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Heating Systems for Wean-to-Finish Facilities

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Summary and Implications

Research was conducted to assess the effects of the type of zone heater and floor mat used in a wean-to-finish facility on pig performance and operating cost. Gas-fired brooder heaters were compared to 250W heat lamps and farm-cut wood sheathing was compared to commercial (unheated) rubber floor mats for a 21-day post-weaning period. There was no effect of heating system or mat type on pig performance, either during the 21-day period immediately post-weaning or to slaughter. Black globe temperatures near the pig zone were slightly higher for the propane-fired heaters compared to the heat lamps, most likely due to the method and temperature settings used to control the gas flow to the heaters. Black globe temperatures were slightly higher for the wood mats versus the rubber mats, most likely due to the difference in infrared energy absorption between the black mats and the natural wood colored mats. When amortized over a seven-year payback period, total operating expense for the heat lamps and propane brooders was estimated to be similar based on 25 pigs per pen and 20 pens per propane control module. These results suggest that both types of heating systems are effective in maintaining an acceptable temperature zone for weaned pigs. They also suggest little difference in performance due to the type of floor mat under the zone heating device. The selection of heating system and floor mat material can be based on reasons other than pig performance.

Introduction

Wean-to-finish facilities now comprise 15% or more of all grow-finish facilities in the United States. With the rapid adoption of wean-to-finish technology comes the question – what is the best zone heating system for these facilities? For a majority of producers, the definition of "best" includes both pig performance and investment/operating cost of the zone heating system.

Heat lamps are a commonly used radiant heat source for zone heating. While inexpensive to install, they are criticized for their high operating expense that includes frequent replacement of bulbs. Propane brooders are fairly expensive to install but have a relatively low operating cost.

In wean-to-finish facilities, producers are using mats on top of the cement slats. These mats serve to reduce drafts through the slats and as a feeding platform for those that hand-feed pigs for a period of time following weaning to encourage feed intake. Rubber mats can be relatively expensive to purchase, and they must be washed, disinfected and stored between uses. In addition, in large pen facilities, large mats are heavy and often require two people to remove from a pen. Black rubber mats often have a "feed saver" lip that reduces the pig's ability to nudge feed from the mat. The black color also absorbs radiant heat.

An alternative to the rubber mats that many are using is plywood or other wood products. The advantage of wood is that it is usually burned after a single use, eliminating the need to wash, disinfect and store the mat. In large pen situations, if the wood is 1/4 inch material, one person can often remove the mat from the pen. Possible disadvantages of wood include the recurring purchase expense and the possibility of wood chips in the manure storage device if the pigs are allowed to begin playing with the mat prior to removal. While unpainted wood doesn't absorb radiant heat as well as the rubber mat, wood is a good insulator, meaning limited heat is transferred from the sleeping pig to the cement slat under the mat.

This research project was designed to examine the impact of two types of zone heating sources and two types of mat material on weaned pig performance from weaning to slaughter.

Materials and Methods

The research project was conducted in a wean-to-finish facility at the Haskell Agricultural

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Laboratory near Concord, Neb. Crossbred pigs (Danbred NA, Seward, Neb.) were weaned at approximately 17 days of age and transported four hours to the facility on Jan. 21, 2004. The effect on pig performance of two heat sources (propane fired brooder heater vs. 250w heat lamp) and two types of floor mats (3/8 inch oriented-strand board vs. rubber) in a 2 x 2 factorial arrangement of treatments was compared. Details of the heat sources and floor mats were provided in the 2004 Nebraska Swine Report (page 34).

The trial was conducted in a fully slatted, naturally ventilated facility with 16 8 ft x 14 ft pens. Each pen held 15 pigs (7.5 ft^2/pig). Each pen had one two-hole FarmWeld wean-to-finish feeder and one wean-to-finish cup drinker. All mats were 41 inches x 41 inches and were located near the feeder along the center aisle of the facility. Treatments were randomly assigned to pens and sex was balanced within pen.

Pigs were weighed weekly for the first four weeks following weaning and at regular intervals thereafter. On day 147 following weaning, 50% of the pigs were sold to slaughter. The remaining pigs were sold on day 161.

From weaning to 45-pound body weight, pigs were fed commercially prepared diets according to a pre-determined feed budget. From 45 pounds to slaughter, they were fed according to the University of Nebraska Swine Nutrition Guide recommendations for pigs with high lean gain potential. Other than the Phase-1 starter diet which was a mini-crumble, all diets were in meal form. Fat additions to the diet varied between 1.5 and 3%.

