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Re-evaluating Floor Space Allowance and Removal Strategy Effects on the Growth of Heavyweight Finishing Pigs

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Re-evaluating Floor Space Allowance and Removal Strategy Effects on the Growth of Heavyweight Finishing Pigs

Abstract

This study was performed to evaluate the impact of initial floor space allowance and various topping strategies (removal of the heaviest pigs in a pen prior to marketing the finishing group) on the growth performance of heavyweight finishing pigs. A total of 1,092 pigs (initially 80.1 lb) were allotted to one of 4 experimental treatments with 14 pens per treatment. The first treatment stocked pigs at 9.7 ft^2 (15 pigs/pen) throughout the study. The other three treatments initially stocked pigs at 6.9 ft^2. The second treatment (2:2:2) topped the two heaviest pigs on d 64 (203 lb), d 76 (227 lb), and d 95 (264 lb), which coincided with the time floor space allowance became limiting, as predicted by Gonyou et al. (2006). The third treatment (2:4) topped the 2 heaviest pigs and the 4 heaviest pigs at an average BW of 240 (d 76) and 280 lb (d 105), respectively. The fourth treatment (6) topped the 6 heaviest pigs at an average BW of 280 lb (d 105). All pigs remaining in pens after topping events were marketed on d 117 of the study. Overall (d 0 to 117), pigs in pens stocked at 9.7 ft^2 had increased ($P < 0.05$) ADG compared to pigs in pens on either the 2:4 or 6 topping strategies, but ADG was not different from pigs in pens on the 2:2:2 topping strategy. This suggests that prediction equations developed by Gonyou et al. (2006) for ADG are useful for predicting the effects of floor space on heavyweight pig ADG. Pigs in pens stocked at 9.7 ft^2 had increased ($P < 0.05$) ADFI compared to pigs in pens initially stocked at 6.9 ft^2 regardless of topping strategy. Total weight gain per pen was greater ($P < 0.05$) for pens initially stocked at 6.9 ft^2 compared to pens stocked at 9.7 ft^2; however, total weight gain per pig was greater for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. Pigs in pens on the 2:2:2 topping strategy had less weight gain ($P < 0.05$) than pigs in pens on the 6 topping strategy. Feed usage per pen was decreased for pens stocked at 9.7 ft^2 compared to those initially stocked at 6.9 ft^2; however, per pig feed usage was increased ($P < 0.05$) for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. Pens on the 2:2:2 topping strategy had less ($P < 0.05$) feed usage, either on a pen or pig basis, than those on the 2:4 or the 6 topping strategy. Interestingly, there was a tendency ($P < 0.10$) for pigs in pens on the 2:4 topping strategy to have less feed usage than pigs in pens on the 6 topping strategy. Income over feed and facility cost (IOFFC) was decreased ($P < 0.05$), either on a pen or pig basis, for pens stocked at 9.7 ft^2. Pigs in pens on the 2:2:2 topping strategy had numerically less IOFFC when revenue was high and feed cost was low compared to pigs in pens on the 2:4 or 6 topping strategy. In conclusion, increasing the floor space allowance or the time points at which pigs are removed from the pen improved the performance of pigs remaining in the pen; however, IOFFC may be reduced due to fewer pigs marketed from each pen (in the case of lower stocking density) or from reducing total weight produced (in pens where pigs are topped earlier at lighter weights).

Keywords

finishing pig, floor space, growth, topping

Cover Page Footnote

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Re-evaluating Floor Space Allowance and Removal Strategy Effects on the Growth of Heavyweight Finishing Pigs[1]

