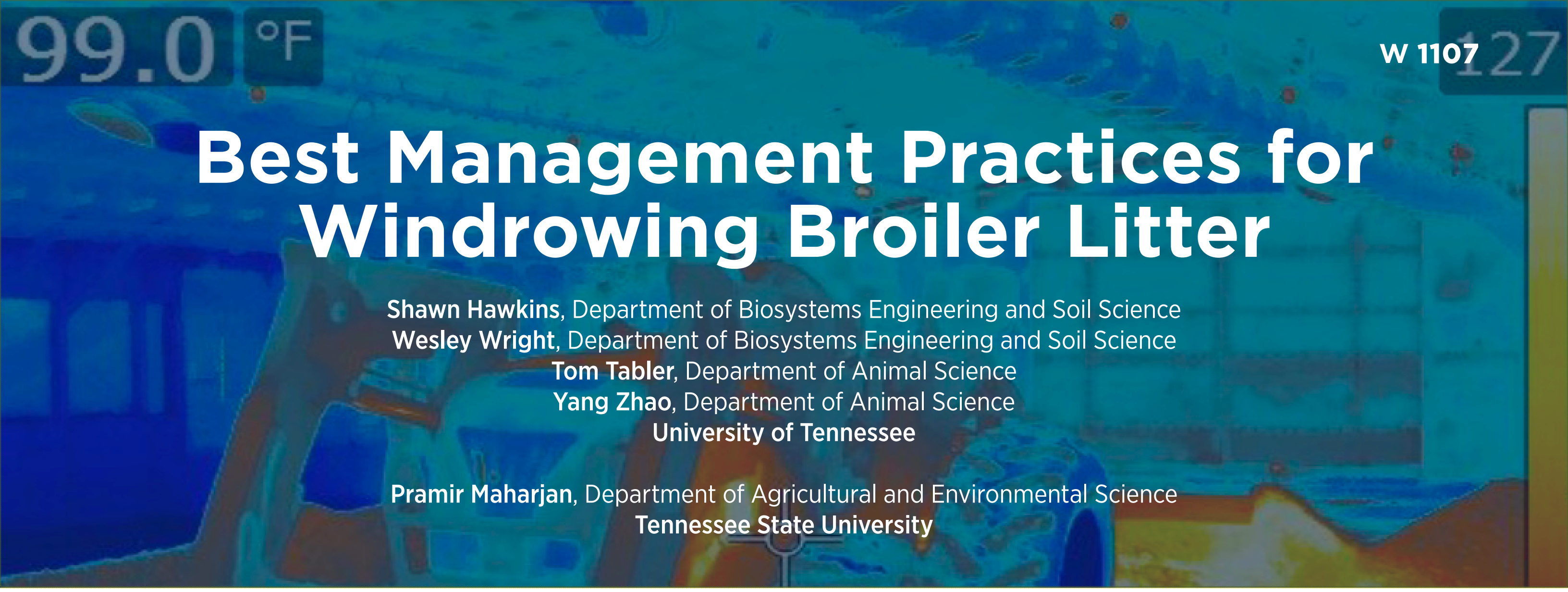

W 1107

Best Management Practices for Windrowing Broiler Litter

Shawn Hawkins, Department of Biosystems Engineering and Soil Science
Wesley Wright, Department of Biosystems Engineering and Soil Science
Tom Tabler, Department of Animal Science
Yang Zhao, Department of Animal Science
University of Tennessee

Pramir Maharjan, Department of Agricultural and Environmental Science
Tennessee State University

INTRODUCTION

Traditionally, broiler producers have used de-caking to manage litter between flocks. De-caking is a proven practice that works by removing cohesive litter from poultry houses found mainly beneath feed and water lines and in front of evaporative pads. De-caking physically removes moisture prior to beginning a new flock, making ammonia control much easier in the subsequent growout. It also removes a potential source of pathogenic bacteria that could harm chicks. However, there are drawbacks to de-caking. One is that Tennessee producers sometimes report declining flock performance during antibiotic free production when continuing to de-cake. Also, de-caking demands high quality bedding for topdressing that is scarce and expensive. Finally, de-caking machines have a low carrying capacity, which makes the process time consuming and labor intensive, and de-caked litter will often be double handled if it can't be land applied as it is removed.

Some Tennessee broiler producers are reconsidering tilling litter between growouts. While de-caking removes only cohesive litter, leaving the underlying more absorbent litter undisturbed, tilling pulverizes the cake and mixes it with the underlying drier litter. The advantage of tilling is that litter storage and double handling are avoided, and oxygen is provided to freshen litter microbial activity. Purportedly, this makes it possible to reduce the amount of fresh bedding required to place chicks safely. A key disadvantage of tilling is a rapid release of ammonia. High ammonia concentrations can be lowered by re-tilling and ventilating to promote drying and ammonia release.