Air temperature in the facility was maintained with unvented propane-fired space heaters. The sensor for the controller was located in the middle of the facility at approximately 54 inches above the floor. Air temperature was set to be maintained at 76°F the first week after weaning and was decreased 2°F per week for the first three weeks post-weaning.

The mats and zone heating were in place for 21 days following weaning in all pens. At 21 days post-weaning, the mats and zone heating were removed. At that time, the controller for the room heaters was set to maintain 76°F and this setting was reduced 1°F per week until a set point of 62°F was attained. Sprinklers were used for heat relief in May and June, with sprinkling beginning at 80°F.

Electricity and propane usage was recorded daily between 8 and 10 a.m. while the zone heat and mats were used.

The pen of pigs was the experimental unit for statistical analysis. Results were analyzed as a complete random design using a 2 x 2 factorial arrangement of treatments using the GLM procedure of SAS. Death loss and pig removal was analyzed by Chi-squared analysis.

Table 1. Effect of experimental treatments on pig performance.

	Floor mats		Heater			P Values		
Item	Rubber	Wood	Lamp	Propane	SEM	Mat x heater	Mat	Heater
No. pens	8	8	8	8				
Pig weight, lb								
Wean	13.8	13.7	13.6	13.9	0.2	NS[a]	NS	NS
d 21	29.1	28.7	28.3	29.5	0.5	NS	NS	NS
d 147	261.9	263.6	261.7	263.8	1.9	NS	NS	NS
Final	275.9	274.7	274.9	275.7	1.4	<0.08	NS	NS
Coefficient of variation of pig weight within pen, %								
Wean	19.7	18.4	17.6	20.5	0.5	NS	NS	<0.01
d 21	23.2	24.1	24.2	23.1	1.8	NS	NS	NS
d 147	9.4	10.0	9.8	9.6	0.7	< 0.05	NS	'NS
Average daily gain, lb								
Wean–d 21	0.73	0.71	0.70	0.74	0.02	NS	NS	NS
d 21–d 147	1.85	1.86	1.85	1.86	0.01	NS	NS	NS
Wean-final	1.70	1.70	1.70	1.71	0.01	NS	NS	NS
Average daily feed, lb								
Wean–d 21	0.97	0.91	0.90	0.97	0.04	NS	NS	NS
d 21-d 147	4.84	4.80	4.77	4.88	0.07	NS	NS	NS
Wean-final	4.36	4.34	4.31	4.39	0.07	NS	NS	NS
Feed:gain								
Wean–d 21	1.32	1.27	1.29	1.30	0.03	NS	NS	NS
d 21–d 147	2.62	2.57	2.57	2.62	0.03	NS	NS	NS
Wean-final	2.57	2.55	2.54	2.58	0.03	NS	NS	NS
No. dead/removed	6	6	5	7				

[a]NS = not significant ($P > 0.1$).

Results and Discussion

The pigs in this experiment were from a PRRS (Porcine Respiratory and Reproductive Syndrome) negative source, and the overall performance was excellent. Causes of death included a strangulated hernia, gastric torsion, ulcer and other miscellaneous causes. There was no effect of experimental treatments on the number of pigs treated or death loss.

There were almost no interactions between heating system and floor mat, so the main effects of heating system and floor mats on pig performance are presented in Table 1. There was no effect of heating system or type of floor mat on pig performance for the

