

FEASIBILITY OF HOOP STRUCTURES FOR MARKET SWINE IN IOWA: PIG PERFORMANCE, PIG ENVIRONMENT, AND BUDGET ANALYSIS

M. S. Honeyman, J. D. Harmon, J. B. Kliebenstein, T. L. Richard

ABSTRACT. Hoop structures are large simple, tent-like shelters that can be used for pigs. The pigs are kept inside the hoop structure and large bales, e.g. straw or cornstalks, are used for bedding. A typical hoop structure (10 × 30 m) holds about 200 market pigs. Bedding is added every two to six weeks as needed until the pigs are marketed at which time clean out occurs. Three demonstrational trials were conducted in Iowa. The pigs were fed from 26 to 117 kg. Pig performance in hoops was acceptable (ADG=.83 kg/d, FE=3.42 kg feed/kg gain) with 9% poorer feed efficiency in winter. Growth rate was equal to or slightly more than typical for pigs in conventional confinement. Pig mortality was less than 3%. Average bedding use was 100 kg per pig in winter and 55 kg per pig in summer. The hoop manure can be composted readily. The bedding pack was variable with some areas actively composting on site in the hoop, generating temperatures up to 62 °C. An economic analysis showed similar total costs of production with the hoops having lower fixed costs and higher variable costs than in conventional confinement. The higher variable costs are due to bedding and extra feed and labor. Hoop structures offer a feasible alternative production system for sustainable swine production in Iowa and surrounding areas.

Keywords. Alternative swine production, Bedded swine housing, Hoop structure, Animal housing.

Modern swine production has emphasized confinement-housing systems with slatted floors, liquid manure storage, automated ventilation systems, and automated feed delivery. These housing systems have relatively low labor requirements but have a high capital cost that is partially offset by pig flow schemes that maximize throughput or the number of pigs grown in the facilities during a given period of time. Such conventional confinement systems have allowed large numbers of pigs to be concentrated on small land areas, which has led to certain economic, environmental, and social problems (Honeyman, 1991, 1996). These problems have encouraged some farmers to turn to alternative swine production systems. An emerging system in Iowa and surrounding states is the use of deep-bedded hoop structures (fig. 1).

Hoop structures, or hoops, consist of arched pipes or trusses in a Quonset-shaped structure covered with an ultraviolet-resistant polyethylene fabric tarp. The hoops are

attached to wooden posts with wood sidewalls that are 1.2 to 2 m high. The ends are open most of the year except for winter when one or both ends are closed or partially closed. Most of the floor is earthen and covered with bedding. Bedding can be cornstalks, straw, wood shavings, or other absorbent organic material. Bedding is added to form a thick manure pack until clean out after each group of pigs. The high-traffic area around waterers and feeders is covered with concrete. A typical hoop layout for finishing pigs is shown in figure 2. Pigs are normally not allowed outside of the hoop, but they are allowed to occupy the entire structure. Gates across the end openings keep pigs in but allow access for bedding. Honeyman et al. (1999) discussed hoop structures for



Figure 1. A typical hoop structure for swine feeding.

Article was submitted for review in August 2000; approved for publication by the Structures & Environment Division of ASAE in October 2001.

Journal Paper No. J-18247 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa, Project No. 3142 and supported by Hatch Act and State of Iowa funds.

The authors are **Mark S. Honeyman**, Associate Professor, Department of Animal Science, **Jay D. Harmon**, ASAE Member Engineer, Associate Professor, Department of Agricultural and Biosystems Engineering, **James B. Kliebenstein**, Professor, Department of Economics, and **Thomas L. Richard**, ASAE Member Engineer, Assistant Professor, Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, Iowa. **Corresponding author:** M. S. Honeyman, B1 Curtiss Hall, Iowa State University, Ames, IA 50011; phone: 515-294-4621; fax: 515-294-6210; e-mail: honeyman@iastate.edu.