Windrowing is another option that producers are now using in Tennessee to manage litter between growouts. In effect, windrowing is composting with certain compromises to make it practical to implement in poultry houses. Conditions that kill pathogens can be easily obtained when windrowing is carefully managed. Anecdotally Tennessee producers report improvements in feed conversion after switching from de-caking to windrowing. However, several challenges exist for windrowing as well. First, the process is laborious and time consuming, and ammonia concentrations can be difficult to control for flocks raised on windrowed litter. Windrowing also requires heightened management.

University of Tennessee Extension has recently conducted on-farm windrowing research to help broiler producers better manage windrowing. This document presents study data which were used to derive several best management practices that improve windrow heating performance. This publication also helps producers better understand the goals and performance criteria for windrow heating.

1. Understand How Windrows Work and Know Your Objective

Composting is a material handling technique designed to enhance the microbial degradation of organic matter. Specifically, organic wastes are manipulated to make sure that it is not too dry or too wet (40-60 percent moisture), that the carbon to nitrogen ratio (C:N) is about 25:1, and that air (oxygen) is supplied. Composting typically takes several weeks to several months to make the leftover organic matter stable. In the early stages of composting, material heating occurs that can kill pathogenic microorganisms.

Litter windrowing adapts a compost material handling technique but makes compromises to minimize expense and labor in the shortened time between flocks. Although the litter C:N ratio is too low (around 12:1), it is not increased by adding carbon (extra bedding); the moisture is often low (around 30 percent), but water is not added. Windrowing does emphasize one compost objective**: pathogen destruction using heat.**

For windrowing to achieve pathogen destruction, the heat generated by organic matter degradation must exceed the heat loss that occurs through convection and conduction. Figure 1 illustrates convective heat loss, which occurs as hot air rises and mixes with surrounding air, as well as conductive heat loss, which occurs where litter touches the floor. Figure 1 also illustrates the chimney effect, wherein heating litter draws fresh, cool air into the bottom of a windrow and exhausts heated air through the top. Figure 1 also shows where temperature sensors were placed during the recent University of Tennessee Extension on-farm windrowing study.

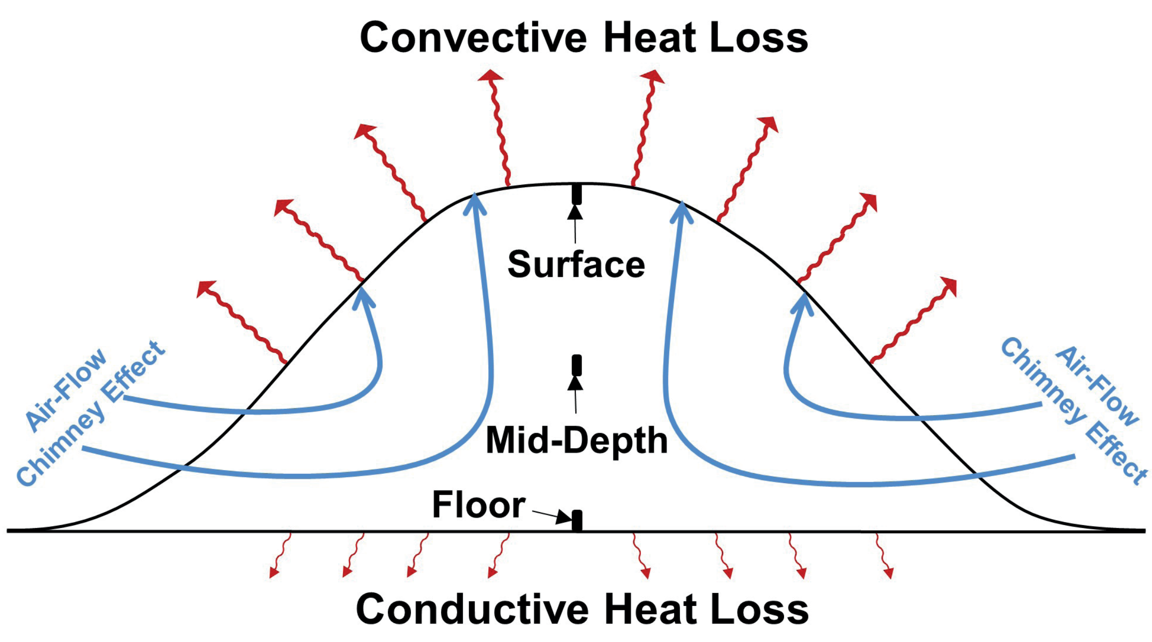

Figure 1. An illustration of processes that impact windrowed heating.