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Summary

This study was performed to evaluate the impact of initial floor space allowance and various topping strategies (removal of the heaviest pigs in a pen prior to marketing the finishing group) on the growth performance of heavyweight finishing pigs. A total of 1,092 pigs (initially 80.1 lb) were allotted to one of 4 experimental treatments with 14 pens per treatment. The first treatment stocked pigs at 9.7 ft^2 (15 pigs/pen) throughout the study. The other three treatments initially stocked pigs at 6.9 ft^2. The second treatment (*2:2:2*) topped the two heaviest pigs on d 64 (203 lb), d 76 (227 lb), and d 95 (264 lb), which coincided with the time floor space allowance became limiting, as predicted by Gonyou et al. (2006[5]). The third treatment (*2:4*) topped the 2 heaviest pigs and the 4 heaviest pigs at an average BW of 240 (d 76) and 280 lb (d 105), respectively. The fourth treatment (*6*) topped the 6 heaviest pigs at an average BW of 280 lb (d 105). All pigs remaining in pens after topping events were marketed on d 117 of the study. Overall (d 0 to 117), pigs in pens stocked at 9.7 ft^2 had increased ($P < 0.05$) ADG compared to pigs in pens on either the *2:4* or *6* topping strategies, but ADG was not different from pigs in pens on the *2:2:2* topping strategy. This suggests that prediction equations developed by Gonyou et al. (2006) for ADG are useful for predicting the effects of floor space on heavyweight pig ADG. Pigs in pens stocked at 9.7 ft^2 had increased ($P < 0.05$) ADFI compared to pigs in pens initially stocked at 6.9 ft^2 regardless of topping strategy. Total weight gain per pen was greater ($P < 0.05$) for pens initially stocked at 6.9 ft^2 compared to pens stocked at 9.7 ft^2; however, total weight gain per pig was greater for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. Pigs in pens on the *2:2:2* topping strategy had less weight gain ($P < 0.05$) than

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[1] This project was supported by National Research Initiative Competitive Grant no. 2011-68004-30336 from the USDA National Institute of Food and Agriculture.

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[5] Gonyou, H. W., M. C. Brumm, E. Bush, J. Deen, S. A. Edwards, R. Fangman, J. J. McGlone, M. Meunier-Salaun, R. B. Morrison, H. Spoolder, P. L. Sundberg, and A. K. Johnson. 2006. Application of broken-line analysis to assess floor space requirements of nursery and grower-finisher pigs expressed on an allometric basis. J. Anim. Sci. 84:229–235.

pigs in pens on the *6* topping strategy. Feed usage per pen was decreased for pens stocked at 9.7 ft^2 compared to those initially stocked at 6.9 ft^2; however, per pig feed usage was increased ($P < 0.05$) for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. Pens on the *2:2:2* topping strategy had less ($P < 0.05$) feed usage, either on a pen or pig basis, than those on the *2:4* or the *6* topping strategy. Interestingly, there was a tendency ($P < 0.10$) for pigs in pens on the *2:4* topping strategy to have less feed usage than pigs in pens on the *6* topping strategy. Income over feed and facility cost (IOFFC) was decreased ($P < 0.05$), either on a pen or pig basis, for pens stocked at 9.7 ft^2. Pigs in pens on the *2:2:2* topping strategy had numerically less IOFFC when revenue was high and feed cost was low compared to pigs in pens on the *2:4* or *6* topping strategy. In conclusion, increasing the floor space allowance or the time points at which pigs are removed from the pen improved the performance of pigs remaining in the pen; however, IOFFC may be reduced due to fewer pigs marketed from each pen (in the case of lower stocking density) or from reducing total weight produced (in pens where pigs are topped earlier at lighter weights).

Key words: finishing pig, floor space, growth, topping

Introduction

The impact of floor space allowance on finishing pig growth performance has been clearly defined in the swine industry. Many view floor space as a welfare issue due to its large impact on individual animal performance. The challenge is that providing floor space allowance needed to maximize growth is not always associated with efficient and profitable use of facilities. Gonyou et al. (2006) developed a set of prediction equations to estimate the impact of floor space on growth performance. Interestingly, the majority of finishing research that was used to develop those prediction equations was with lighter market weight animals than those marketed today.

Marketing the heaviest pigs several weeks prior to closing out the entire barn (topping) is a common practice. This allows producers to market the heaviest pigs when they approach ideal or targeted market weights. This helps ensure additional premiums for those pigs marketed early. Another benefit from removing the heaviest pigs is the additional pen space provided to those pigs remaining, which typically leads to improved performance for those animals. This practice can be beneficial from both a performance and economic perspective; but it could also lead to increasing overall production costs from increased labor requirements and if pigs are not the appropriate weight when removed.

Although domestic market weights have continued to increase over time, little emphasis has been placed on the increase in floor space needed to accommodate the additional weight. There is a need to re-evaluate the impact of topping strategies and floor space for pigs at heavier market weights to provide information for future management decisions. The objective of this study was to determine the economic impacts of different topping strategies on growth performance of the remaining pigs when pigs are fed to heavy finishing weights. This experiment also evaluated the applicability of the prediction equations developed by Gonyou et al. (2006) when pigs are fed to heavier weights.