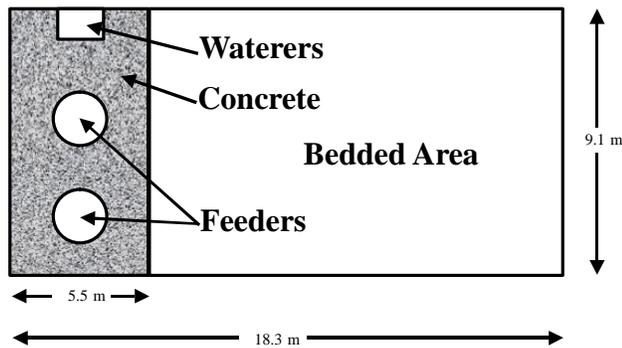


Figure 2. Typical hoop structure layout for swine. The end with concrete is typically the south end.

market pigs. Hoops are used primarily for grow–finish pigs but also for gestating sows (Brumm et al., 1999). This study documents hoops for grow–finish pigs in Iowa.

It is estimated that in 1999 there were approximately 1,500 to 2,000 hoops in Iowa used for swine housing. Most of the Iowa hoops have been built since 1995 or 1996. Several private companies are actively selling the structures.

Hoop structures were developed in Canada and have been used there for finishing pigs for about 10 years. Early work by Connor (1993a, b, 1994) reported that pigs fed in hoops had excellent health, similar growth rate, and lower mortality than pigs in partial slatted–floor confinement units. Feed efficiency was also similar except during cold winter months (10 to 20% poorer).

The hoops have the advantages of low initial cost, versatility, and simplicity. The initial cost of hoops for finishing pigs is \$50–60/pig space for the hoop and feeders plus the cost of manure and feed handling equipment, or about one–third to one–half that of curtain–sided, slatted–floor confinement barns with a deep pit. The hoops are versatile because they are modular, usually built in units holding 200 finishing pigs, whereas the confinement buildings are often found in units of 1,000 finishing pigs. The hoops can also be used for other agricultural purposes — for example, to store hay, grain, or machinery. The ends can be opened quickly for easy access by power machinery. The hoops are simple to construct and maintain with no major mechanical maintenance needs. Most do not require electricity service because they use natural ventilation. The solid manure of hoops avoids most of the current environmental problems of liquid systems — odor, spills, and leaks — as well as the regulatory hurdles.

The purpose of this work was to document the use of hoops for growing and finishing pigs in Iowa and to compare pig performance and cost of production to confinement production. The study describes three feasibility trials in which pigs were fed in a single hoop structure in central Iowa to determine whether the hoop structures would work in that climate. The trials were conducted in 1995 and 1996.

METHODS

The finishing demonstrations were conducted in a 9.1 × 18.3 m hoop structure with 1.8–m sidewalls. The hoop was oriented north to south and had 5.5 × 9.1 m (full width) of concrete in the south end for feeders and waterers (fig. 2). This orientation allowed capture of the prevailing southerly

air currents. A sprinkler system was installed for hot weather. Large, round bales of cornstalks were used as the major bedding source.

The finishing pig demonstrations consisted of three trials that were conducted at the Iowa State University (ISU) Rhodes Farm, Rhodes, Iowa. The first, which will be referred to as “Winter 1,” began on 16 November 1995 with 151 pigs that were marketed during February and March 1996. The second trial, called “Summer,” began on 15 April 1996 with 150 pigs, which were marketed during August and September 1996. The final trial, called “Winter 2,” began on 18 November 1996 with 163 pigs that were then marketed during February and March 1997. Data were gathered on pig performance, environmental performance, and bedding. Stocking density of the first two trials was 1.1 m² per pig. The stocking rate for the Winter 2 trial was 1.0 m² per pig.

The pigs were fed ad libitum corn and soybean meal–based diets in phase according to published nutrient guidelines (ISU, 1996). The pigs were weighed at the beginning of the trial and at marketing. Marketing occurred at two times for each trial. Feed was weighed when it was added to the feeders. Feed waste was not recorded or estimated. Feed intake values represent feed disappearance. Backfat thickness and lean percentage were recorded from slaughter summaries from the packing plant.