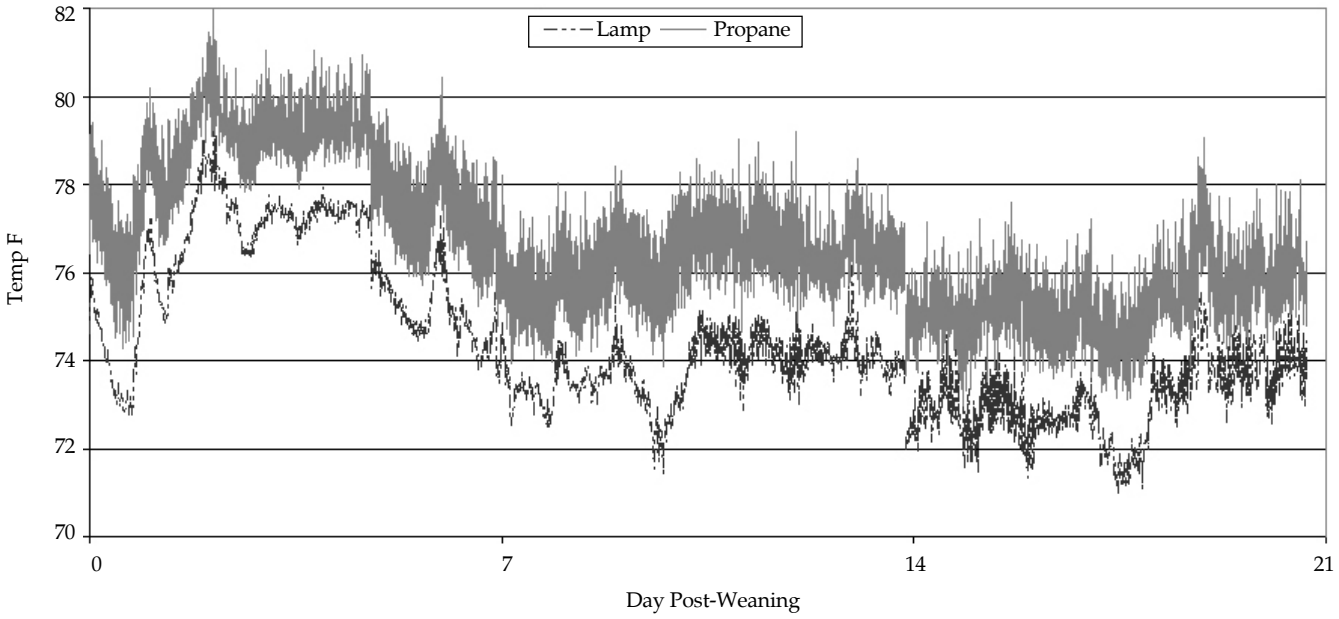

Figure 1. Black globe temperature by heat source averaged every 10 minutes.

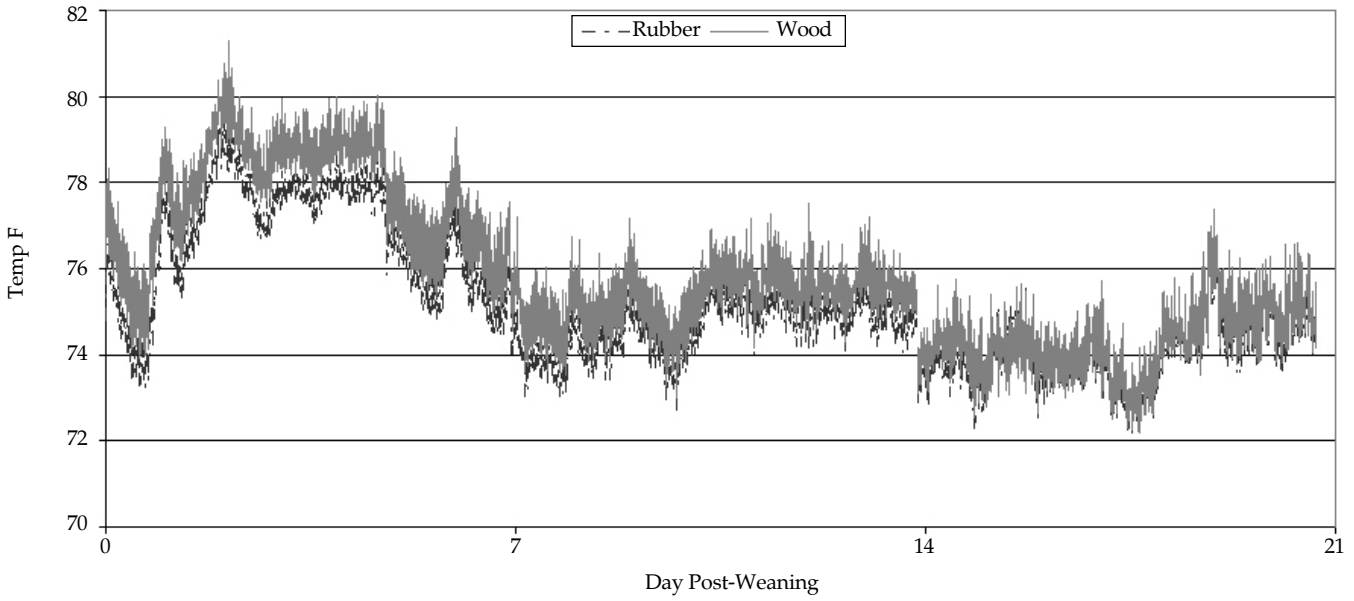

Figure 2. Black globe temperature by mat type averaged every 10 minutes.

first 21 days post-weaning. There was no carryover effect of heating system or type of floor mat on pig performance as indicated by the lack of difference in any performance variable for the day 21-147 period or overall.

