisture contents of about 15-25% or near field capacity. Field capacity is the soil moisture content that free water drainage ceases and occurs about two days after a "normal" rain.

Naturally occurring compacted zones, known as fragipans, are also found in some soils, more commonly in Western Kentucky and Western Tennessee. These compacted areas are typically found deeper than tillage compaction and may range in depth from 12 to 30 inches or more. Fragipans are responsible for poor water drainage in the spring and limited plant-available water during the summer. The degree to which they adversely affect tobacco production depends upon the depth and severity of compaction.

The aboveground signs of a soil compaction problem are difficult to recognize and are often mistaken for other problems. These signs can include stunted growth, multiple nutrient deficiencies, and reduced drought tolerance due to limited root growth. If soil compaction is suspected, the best way to identify it is by digging up and examining roots. The root system of a normal tobacco plant should be roughly bowl-shaped with a horizontal spread approximately two to three inches wider than the leaf spread. The presence of flat spots or areas with little or no roots suggests that compaction may be a problem (Figure 1).

Compaction in fields may also be characterized with the use of a soil probe or a penetrometer, a device specifically designed to measure compaction. The penetrometer is a pointed rod with a tee-handle attached and a gauge for reading the pressure required to push the rod into the soil. It is important to note the depth at which the compacted layer begins and the overall thickness of the compacted layer so that appropriate remediation procedures can be planned.

The best management for dealing with tillage-induced compaction is to avoid it. This means not working ground that is too wet and avoiding overworking. The potential for compaction can be lessened by practicing rotation, which adds organic matter to the soil and strengthens soil structure. Using less intensive tillage implements like chisel plows and field cultivators can also help. Deep tillage to break up compaction should only be used when the compacted layer has been confirmed and should only be used to the depth of that layer. Deep tillage to depths greater than the compacted layer does little to improve plant growth and results in excessive fuel use. Further, deep tillage should be done when the soil is dry enough for the soil to fracture, typically in the fall. If deep tillage is conducted when the soil is too wet, the soil will not properly fracture and can lead to increased soil compaction due to the heavy weight of the machinery typically used for this operation.

Shallow in-row tillage has been shown to be an effective means of reducing the negative effects of compaction on tobacco in some Western Kentucky soils (Table 1). In these studies, the compacted layer was measured using a penetrometer, and the

Figure 1. Tobacco root system showing distinct signs of soil compaction. Note the flattened appearance of the bottom, protrusion of the transplant root ball, and limited new root growth from the lower portion of the root ball.

Table 1. Effect of in-row sub-soiling on the yield of burley and dark tobacco.

		Conventional	Sub-soiled
Soil Type	**Compaction**	**Cured Leaf Yield (lb/A)**	
Loring	Moderate	2626	3333
Vicksburg	Moderate	1924	2448
Grenada	Moderate	1473	1691
Loring	Severe	2463	3450
Grenada	Slight	2755	2799
Tilsit	Slight-Mod	2012	2158
Loring	Moderate	2365	2679
Avg.		**2200 A***	**2605 B**

* Means followed by the same letter are not significantly different at p = 10%.
Data from Lloyd Murdock and others, 1986.

depth and thickness of the layer were determined. The degree of compaction was characterized as slight, moderate, or severe. In all cases where moderate or severe compaction existed there was a positive benefit from in-row sub-soiling. Where compaction was only slight, no benefit from sub-soiling was observed. In-row sub-soiling is a relatively easy and inexpensive way to deal with shallow compaction in tobacco, as long as the tillage is done when the soil is relatively dry. In-row sub-soiling under wet soil conditions can lead to the development of an air cavity under the roots of young transplants.

Cultivation of established tobacco can be used to control weeds, but must be conducted at the appropriate time and for the appropriate reason. Before the widespread use of preplant chemicals for weed control, it was not uncommon for a tobacco producer to cultivate a crop five or more times during a season. Some producers were so accustomed to cultivating that they just made it a routine management practice in their operation. Cultivation should only be used in certain situations, mainly to control weeds. Other reasons for cultivation would include: incorporation of fungicides to control diseases such as black shank; incorporation of urea-based fertilizers to reduce volatilization losses of N; and to push soil around the base of plants to help prevent ground suckers or lodging with tall or "leggy" plants.