Procedures

This study was approved by and conducted in accordance with the guidelines of the Kansas State University Institutional Animal Care and Use Committee. The experiment was conducted in a commercial research finishing barn in central Iowa. The barn was tunnel ventilated, and the study was conducted from the fall of 2014 to the winter of 2015. Pens were 18.5 × 8.2 ft with completely slatted floors and deep pits for manure storage. Each pen was equipped with a 4-hole SDI (Alexandria, SD) stainless steel dry self-feeder with a feed pan dimension of 50.0 × 7.0 × 5.75 in. Water was provided ad libitum through a pan waterer (21 × 8 in.) installed in each pen.

A total of 1,092 pigs (PIC 359 × Genetiporc F25 females, initially 80.1 lb) were used. Pigs were penned by gender (barrow or gilt) at arrival to the facility after weaning. Prior to initiation of the study, there were 21 pigs per pen. On d 0 pigs were individually weighed, and the number of pigs per pen was adjusted to achieve the desired floor space treatments. Pens were allotted to initial floor space treatments of either 6.9 or 9.7 ft^2, consistent with either 15 or 21 pigs per pen. To maintain similar variation of mean pig BW within pens across floor space treatments, pen standard deviations were considered along with initial BW when removing pigs to achieve the initial floor space allowances. Fourteen pens (7 barrow and 7 gilt pens) were allotted to an initial floor space treatment of 9.7 ft^2. Meanwhile, 42 pens (21 barrow and 21 gilt pens) were allotted to initial floor space treatments of 6.9 ft^2. Of the 42 pens stocked at 21 pigs per pen, 3 separate pig removal strategies were initiated. The first strategy (*2:2:2*) was to remove the 2 heaviest pigs when average pen BW (188, 219, and 256 lb) reduced the *k* coefficient below the critical threshold (0.0336) to reduce ADG, as suggested by Gonyou et al. (2006). These removals were performed on d 64, 76, and 95 of the study. The second (*2:4*) pig removal strategy was to remove the 2 heaviest pigs when average pen BW approached 240 lb (d 76) and the heaviest 4 pigs when average BW approached 280 lb (d 105). The third strategy (*6*) was to remove the 6 heaviest pigs when the average pen BW reached 280 lb (d 105). All pigs remaining in the pen after the specific topping strategies were marketed on d 117 of the study. Table 1 illustrates the topping strategies and the number of pigs remaining after topping events. After d 105, all pens contained 15 pigs per pen, which was calculated to be the stocking density needed to keep the *k* coefficient above the critical breakpoint. Therefore, this study was evaluating the Gonyou et al. (2006) prediction equations and determining if they were still applicable for heavier weight market pigs.

During the study, one feeder hole was blocked in pens stocked at 15 pigs to more closely balance feeder space (5.25 and 5.00 pigs per feeder hole, and 2.40 or 2.28 in. of linear trough space/pig for pigs stocked at 15 or 21 pigs pen, respectively). Additionally, to maintain floor space allowance, if pigs were removed as a result of sickness or death, gates were adjusted to maintain the same floor space allowance initially provided. This ensured that pigs were provided the desired floor space allowance throughout the study. As pigs were marketed from the pen based on treatment, gates were not adjusted. Thus, floor space for pigs remaining in the pen increased accordingly.

Pigs were fed common corn and soybean-meal based diets that contained 20% dried distillers grains with solubles and 3% added fat (Table 2). Pigs were fed in 4 sequential dietary phases from approximately 80 to 130, 130 to 180, 180 to 220, and 220 lb to market (average of 310 lb). Diets were formulated to contain 1.10, 0.90, 0.80, and 0.70% SID Lys corresponding to phase 1 to 4, respectively. Pens of pigs and feed disappearance were determined on d 21, 42, 64, 76, 95, 105, 117, and 123 to calculate ADG, ADFI, and F/G. Individual pig weights were also collected on d 0, 64, 76, 95, 105, 117, and 123 to separate pigs into the lightest, middle, and heaviest thirds of the pen to evaluate growth rates of the different populations in the pen in response to experimental treatments. Coefficients of variation were also determined within each pen by using the individual weight information.