Black-globe temperatures are presented in Figures 1 and 2 for the heating systems and mat types. Measurement of "black-globe temperature" directly incorporates the effect of radiant heating — the type of heating provided by both zone heating systems. The variation in black-globe temperature for the propane brooders is due to the control system chosen for this heating system. Gas flow to the propane heaters was controlled via a gas manifold linked to an electronic ventilation controller. This controller had a shielded temperature sensor suspended beneath one of the propane brooders. The controller was set to increase gas flow to all eight brooders when this sensor was at 94°F and decrease gas flow at 95°F,

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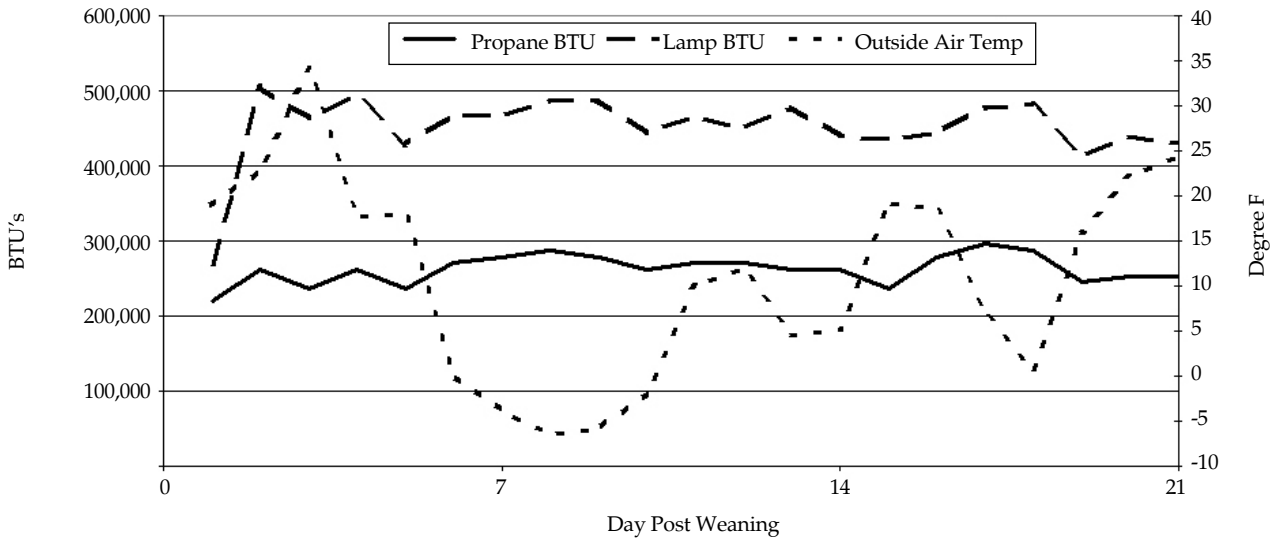

Figure 3. Daily energy usage (Btu's) for each heating system and 24 hour average outside air temperature.

Table 2. Heating system investment costs, 25 pigs/pen.

	Lamp fixture ($)	Total unit fixed cost ($)	Number of units (pens)		Total system fixed cost ($)	System fixed cost per pen ($)	System fixed cost per pig ($)	Useful life N (years)	Annualized fixed cost @ i=8% ($/yr/pig)
Lamps	10	10	8		80	10	0.40	7	0.08
	5400 Btu heater & hose & coupler ($)	Total unit fixed cost ($)	Number of units (pens)	Modulating gas valve & regulator ($)	Total system fixed cost ($)	System fixed cost per pen ($)	System fixed cost per pig ($)	Useful life N (years)	Annualized fixed cost @ i=8% ($/yr/pig
Propane	110	110	8	532	1,408	176	7.04	7	1.35
Propane	110	110	20	532	2,722	136	5.44	7	1.05

with these temperatures lowered 2°F per week along with the room temperature. Variation would have been less if the controller on-off set points had been 0.5°F apart versus the 1°F difference in the setting.