2. Moisture is Critical – Conserve and Then Consume it When Windrowing

Windrow heating and induced air flow result in litter drying (Figure 1). In turn, the litter moisture content controls heating performance (Figure 2). By the time the third windrow has aged, litter will often be around 25 percent moisture, at which point heating becomes ineffective. **To be moist enough to heat well, litter that is compressed should be cohesive rather than falling apart when pressure is released.** If you begin with dry litter, for example after a hot summer growout with low relative humidity, heating performance will be poor. Dry litter should not be windrowed.

Do not till litter, delay windrowing or de-cake. These practices cause moisture losses that degrade heating performance. Windrow litter as soon as possible after the catch to take advantage of all the initial litter moisture.

Form your initial windrows using tined/augured windrowing machines rather than blades. Blades don't break up caked litter sufficiently for good moisture release and airflow. Producers using a blade to form windrows should pulverize the litter first.

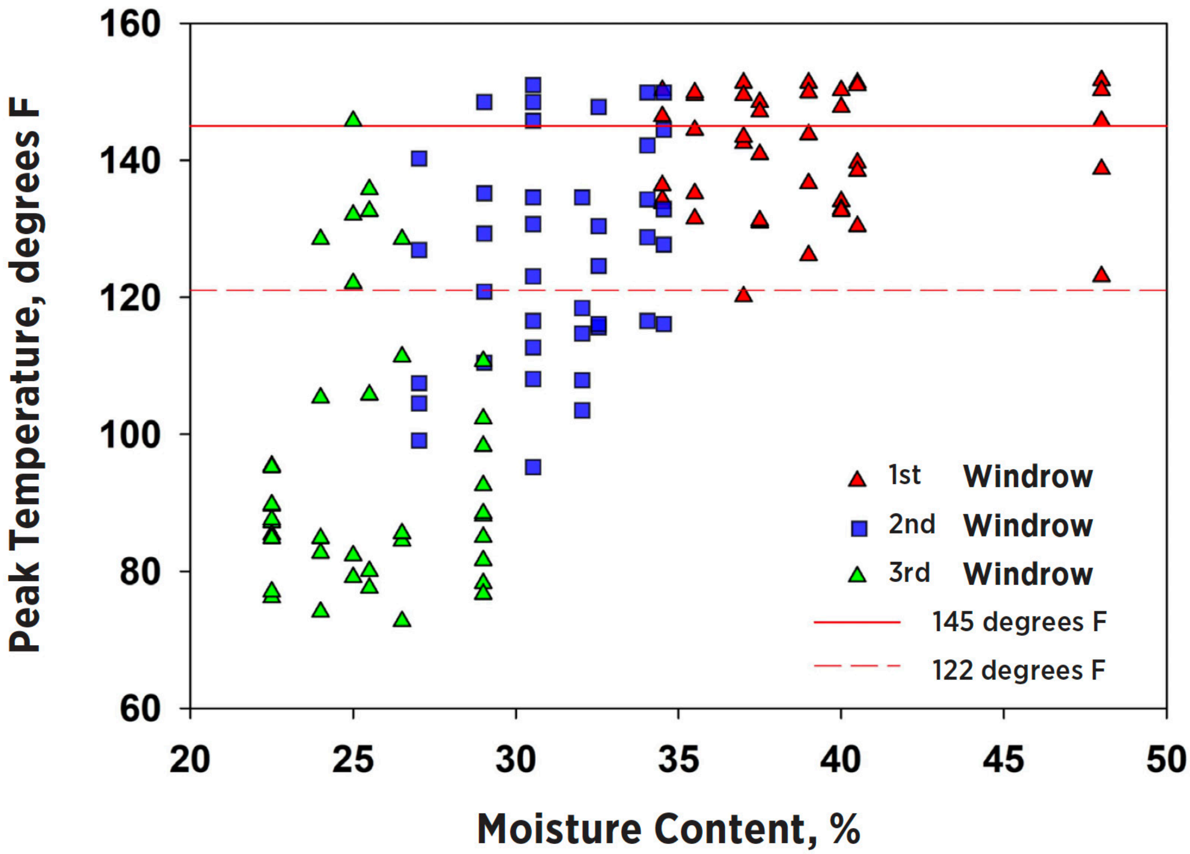

Figure 2. Windrow mid-depth peak temperatures versus litter windrow moisture content.