Pigs were checked daily and bedding was added every two to six weeks as needed. Bedding was weighed when added. Pig performance was compared with ISU Swine Business records (Baas, 1996, 1997, 1998) and PigCHAMP (1995).

For a winter and a summer trial, the environmental temperature in the hoop was monitored by suspending a thermometer from the hoop arch about 1.2 m above the manure pack. Temperatures were recorded hourly. Manure pack temperatures were taken by placing a thermometer in the pack at 15, 30, and 45 cm below the surface. Measurements were taken at nine locations as shown in figure 3. The manure was piled outside and allowed to compost after the hoops were cleaned.

RESULTS

PIG PERFORMANCE

The pig performance for the three trials is shown in table 1. In general, the pigs had numerically slightly greater feed intake and slightly poorer feed efficiency during colder seasons. The average daily gain (ADG) was relatively consistent among the three groups. PigCHAMP (1995) gives

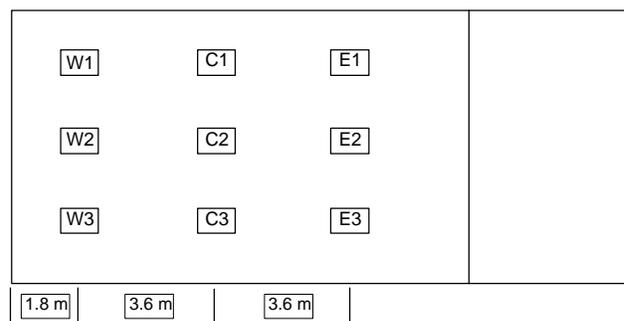


Figure 3. Measurement sites of bedding traits. The right end is the concrete feeding area.

Table 1. Finishing pig performance in hoop structures in Iowa.

Item	Winter 1	Summer	Winter 2	Winter Average ^[a]	Overall Average ^[b]
Starting weight (kg)	25	23	27	26	24.5
ADFI (kg) ^[c]	4.36	3.85	4.53	4.45	4.15
ADG (kg) ^[d]	.81	.85	.80	.81	.83
FE (feed/gain)	3.53	3.27	3.62	3.58	3.42
Mortality (%)	2.6	2.7	2.5	2.55	2.63
FFLI (% lean) ^[e]	46.7	47.6	48.1	47.4	47.5
Backfat (mm)	25.7	25.1	22.6	24.2	24.6
Market wt (kg)	112	120	114	113	117

^[a] Winter Average = average of winter 1 and 2.

^[b] Overall Average = average of winter and summer.

^[c] ADFI = Average Daily Feed Intake based on feed disappearance.

^[d] ADG = Average Daily Gain (liveweight).

^[e] FFLI = Fat free lean index.

the average ADG on 3,600 groups using the PigCHAMP record system as 0.73 kg with a 90th percentile of 0.82 kg. The summer trial tended to perform better than the 90th percentile whereas the winter trials were slightly less than the 90th percentile. The better summer and poorer winter pig performance is consistent with reports from Connor (1993a, b), which concluded that ADG was not significantly different from that of pigs reared in a system referred to as a conventional system (partial-slat confinement).

The two winter trials exhibited numerically poorer feed efficiency (FE) than did the summer trial. For a Midwestern U.S. climate, a 10% poorer feed efficiency is not unexpected during winter conditions. PigCHAMP (1995) stated that farms on record achieved an average FE of 3.18 and the 90th percentile was 2.80. These numbers indicate that all three trials had a poorer than average feed efficiency. Although these numbers are good for comparisons, it should be noted that PigCHAMP records are compiled for many types of pigs, facilities, and management styles and averaged together.

Mortality for the three trials averaged 2.6%. PigCHAMP (1995) records show an overall average of 2% for farms on record and a 90th percentile of no death losses. The hoop structure had mortality that was slightly poorer than the average of the PigCHAMP record participants. The higher pig mortality in hoops may be due in part to the fact that pigs may be more difficult to check in a large group (>150 pigs per pen) than they are in small groups of 20 to 30 pigs per pen, typical of confinement. Thus later disease outbreak detection may occur in the larger groups of pigs in hoops.