Statistical analysis was performed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) to test for the main effects and interactions of experimental treatment and gender. Data were analyzed as a generalized randomized block with gender as the blocking factor and pen as the experimental unit. The effect of initial floor space allowance was evaluated by comparing the mean of pigs stocked at 9.7 ft^2 versus the mean of pigs stocked at 6.9 ft^2. Individual treatment means were evaluated for differences using the Tukey-Kramer adjustment for multiple comparisons. For data pertaining to BW groups (light, medium, or heavyweight pigs within a pen), the Rank procedure was used to assign a rank to each pig based on BW prior to each growth phase. The assigned rank was then used as a fixed effect in the model to evaluate the interaction and main effects of BW group and experimental treatment on individual growth performance within each phase. Results were considered significant at $P \leq 0.05$ and a tendency at $P \leq 0.10$.

Results and discussion

No gender × treatment interactions were observed for growth performance throughout the length of the study.

From d 0 to 64 barrows had increased ($P < 0.001$) ADG and ADFI compared to gilts, but F/G was similar (Table 3). Barrows and gilts had similar ADG from d 64 to 76; however, barrows had increased ($P < 0.001$) ADFI and poorer ($P < 0.001$) F/G during this period. From d 76 to 95, barrows tended ($P < 0.098$) to have decreased ADG and increased ($P = 0.068$) ADFI compared to gilts, which resulted in poorer ($P = 0.016$) F/G. Barrows had increased ($P = 0.018$) ADFI from d 95 to 105; although ADG and F/G were similar between genders. During the final period (d 105 to 117), barrows had less ($P > 0.001$) ADG and poorer ($P > 0.001$) F/G than gilts, but ADFI was not different. Overall (d 0 to 117), barrows had increased ($P < 0.002$) ADG and ADFI and poorer ($P < 0.002$) F/G and adjusted F/G compared to gilts.

From d 0 to 64 (prior to topping any pigs), pigs in pens stocked at 9.7 ft^2 had increased ($P < 0.05$, Table 4) ADG and ADFI compared to pigs in pens initially provided 6.9 ft^2, but F/G was similar regardless of initial floor space allowance. There was a significant treatment × BW group interaction ($P = 0.048$, Table 5) for ADG from d 0 to 64. This was due to a greater magnitude of increase in ADG from medium to heavyweight pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. This suggests that although pigs in pens initially stocked at 6.9 ft^2 should not have been limited on space, it appeared the heavyweight pigs in these pens were limited, which resulted in a reduced ADG. On d 0, CV of average BW was similar regardless of treatment (Table 6). Ending BW on d 64 was heavier ($P < 0.05$; Table 7) for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. On d 64, CV of average BW was similar regardless of treatment.

From d 64 to 76, ADG of pigs in pens stocked at 9.7 ft^2 and those on the *2:2:2* topping strategy was greater ($P < 0.05$) than the ADG of pigs in pens on the *2:4* topping strategy. This was expected due to the planned removal of the 2 heaviest pigs from the *2:2:2* treatment group, which relieved stocking density above the predicted requirement. Pigs in pens stocked at 9.7 ft^2 had increased ($P < 0.05$) ADFI compared to other treatments; however, ADFI of pigs in pens on the *2:2:2* topping strategy was greater ($P < 0.05$) than for pigs in pens on the *2:4* topping strategy. It was thought that ADFI for pens on the *2:2:2* treatment should return to a level similar to that of pigs stocked at 9.7 ft^2 after the heaviest two pigs were removed, which provided more space, but the difference between these treatments may be due more to pigs remaining in the pen having lower voluntary feed intake levels than of the intact pens stocked at 9.7 ft^2. Pigs in pens on the *2:2:2* topping strategy also had improved ($P < 0.05$) F/G compared to pigs in pens on the *2:4* topping strategy. Individual pig weights suggested no interaction of experimental treatment × BW group from d 64 to 76, but lightweight pigs had less ($P < 0.001$) ADG than medium or heavyweight pigs. It was expected that heavyweight pigs in pens on the *2:4* and the *6* marketing strategy would still have reduced ADG compared to heavyweight pigs in pens stocked at 9.7 ft^2 or those in pens on the *2:2:2* marketing strategy. However, the lack of an interaction suggests that all BW groups in pens on the *2:4* and the *6* marketing strategies had reduced ADG, meaning that all pigs were becoming limited on space. Pigs in pens stocked at 9.7 ft^2 had heavier ($P < 0.05$) d 76 BW compared to those pigs on the *2:4* or the *6* topping strategies. On d 76, CV was higher ($P < 0.05$) for pens stocked at 9.7 ft^2 compared to pens on the *2:2:2* topping strategy.