3. Use a Thermometer, Know your Heating Goals and Turn ASAP

Several studies of windrowed or composted litter have shown that heating suppresses pathogen populations. However, the temperature and exposure time to reliably kill litter pathogens isn't well established. Fortunately, composting research has been conducted for decades with biosolids, a residual organic waste from domestic wastewater treatment. Heating standards are written into regulations to assure biosolids are safe to land apply and specify that windrows should reach 131 degrees F for 15 days over five turning events. This is a conservative standard that is not practical for poultry producers to use.

Biosolids composting studies have resulted in other, less conservative heating standards that still protect against a host of pathogenic organisms, including worm larvae, *Salmonella* and intestinal viruses. Two standards that work equally well and that are practical for poultry producers to use are:

- **122 degrees F maintained for 24 hours.**
- **145 degrees F maintained for one hour.**

Figure 3 presents a set of typical temperature data recorded at the centerline of windrows at three different positions (see Figure 1: floor, mid-depth and surface). Examining this data reveals that it took a little over a day for the 1st windrows to reach 145 degrees F at the mid-depth position. That high temperature was typically not reached in the litter near the floor because of conductive heat loss (Figure 1), but 122 degrees F was reached after two days and maintained for well over 24 hours. Litter heats poorly at the surface of the windrows, likely because of convective heat loss and drying (Figure 1; Figure 3).

Figure 3 illustrates that the suggested temperature-time standards can be met at the mid-depth and floor positions when litter is windrowed. **In order to know when these standards have been met, purchase a compost thermometer that is 3 feet long and measure the temperature at the windrow core and near the floor at the same time every day.** Temperature should be measured in several locations along the length of two or more windrows.

When at least one of the heating standards is met at both the floor and mid-depth position, windrows should be turned immediately. Windrows that are aged excessively, beyond the time required to meet pathogen control standards, lose moisture which degrades heating performance when the windrows are eventually turned. Figure 3 clearly illustrates that the first windrows made at the test farm should have been turned sooner than they were – after three days as opposed to seven days.