Another comparison can be made with the Iowa Swine Business Records. Primarily an Iowa swine enterprise record program with approximately 40 producers that market approximately 1,700 pigs per year in feeder pig to finishing systems (Baas, 1996, 1997, 1998). The producers are small to moderate-sized Iowa operations that use primarily confinement systems. The comparison between pig performance in hoops and pig performance from Iowa Swine Business Records is shown in table 2. Starting and ending weights are similar; feed efficiency was similar. Pig mortality in the hoops was 30% less than the average of the Iowa records program (2.6 vs. 3.7%). It should be noted, however, that the hoop was a new structure and frequently pigs perform better in a new facility than in an older facility. Also, there were only three trials to compare with the PigCHAMP or ISU record programs.

Table 2. Comparison of performance of finishing pigs in hoops to Iowa Swine Business Record averages 1995–97.

	Average Pig Performance in Hoops	Average Iowa Swine Business Records (1995–97)
Start wt. (kg)	24.5	22.3 ^[a]
Market wt. (kg)	117	114
FE (feed/gain)	3.42	3.42
Mortality (%)	2.63	3.74

^[a] 1995 only, other years not reported.

ENVIRONMENTAL MONITORING

The environment within any building is defined by several factors that affect the comfort level of the animals. Such factors include temperature, relative humidity, air speeds, and temperatures of surrounding surfaces. Hoop structures are not intended to be warm, mechanically ventilated structures. They are merely intended to temper the environment and give pigs the opportunity to modify their own environment by the utilization of bedding.

Figure 4 shows the average temperatures that were measured inside and outside the hoop structure during the first winter trial. On average, the air temperature in this structure was only 3 to 5°C warmer than the outside temperature. Results from the second winter trial were similar. Although this temperature is certainly cooler than is desired to raise pigs, the actual effective temperature that the pigs experience is somewhat different because the pigs can modify their environment by burrowing in the bedding and also because some heat comes off the manure pack. Figure 5 indicates the temperature contours at 15, 30, and 45 cm depths on 28 February 1997. Temperature outside the hoop was 3°C and inside the hoop was 5°C.

Figure 6 illustrates the summer environmental performance. During the summer, both ends of the building were open and a temperature-controlled sprinkler system was in place. Average temperatures were usually only slightly higher than the outside temperature. This is also common in conventional confinement facilities. The sprinkler system operated very little during the summer of 1996 because of relatively cool temperatures.

Large, round bales of cornstalks were used for bedding. The winter trials (108 days) required an average of 100 kg of cornstalks per pig. The summer trial (114 days) required about 55 kg of cornstalks per pig. Bedding is important as a urine and feces absorber and for the pig to use to modify cold environments, and it may have a positive effect on pig behavior. Before pigs were delivered, bales were unrolled in the hoop to a depth of about 22 cm. For the remainder of each trial the bales were placed on end and the pigs were allowed to unravel them. Additional bedding was not needed during the first six to eight weeks and then was added every two to six weeks as needed thereafter.

MANURE MANAGEMENT

Because the pigs in hoop structures maintain relatively constant areas for dunging and sleeping throughout a cycle, at the time of clean out there are dry, nutrient-poor sleeping areas and wet, nutrient-rich dunging areas. Composting is quite common with hoop manure, occurring without effort or intent whenever the material is piled prior to spreading in the field. Composting resulted in significant mass ($42 \pm 13\%$)