When it is necessary to cultivate, the cultivators should be set as shallow as possible but still remove weeds or disrupt the soil-to-root contact of the weeds. Cultivating deeper than necessary will pull moisture from depth to the soil surface and cause the soil to dry out faster. Cultivating too close to the plant will prune many roots or can physically "shake" the plants, disrupting the soil-to-root contact. Depending on the amount of roots pruned or the extent of "shaking", plants can either be stunted, or in severe cases, killed.

There are other factors that should be considered prior to cultivating. Two common soil-borne diseases in tobacco are black shank and Fusarium wilt (see Disease Management on page 33). Both of these diseases can be moved within and between fields on equipment. Another factor that one should consider prior to cultivation is weed control. A soil-applied herbicide will form a barrier in the soil that prevents weed seed from germinating. Cultivating can disrupt this barrier and actually allow weed seed to germinate that might not have germinated if the ground was not disturbed. A series of field trials conducted in Central Kentucky showed that cultivation was not necessary to produce good burley tobacco yields when adequate weed control was achieved with preplant herbicides (Table 2).

Throughout the burley and dark tobacco growing regions, tobacco is grown on sloping fields, much of it on slopes of 6% or more. When these fields are tilled, they are extremely vulnerable to erosion losses for at least two to three months during the spring and early summer when strong storms with heavy rainfall are common. Gullies to the depth of plowing are a common site in tobacco fields (Figure 2). Losses can be minimized by waiting until just before transplanting to do secondary tillage operations and by planting rows of tobacco across the slope rather than up and down the slope. Leaving the tractor tracks in place until the first cultivation can increase surface roughness, thus lessening the velocity of water runoff and soil erosion. Alternatively, some growers may want to consider some form of conservation tillage.

Table 2. Cured leaf yield at Spindletop (ST) and Woodford County (WC), KY, 2008, 2009, and 2010†.

	Cured Leaf Yield (lb/A)			
Treatment	**ST 2008**	**ST 2009**	**ST 2010**	**WC 2010**
No Cultivation, not weeded	2493	3094	2863	1927
No Cultivation, hand-weeded	2623	---	2774	---
Early Cultivation	---‡	2937	---	2061
Late Cultivation (at layby)	2539	3009	2935	2024
Early and Late Cultivation	---	3082	---	2165
Three Cultivations	2340	---	---	---

† No statistical differences were observed between treatments for any year or location.
‡ No data collected.

Conservation Tillage

The adoption of conservation tillage methods for tobacco production has been relatively slow compared to common row crops such as corn or soybean. Traditionally, tobacco growers have used intensive tillage to care for this high value crop, and many still believe that tobacco must be cultivated routinely for good growth. There are other reasons that tobacco growers have been slow to adopt conservation tillage, including a lack of appropriate transplanters, limited weed control options, and uncertainty over the future levels of tobacco production. Some of these issues have been partially addressed such that some growers now consider conservation tillage to be a feasible option for tobacco production.

The principal advantage of conservation tillage is a reduction in soil loss caused by erosion; however, there are other advantages for the grower as well. The mulch layer on the soil holds in moisture and may help reduce stress during periods of short-term drought. Additionally, the mulch layer may help to keep the leaf cleaner by reducing mud splash on cut tobacco during late-season

Figure 2. Severe gully erosion in conventionally prepared tobacco field.

rain storms. Fewer heavy tillage trips means less time and less fuel use than with conventional tobacco production. No-till or strip-till fields may also have better trafficability in wetter times, allowing more timely application of needed fungicides, insecticides, or sucker control materials during rainy periods.