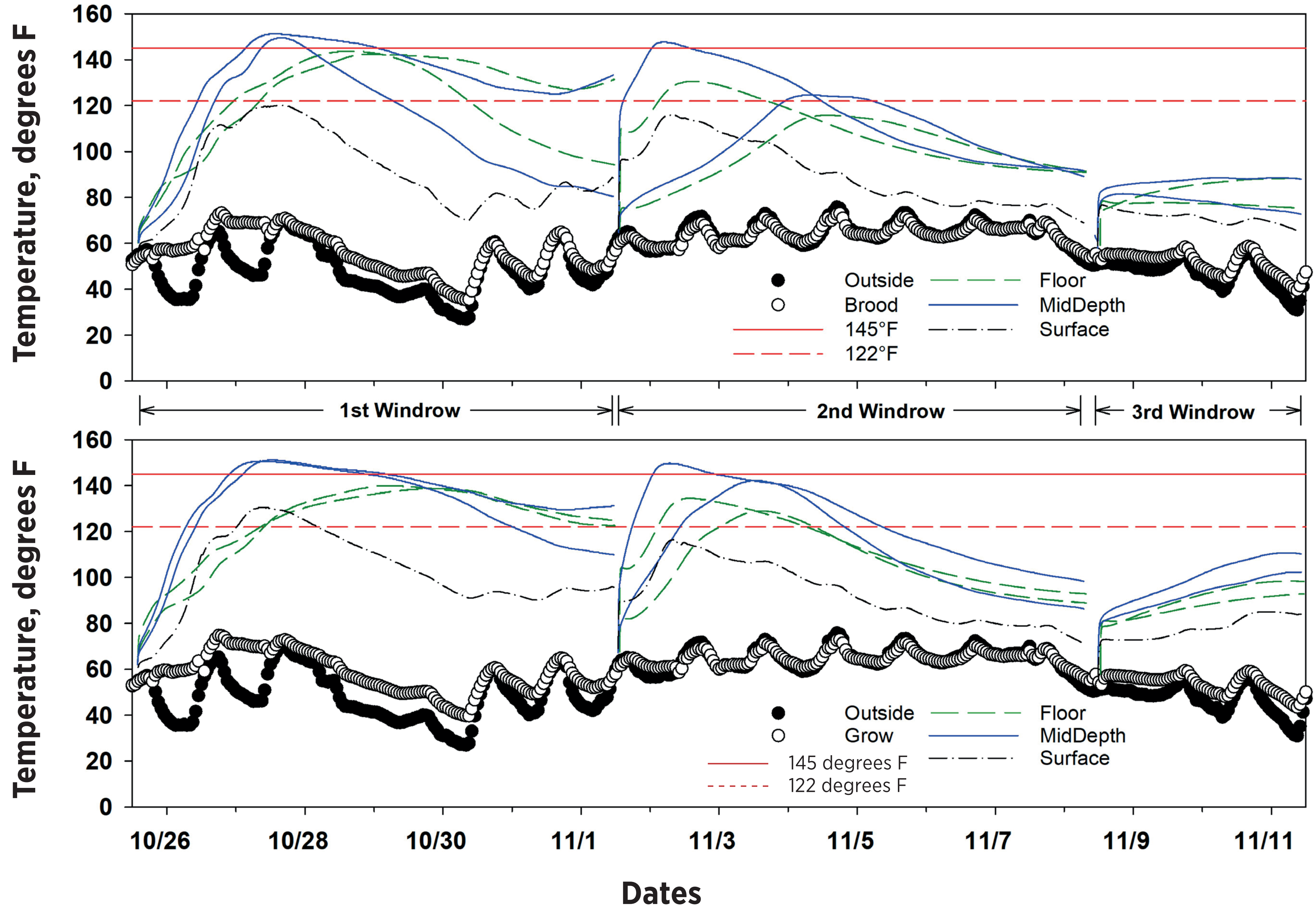

Figure 3. Temperatures (floor, mid-depth and surface) in grow (top) and brood (bottom) end windrows of a broiler house versus date. Outside and house temperatures are provided. Heating goals of 145 degrees F and 122 degrees F are illustrated.

4. You Must Turn Windrows at Least Once

Windrows do not heat evenly (Figure 3). A layer of litter near the surface of a windrow will typically not meet temperature-time pathogen control standards (Figure 4). This results from a combination of convective and conductive heat loss (Figure 1).

Understand why windrowed litter must be turned at least once. An important goal during windrowing is to assure that all the litter meets pathogen control temperature-time heating standards. When we turn windrows, we are attempting to aerate the pile and move litter at the surface of the windrow, where it likely did not heat adequately, to the interior of the subsequent windrow, where it can be heated adequately. To accomplish this, the initial windrow that is formed must be turned.

Turning a second time to form a third windrow may be advisable. A third windrow can be formed and will help assure that all the litter is heated adequately. However, this is advised only if there are at least seven days left before chicks are placed (three days for the third windrow to age, plus four or more days for drying after leveling). In addition, this should only be considered if enough moisture remains for the windrow to heat adequately (Figure 2). The third windrow should age 24 hours. If heating is clearly inadequate at that point, the windrow should be leveled immediately. If heating does occur, the third windrow should be leveled as soon the mid-depth location reaches 122 degrees F for 24 hours.