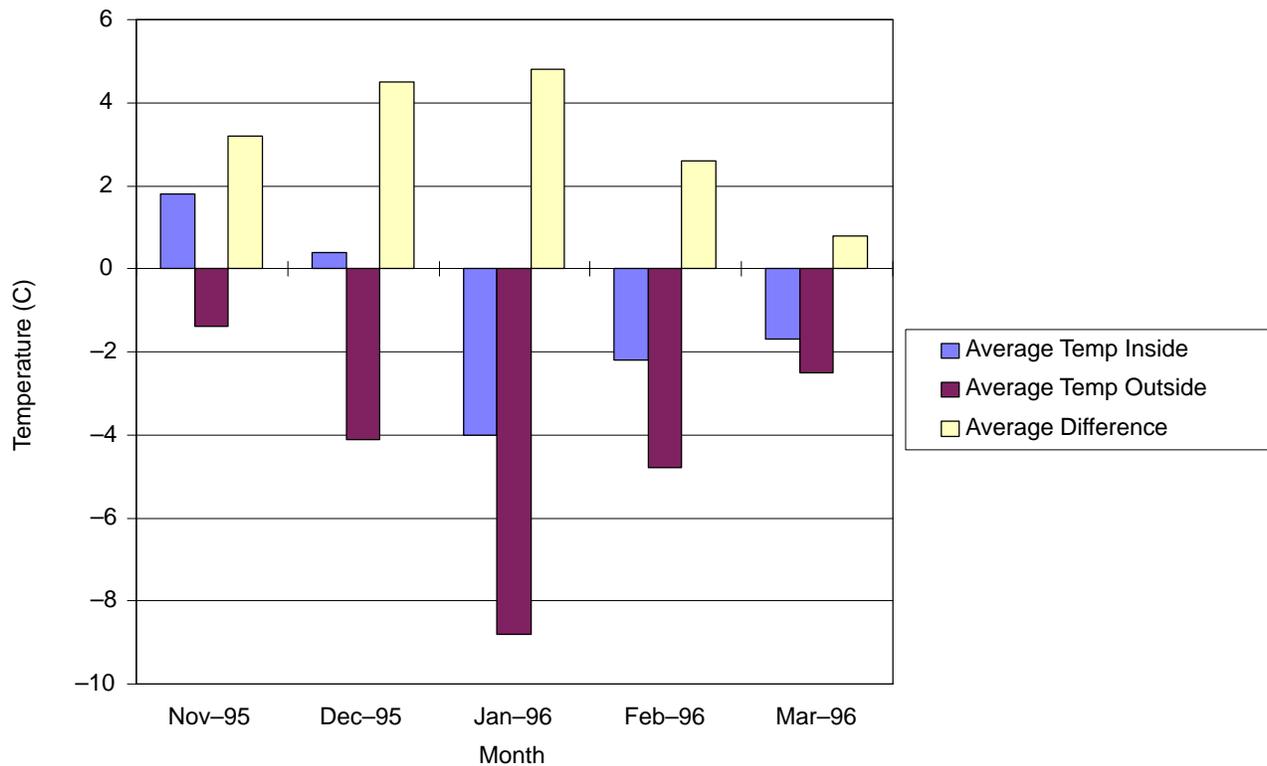


Figure 4. Winter temperatures from the ISU Rhodes Farm hoop structure.

and volume ($40 \pm 10\%$) reductions, as observed in 20 experimental windrows tracked for their initial six weeks (Tiquia et al., 2000). Nitrogen losses were quite variable during these composting trials, ranging from 3 to 60% of the initial compost N. This variable N loss reflects varying C:N ratios as well as seasonal precipitation differences during the spring, winter, and summer that these composting trials occurred (Tiquia et al., 2000). Phosphorus and potassium losses were also significant, ranging from 20 to 43% for both P and K during the relatively high rainfall summer composting trial (Tiquia

et al., 2002). Additional trials will investigate whether leaching and runoff can be reduced by the use of fabric covers. Although any loss of nutrient represents a potential environmental threat, nutrient losses that are low relative to the total mass and volume losses increase the nutrient density of the manure, reducing transportation and application costs for crop utilization (Richard and Choi, 1999). Combined with moisture reduction, the mass and volume reduction increased the nutrient density of the manure (on a wet or fresh basis) and reduced required trips to the field.