Conservation tillage includes no-till, in which the soil is not worked prior to transplanting; minimum-till, in which the soil is worked in such a way as to leave 30 to 50% of the residue on the surface; and strip-till, in which a 10- to 12-inch-wide band is tilled before transplanting. Each system has its advantages and disadvantages that the tobacco grower must consider.

No-till tobacco is really a form of strip-tillage in which the tillage and transplanting functions occur in one operation. Considerable modifications must be made to the transplanter for successful no-till planting. Figure 3 shows an example of the modifications required. At a minimum, a no-till transplanter needs a wavy (fluted) coulter in front to cut residue, a sub-surface tillage shank to till the root zone and pull the unit into the ground, and modified press wheels to close the planting trench. Some growers have added row cleaners to assist in moving residue away from the row, allowing easier planting. Costs for modifying conventional transplanters range from $300 to $600 per row, depending on how much fabrication growers are able to do themselves. No-till ready transplanters are currently available from some manufacturers.

No-till tobacco works best on medium-textured soil (silt loam to sandy loams). Tobacco can be grown no-till in clay ground, but the grower must be patient and wait for the soil to dry sufficiently before transplanting. One of the persistent myths about no-till tobacco is that it can be planted when conventionally prepared ground is still too wet. In fact, experience has shown that it takes two or three days longer for no-till sites to dry out prior to setting. Even though the ground may be firm enough to support equipment, the mulch layer slows the drying rate at the surface. Transplanting in ground that is too wet can lead to compaction of the trench sidewall, which restricts root growth and may suppress growth and yield potential.

Minimum or strip-till may be better on heavy clay ground, since some of the surface residue is incorporated, allowing the soil to warm up and dry out quicker. These methods require additional tillage passes, leaving the soil more vulnerable to erosion than no-till. Growers using strip tillage are able to transplant using their normal transplanter. However, they often have one or more modified tillage implements matched to the row spacing and number of rows of the transplanter to prepare the 10- to 12-inch-wide planting band.

In conservation tillage studies conducted in Tennessee during the 2009 growing season, no-till and strip-till yields compared favorably to a chisel plow-disk conventional tillage system at the Greeneville Research and Education Center on a deep, well-drained loam soil (Table 3). On a moderately well-drained silt loam soil with a fragipan at the Highland Rim Research and Education Center, no-till yielded significantly less than strip-till and conventional tillage.

A good cover crop or previous crop residue is an essential part of successful conservation tillage tobacco production. The cover crop or residue helps to reduce soil erosion losses and conserve water in the soil, much like mulch in the garden. Tobacco growers have been successful planting no-till tobacco in winter grain cover crops, sod, and row crop residues.

One of the keys to success when planting no-till tobacco into a small grain is timing the kill of the cover crop. The initial burndown of winter small grains should be made when the cover is approximately 6 to 8 inches tall, which allows a sufficient buildup of residue while limiting the production of straw that complicates transplanting. Research has shown that tobacco transplants grew better and yielded more when the cover crop was killed at least 30 days prior to transplanting.

When conservation tillage follows a sod crop, it is best to burn down the sod in the late fall. If erosion is a concern due to steep land and/or a thin cover of old sod, a no-till cover crop can be planted in the fall to be burned down the following spring. If burndown occurs in the spring, it should be at least four to six weeks prior to transplanting. This allows sufficient time for the root mass to break down so that the soil will crumble and fill in around the plant root ball. Research at the University of Tennessee has shown advantages for fall burndown. Elimination of a sod that includes alfalfa can be particularly difficult due to the persistence of the alfalfa crowns. To eliminate alfalfa stands to prepare for no-till tobacco, an application of burndown in the fall and a follow-up application in the spring may be required. Even then, some volunteer alfalfa may be present in no-till tobacco fields.

Weed Control for Conservation Tillage

General weed control for tobacco production is covered in the Weed Management article in this guide, but some recommendations specific to conservation tillage are covered here. Because no-till tobacco is a relatively small use crop, there are very few products labeled specifically for this use. Glyphosate-containing products do not include tobacco as a crop listed

Figure 3. Modifications to a transplanter for no-till transplanting of tobacco.