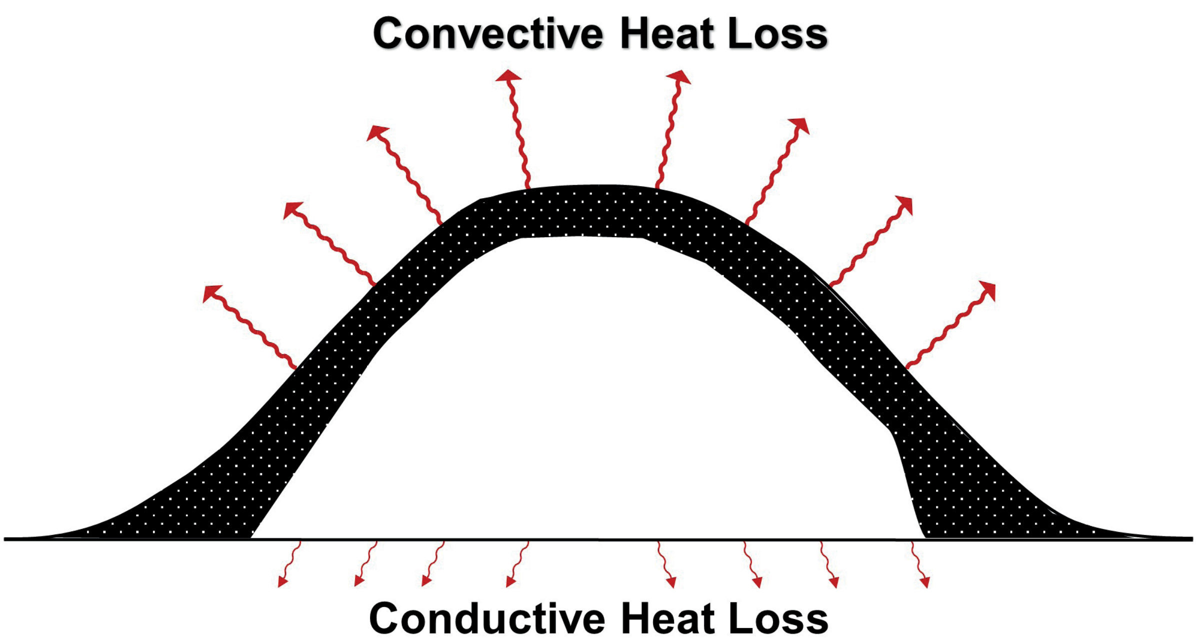

Figure 4. Illustration showing the layer of windrowed litter that typically will not meet the temperature-time standards for pathogen control. The goal in turning a windrow is to move this litter into the central part of a new windrow for adequate heat exposure.

5. The First and Second Windrows Should Age About Four Days

A question poultry producers often ask is how long windrows should be left to heat. **Ideally, that would be determined by measuring the temperature at the mid-depth and floor daily.** When a temperature-time standard is met or the temperature declines at both locations, the windrow should be turned or leveled, whichever is appropriate.

Temperature data were recorded during the UT Extension windrowing study using 10 sensors in the brood and grow ends of four broiler houses during four between flock windrowing events (fall to spring). Many data sets such as that shown in Figure 3 were recorded and collectively analyzed to determine how often different windrow positions achieved a pathogen control heating standard; when a standard was met, the maximum time to meet the standard was recorded (Table 1).

Mid-depth and floor temperatures during the first and second windrows often reached 122 degrees F for 24 hours (Table 1; Figure 3); the mid-depth position reached 145 degrees F for one hour only during the first windrow. By the time the third windrow was formed, litter was often too dry to heat adequately (Table 1; Figure 2). **Thus, as a rule of thumb, the first two windrows should heat four days each before turning. If these windrows are turned promptly, enough moisture MAY be left for a third windrow to heat adequately.**

Table 1. Heating performance observed during a UT Extension on-farm windrowing study. The percentage of recorded temperature curves achieving two heating standards is listed by position; when a heating standard was achieved, the maximum time to achieve is listed. Green and red values indicate good and poor heating performance, respectively.

		Greater than or equal to 122 degrees F for over 24 hours		Greater than or equal to 145 degrees F for over one hour	
Windrow Position		% Achieving	Maximum Days Needed	% Achieving	Maximum Days Needed
1	Floor	96	3.9	4	2.4
	Mid-depth	100	2.2	95	2.3
	Surface	33	3.0	0	-
2	Floor	49	2.9	0	-
	Mid-depth	61	3.5	35	1.6
	Surface	3	1.9	0	-
3	Floor	7	2.7	0	-
	Mid-depth	14	2.9	4	2.0
	Surface	0	-	0	-

6. Make Your Windrows At Least 18 Inches Tall

Windrow size affects heating performance. A practical question poultry producers ask is how big to make windrows. Farm visits by UT Extension indicate that producers often make some small windrows in the rush to get the job done.

It all goes back to moisture management. Smaller windrows have a high surface area to volume ratio, which quickly leads to excessive drying. Although small windrows will sometimes heat initially, especially if the litter moisture content is high, rapid drying will subsequently degrade heating performance often before pathogen control heating standards are met. Larger windrows tend to have enough litter to insulate the core for better heating and to protect the bulk of the litter from rapid drying. Only the exterior surface of large windrows dry, and then only to a depth of a few inches; rapid and excessive drying is one reason the windrow surfaces heat poorly (Figure 2; Figure 3).

Make windrows that are at least 18 inches tall. This recommendation is based on the peak windrow temperatures measured at the floor versus the windrow depth (Figure 5). Heating performance clearly increase as the windrow depth reaches 18 inches or more.