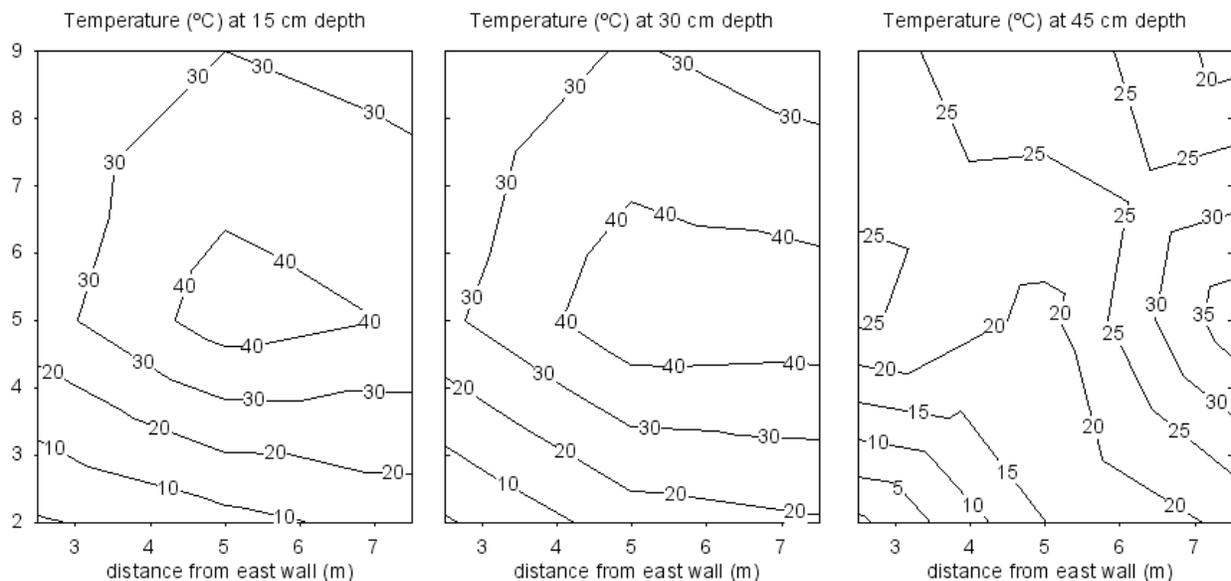


Figure 5. Temperatures ($^{\circ}\text{C}$) at 15-, 30-, and 45-cm depths in the bedded pack, 28 February 1997.