Black globe temperature in the pens with the propane brooder were consistently 1-2°F above black globe temperatures in the pens with heat lamps. The temperature settings for the propane controller and the height of the electric heat lamps were chosen with the intent of maintaining consistently comfortable thermal conditions in each pen (based upon operator observations and experience). The goal was to have the pigs select the mats directly under the heat source as the preferred sleeping area, and when sleeping to be in a "pig-and-a-half pile" in terms of sleeping posture. The fact that standard deviations in air and black-globe temperatures within treatments were relatively low suggests that farm management was able to produce similar thermal environments within similar zone-heating treatments.

Black globe temperatures were very similar for both wood and rubber mats (Figure 2). The slightly higher black globe temperature for the wood mats versus the rubber mats may be due to a slightly greater infrared heat absorption (less reflected heat) for the black mats versus the natural colored wood mats.

Daily energy usage, expressed in Btu units, is presented in Figure 3. This figure also contains a plot of the 24-hour average outside air temperature.

The annualized fixed costs of each heating system are presented in Table 2. While there were 15 pigs per pen in the experimental facility, fixed costs are estimated based on 25 pigs per pen, a more typical situation. Brooder fixed costs are estimated for eight brooders, similar to what was used in this experiment, and for 20 brood-

Table 3. Total estimated operating and ownership costs for the experimental heating systems at various energy rates.

	Annualized fixed cost @ i=8% ($/yr/pig)	250W bulb ($/pen/yr)	Electric use (kWh/pen/d)	Electric rate ($/kWh)	Electric cost ($/pen/yr)	Electric cost ($/pig/yr)	Operating cost ($/pen/yr)	Operating cost ($/pig/yr)	Total cost ($/pig/yr)
Lamps	0.08	1.8	6.0	0.06	15.12	1.01	16.92	1.13	1.20
Lamps	0.08	1.8	6.0	0.07	16.63	1.11	18.43	1.23	1.31
Lamps	0.08	1.8	6.0	0.08	18.90	1.26	20.70	1.38	1.46
Lamps	0.08	1.8	6.0	0.09	22.68	1.51	24.48	1.63	1.71
Lamps	0.08	1.8	6.0	0.12	30.24	2.02	32.04	2.14	2.21
			LP gas use (gal/pen/d)	LP gas rate ($/gal)	LP gas cost ($/pen/yr)	LP gas cost ($/pig/yr)	Operating cost ($/pen/yr)	Operating cost ($/pig/yr)	Total cost ($/pig/yr)
Propane	1.35		0.381	0.70	11.20	0.75	11.20	0.75	2.10
Propane	1.35		0.381	0.77	12.32	0.82	12.32	0.82	2.17
Propane	1.35		0.381	0.88	14.00	0.93	14.00	0.93	2.29
Propane	1.35		0.381	1.05	16.80	1.12	16.80	1.12	2.47
Propane	1.35		0.381	1.40	22.40	1.49	22.40	1.49	2.85
Propane	1.05		0.190	0.70	5.59	0.37	5.59	0.37	1.42
Propane	1.05		0.190	0.77	6.14	0.41	6.14	0.41	1.46
Propane	1.05		0.190	0.88	6.98	0.47	6.98	0.47	1.51
Propane	1.05		0.190	1.05	8.38	0.56	8.38	0.56	1.60
Propane	1.05		0.190	1.40	11.17	0.74	11.17	0.74	1.79

ers, a more typical installation. The difference in these scenarios is the larger number of pigs available to spread the expense of the modulating gas valve and regulator.

Total operating and ownership expenses at various energy prices are presented in Table 3. Operating expenses are based on two turns of pigs per year. It is possible that operating expenses for the propane brooders are over estimated in this scenario since the data is based on usage of brooders in January and February. It would be logical to expect a lower rate of propane usage for summer weaning. However, since heat lamps use a fixed rate of energy, their usage for winter versus summer months is probably more similar. For the number of pens used in this experiment, the brooders are not as cost efficient, regardless of energy prices when compared to the electric heat lamps. However, when the installation costs are spread over a larger number of pens and pigs, the difference in costs narrows considerably. This suggests that with energy expenses in the range of $0.08/kWh for electricity and $0.88/gal for propane, total operating and fixed costs for the two heating systems may vary as little as $0.05/pig.

Conclusions

The lack of differences in pig performance between treatments during both the 21-day post-wean period and overall suggests that any of the combinations of heating system and mat materials is capable of providing for the weaned pigs needs if managed correctly. These results suggest that producers with wean-to-finish facilities can base their selection of zone heating systems on criteria other than pig performance, such as ease of use, installation and operating expense, etc.

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