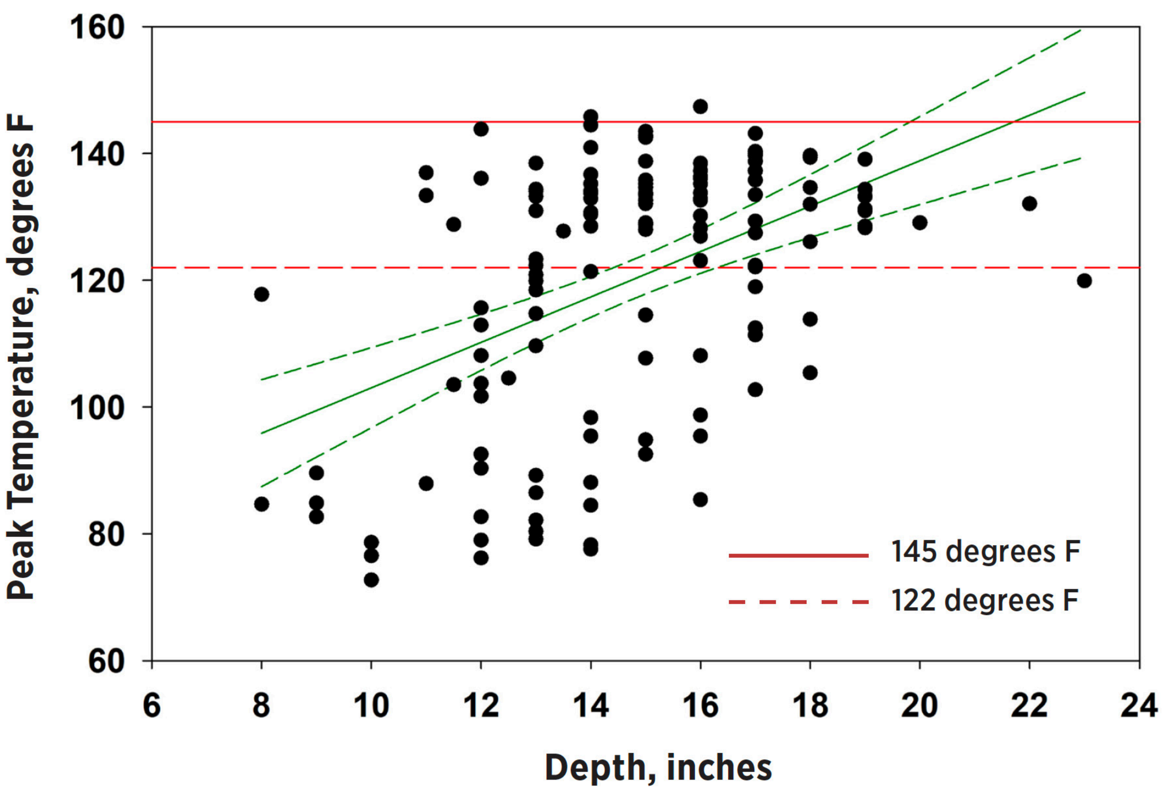

Figure 5. Windrow peak floor temperatures versus the measured windrow depth. A best fit line with dashed error bars shows that as the depth increases the peak temperature increases. Reference lines illustrate the 145 degrees F and 122 degrees F standards.

7. Manage Ammonia with Full Dose Litter Acidifiers

Don't let litter stay in windrows and retain moisture if it is not heating! The critical aspect for improving subsequent flock litter moisture and ammonia control is leveling the litter as soon as heating becomes ineffective. Leveling maximizes the litter to air surface area ratio, promoting rapid loss of moisture and ammonia, especially during warm weather (around 50 degrees F or greater) when the barns can be opened and/or ventilated. This is one reason windrowing during the middle of winter should be avoided – the litter will continue to dry very poorly after it is leveled because ventilating during cold weather is impractical and ineffective. In any case, moisture and ammonia control improve as the time between leveling and the beginning of a new flock increases and is, of course, challenging any time flock downtime is short.

Use a full dose of litter acidifier when you windrow and consider acidifying brood end litter. Research has revealed that windrowing often results in higher flock ammonia concentrations versus the traditional practice of de-caking, especially during winter. For windrowed litter in winter, when the grow end does not receive acidifier, it is prone to causing high ammonia concentrations when the brood curtain is raised (Figure 6).