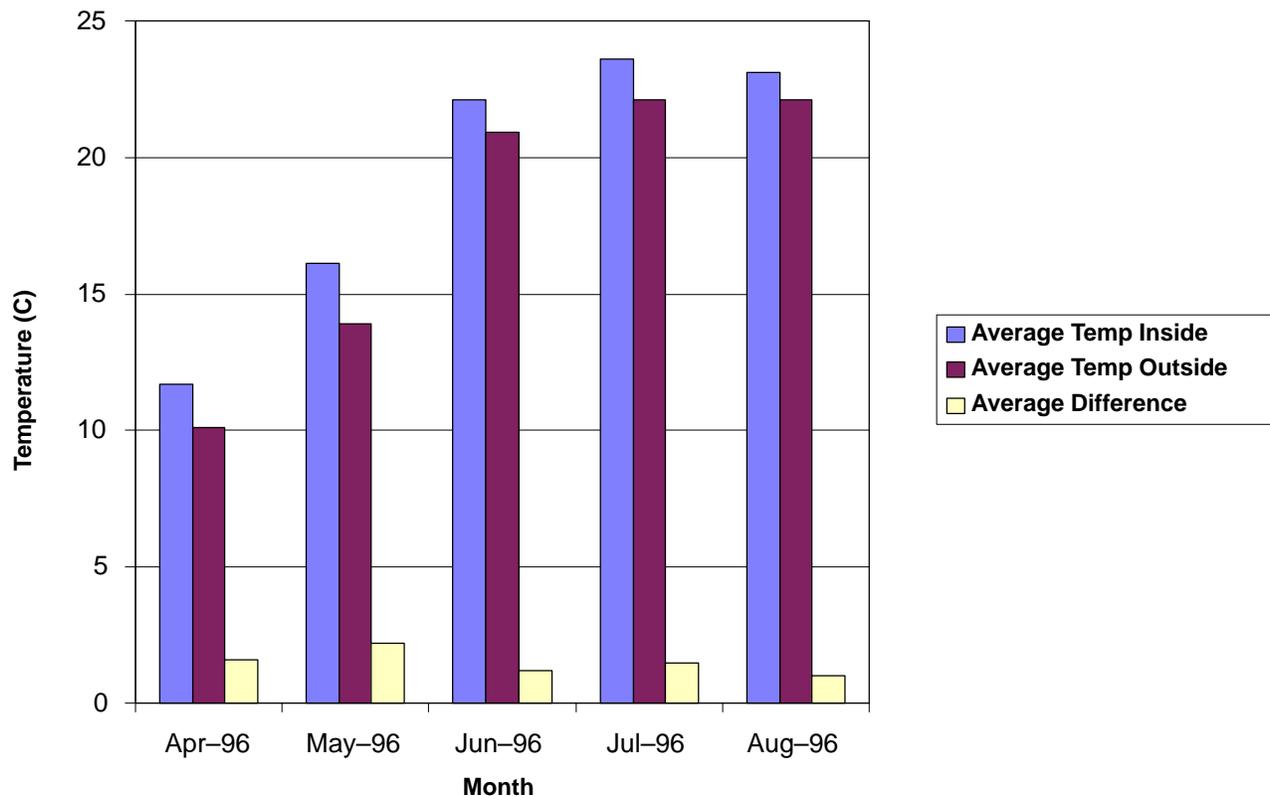


Figure 6. Summer temperatures from the ISU Rhodes Farm hoop structure.

ECONOMIC ANALYSIS

Production cost information is shown in table 3. A budget was prepared for a starting weight of 22.7 kg (50 lb.). The budget was based on Iowa Extension budgets (Lawrence and Vontalge, 1996). Budget comparisons are based on an initial cost of \$216 per pig space for confinement and \$91 for a hoop, including feed and manure-handling equipment. Fixed costs are 13.2% of the initial cost for total confinement and 16.5% for hoops, including 6.7% annually for depreciation in confinement and 10% annually for hoops (due to an assumed shorter lifespan), insurance and tax is at 1.5%, and interest is at 5% of initial investment (10% of average

investment). There are 2.8 turns per year. Kilograms of feed per pig produced (from 22.5 to 112 kg liveweight) are 308 and 327 kg for the confinement and hoop-raised pigs, respectively. Labor usage was based on the Iowa Swine Business Records for confinement (Baas, 1997, 1998, 1999) and a survey of hoop users (Duffy and Honeyman, 1999).

The overall production cost per pig was similar for the two systems: \$94.88 for the confinement system and \$95.86 for the hoop system. The major differences were lower fixed cost and higher operating costs (feed, bedding, and labor) for the pigs in hoops.

Table 3. Swine grow-finishing cost of production per pig.

	Confinement (\$)	Hoop (\$)
Fixed costs		
Interest, taxes, depreciation, insurance	10.18	5.36
Operating costs		
Feeder pig (22.7 kg)	35.00	35.00
Interest on feeder pig (10% for 4 mo.)	1.17	1.17
Fuel, repairs, utilities	2.00	.50
Bedding (545.5 kg bale @ \$20 ea.)	0	3.33
Feed 308 kg feed @ \$.32/kg confinement	40.65	43.16
Vet/medical	1.50	1.50
Marketing/misc.	1.50	1.50
Interest on fuel, feed, etc. (10% for two months)	.76	.83
Labor (.21 h/pig @ \$7.50/h using confinement) (.31 h/pig @ \$7.50/h using hoop)	1.58	2.33
Total operating cost	84.70	89.75
Total cost (per pig marketed)	94.88	95.86
Total cost per kg market weight live (112 kg market hog)	.85	.86