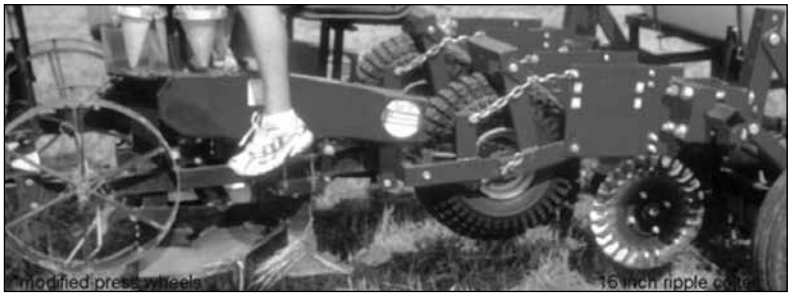

Table 3. Burley yields by tillage system, Greeneville and Springfield, TN, 2009

Tillage System	Greeneville	Springfield
	Cured Leaf Yield (lb/A)	
No-till	2864	1854 a*
Narrow Chisel Strip-Till	2912	2241 b
KMC Strip-Till	2983	2236 b
Rototill Strip	3012	2282 b
KMC Strip plus Rototill	2968	2256 b
Chisel Plow-disk	3054	2128 b

* Means followed by the same letter are not significantly different at P= 10%. No differences in yield at Greeneville.

on the label. Therefore, it cannot be applied on tobacco fields unless an interval of 30 to 35 days occurs before transplanting. Some products containing paraquat (Gramoxone SL 2.0) have EPA approval for use on no-till tobacco in specific states (KY, TN, and NC). Growers must take care to obtain a copy of the supplemental label for this use, as it does not appear on the label normally included with the product.

There are labeled weed control products that work well for no-till tobacco, but "rescue" options are very limited, so it is best to choose sites with as low of a weed potential as possible. Winter pastures, feed lot areas, and areas with sparse cover often make poor sites for conservation tillage tobacco due to large amounts of weed seed in the soil and/or established populations of perennial weeds. Perennial weeds and vines should be controlled during the rotation prior to growing no-till tobacco.

Sulfentrazone (Spartan or generic) should be a part of any weed control program for conservation-till tobacco. Research has demonstrated that this product provides more consistent control in the absence of tillage than other herbicide option. Clomazone (Command) can be tank-mixed with sulfentrazone for improved control of certain weeds and grasses. However, the most consistent control has been achieved by applying sulfentrazone seven to 10 days prior to transplanting and then making an application of clomazone within seven days after transplanting. The post-transplant application helps to control weeds in the strips of soil disturbed by the transplanting operation. For all herbicides, the highest labeled rate for the soil type is recommended when used in conservation tillage (see Weed Management on page 27, for labeled rates of herbicides.)

Marestail has become a problem in recent years in some fields of conservation tillage tobacco in Kentucky and Tennessee. Options for controlling this troublesome weed in tobacco are very limited, so a proactive approach is a must. The marestail populations found in many fields are not well controlled by glyphosate applications. Preliminary studies have shown that well timed burndown applications of paraquat are effective in control of young emerged marestail. However since marestail seedlings emerge over a period of weeks or months, multiple applications may be required and full control may still not be achieved. Flumioxazin (eg. Valor SX) is approved for use in fall and spring burndown programs for tobacco. For spring burndown applications the product may be applied at 1 to 2 oz/A when applied with labelled burndown herbicides such as paraquat. A minimum of 30 days must pass with at least 1 inch of rainfall or irrigation occurring before tobacco can be transplanted. The flumioxazin product labels indicate residual control of marestail, but these claims have not been verified by University trials on conservation tillage tobacco.

Sethoxydim (Poast) can be used over tobacco for control of annual and perennial grasses, including johnsongrass. In cases where weed control has been poor due to environmental conditions, some growers have used mechanical means, such as lawn mowers and cultivators, to control weeds in conservation-till tobacco.