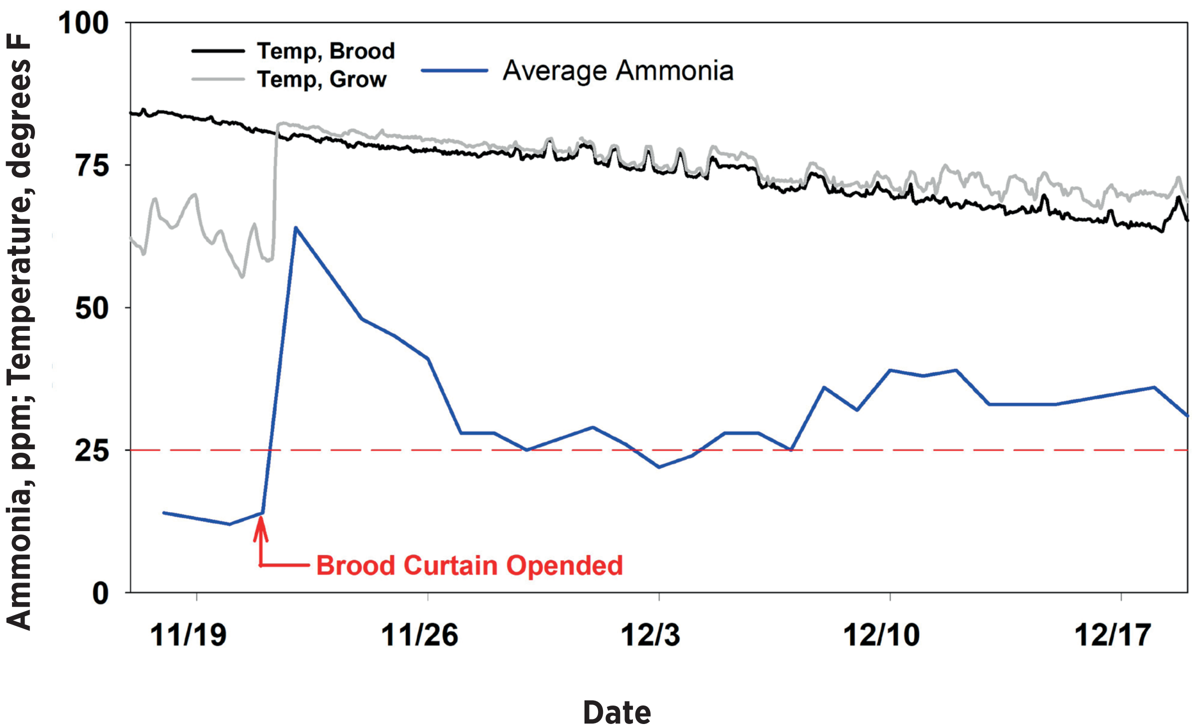

Figure 6. Temperature in the brood and grow ends of a broiler house containing litter that had been windrowed (see Figure 3). Chicks were set on 11/18. The ammonia concentration on the brood side of the brood curtain is presented. A 25 ppm desired ammonia threshold is illustrated. Although full dose acidifier was used in the brood end, and the house was ventilated to exhaust through the grow end, ammonia concentrations increased dramatically when brood curtain was opened.

CONCLUSIONS

Windrowing is a time consuming and laborious task. It can also wear down tillers, augers and scrappers, increasing maintenance costs. However, the end results can be worth the effort in this new era of antibiotic free poultry production. To make sure your efforts are worthwhile and result in sustained flock performance improvements, it is vital to understand the objective of windrowing is heat and the **heating goal** is 122 degrees F for 24 hours or 145 degrees F for one hour.

The **purpose** for windrowing is to **produce largely pathogen free litter with a favorable microbe population for chick placement.** This should improve subsequent flock performance and may reduce the need to generously topdress carryover litter with scarce and expensive high-quality bedding.

It's hard to manage windrowing effectively if you don't measure temperatures, so invest in a high-quality compost thermometer and make that a routine daily task. **Turn windrows as soon as your heating goals are reached**, because this conserves moisture which will improve heating performance for remixed litter in a subsequent windrow.

You **must** turn the first windrow you form because litter does not heat evenly – turning the first windrow will help assure litter on the exterior is exposed to good heating within the interior of the second windrow. Expect the first and second windrows to require about four days to meet your heating goals. **Avoid creating small windrows** as they don't heat well because they dry out too quickly.

Heating is mainly controlled by the litter moisture concentration, which means that windrowing must be managed very carefully. Start windrowing as soon as practical when a flock ends to conserve moisture. Stop windrowing when litter gets too dry (less than 25 percent moisture) to heat effectively, which typically occurs after the second or third windrow is aged a few days. At that point, immediately level and further dry the litter as much as possible so that the litter moisture is reduced to 15-18 percent over the course of about 4-7 days. During cold weather, keep in mind that drying may be ineffective after litter is leveled following windrowing. It may be better to de-cake between flocks during especially cold weather.

Expect that ammonia management in a flock raised on windrowed litter will be more challenging than with de-caked litter. When you windrow litter between flocks, it is important to adequately ventilate to control ammonia during growouts. It is critical to use a full dose of litter acidifier, including perhaps in the grow end of your houses, when you windrow; a second acidifier application may be warranted in production systems that never use antibiotics.

UTIA
INSTITUTE OF AGRICULTURE
THE UNIVERSITY OF TENNESSEE

UTIA.TENNESSEE.EDU
Real. Life. Solutions.™

W 1107 9/22 23-0037 Programs in agriculture and natural resources, 4-H youth development, family and consumer sciences, and resource development. University of Tennessee Institute of Agriculture, U.S. Department of Agriculture and County governments cooperating. UT Extension provides equal opportunities in programs and employment.