CONCLUSIONS

Additional research is needed to fine-tune the management of hoops for swine to improve pig performance and reduce variable costs. Hoops offer an alternative to conventional confinement housing systems. Many small and medium-sized diversified crop and livestock farmers, who are abundant in Iowa, have found hoops a viable alternative. The simple construction, very low maintenance, low utility costs, cornstalk bedding, low capital costs, and inherent versatility in a rapidly changing swine industry make hoops an attractive and practical alternative for some producers. The hoops are cost competitive. Cost of production is similar to that of more capital-intensive systems. Challenges include procurement of sufficient bedding, management of the bedding packs, and health of the pigs in larger groups. Management is much different from conventional facilities and animal observation skills are important. Hoops are a sustainable alternative for producing pigs because they are 1) environment-friendly with solid manure that can be

composted, and 2) farmer-friendly with low capital cost and competitive cost of production.

REFERENCES

- Baas, T. J. 1996. ISU Swine Enterprise Records Program. ASL-R1397. *Swine Research Report*. AS-634. Iowa State Univ. Ext., Ames, Iowa.
- _____. 1997. ISU Swine Business Record Program. ASL-R1502. *Swine Research Report*. AS-638. Iowa State Univ. Ext., Ames, Iowa.
- _____. 1998. ISU Swine Business Record Program. ASL-R1579. *Swine Research Report*. AS-640. Iowa State Univ. Ext., Ames, Iowa.
- Brumm, M. C., J. D. Harmon, M. S. Honeyman, J. B. Kliebenstein, and J. M. Zulovich. 1999. Hoop structures for gestating swine. AED44. *MidWest Plan Service*. Iowa State Univ., Ames, Iowa.
- Connor, M. L. 1993a. Evaluation of a biotech housing for feeder pigs. *Manitoba Swine Update*. 5(3): 1.
- _____. 1993b. Biotech shelters. Alternative housing for feeder pigs. *Manitoba Swine Seminar Proc.* 7: 81.
- _____. 1994. Update on alternative housing for pigs. *Manitoba Swine Seminar Proc.* 8: 93-96.
- Duffy, M., and M. Honeyman. 1999. Labor requirements for market swine produced in hoop structures. ASL-R1685. *Swine Research Report* AS-642. ISU Ext. Serv., Ames, Iowa.
- Honeyman, M. S. 1991. Sustainable swine production in the U.S. Corn Belt. *Am. J. Alt. Agric.* 6(2): 63 - 70.
- _____. 1996. Sustainability issues of U.S. swine production. *J. Anim. Sci.* 74: 1410 - 1417.
- Honeyman, M. S., F. W. Koenig, J. D. Harmon, D. C. Lay, Jr., J. B. Kliebenstein, T. L. Richard, and M. C. Brumm. 1999. Managing market pigs in hoop structures. PIH-138. *Pork Industry Handbook*. Purdue Univ., W. Lafayette, Ind.
- Iowa State University (ISU). 1996. Life cycle swine nutrition. Pm-489. Iowa State Univ. Ext., Ames, Iowa.
- Lawrence, J., and A. Vontalge. 1996. Livestock enterprise budgets for Iowa. Fm-1815. Iowa State Univ. Ext., Ames, Iowa.
- PigCHAMP. 1995. *PigCHAMP Database Summary*. Jan. 1990-May 1995. Apple Valley, Minn.
- Richard, T. L., and H. L. Choi. 1999. Eliminating waste: strategies for sustainable manure management. *Asian-Aus. J. Anim. Sci.* 12(7): 1162-1169.
- Tiquia S. M., T. L. Richard, and M. S. Honeyman. 2000. Effect of windrow turning and seasonal temperatures on composting of hog manure from hoop structures. *Environ. Technol.* 20(9): 1037-1046.
- _____. 2002. Carbon, nutrient and mass loss during composting. *Nutrient Cycling in Agricultural Ecosystems* In Press.