From d 76 to 95, pigs in pens stocked at 9.7 ft^2 had greater ($P < 0.05$) ADG than pigs in pens on either the *2:4* or the *6* topping strategy. Pigs in pens stocked at 9.7 ft^2 had greater ($P < 0.05$) ADFI compared to pigs in pens initially stocked at 6.9 ft^2, regardless of topping strategy. Feed efficiency was similar among the experimental treatments. Similar to the previous phase, pigs in pens on the *2:2:2* marketing strategy had similar ADG to those in pens stocked at 9.7 ft^2, which was expected due to the removal of pigs to keep those remaining in the pen above their predicted space requirement. However, pigs in pens on the *2:4* marketing strategy did not show improvement in ADG after the removal of the heaviest 2 pigs (on d 76) from their pens. This is probably due to the fact that the remaining pigs were still potentially limited on space. There was a tendency ($P = 0.085$) for an interaction of experimental treatment × BW group from d 76 to 95. Lightweight pigs in pens on the *2:4* topping strategy had reduced ADG compared to lightweight pigs in pens initially stocked at 9.7 ft^2 and pens on the *2:2:2* marketing strategy. This helps illustrate that pigs on the *2:4* marketing treatment did not respond in improved ADG to the additional floor space following the removal of the heaviest two pigs, suggesting they were still potentially limited on space. Pigs in pens stocked at 9.7 ft^2 had heavier ($P < 0.05$) BW on d 95 compared to pigs remaining in pens that were initially stocked at 6.9 ft^2, regardless of topping strategy. On d 95, CV was greater ($P < 0.05$) for pens stocked at 9.7 ft^2 and those on the *6* topping strategy compared to pens on the *2:2:2* topping strategy.

From d 95 to 105, pigs in pens on the *2:2:2* topping strategy tended to have greater ($P < 0.10$) ADG than pigs in pens on the *6* topping strategy. The reduction in gain observed from pigs in pens on the *6* topping strategy during this period demonstrates how important space is for the late finishing pig, considering these pigs were still stocked at 6.9 ft^2. Also, ADFI of pigs in pens on the *6* topping strategy was less ($P < 0.05$) than pigs in pens stocked at 9.7 ft^2 or pigs in pens on the *2:2:2* topping strategy. Regardless of treatment, F/G was still similar. Individual pig weight data from d 95 to 105 suggested neither an interaction of experimental treatment × BW group nor a BW group main effect influenced ADG. Pigs in pens stocked at 9.7 ft^2 had heavier ($P < 0.05$) BW on d 105 compared to pigs in the pens initially stocked at 6.9 ft^2, regardless of topping strategy. On d 105, CV was higher ($P < 0.05$) for pens stocked at 9.7 ft^2 and those on the *6* topping strategy compared to pens on the *2:2:2* topping strategy.

During the final phase (d 105 to 117), ADG and ADFI were similar across treatments, but pigs in pens initially stocked at 9.7 ft^2 tended ($P < 0.10$) to have poorer F/G than pigs in pens on the *2:4* topping strategy. Another treatment × BW group interaction was observed ($P = 0.035$) from day 105 to 117, because lightweight pigs in pens stocked at 9.7 ft^2 performed worse than lightweight pigs in pens initially stocked at 6.9 ft^2, and heavyweight pigs in pens on the *2:4* topping strategy had greater ADG than heavyweight pigs in pens on other treatments. These results were not expected, but the reduction in ADG of lightweight pigs stocked at 9.7 ft^2 may have been partially a result of their limitation on space during this last period, since the 9.7 ft^2 provided was the predicted requirement of pigs up to 310 lbs. Average final BW of pigs in these pens was 319.3 lb at the end of the study. Pigs in pens initially stocked at 9.7 ft^2 were heavier ($P < 0.05$) on d 117 compared to pigs in pens initially stocked at 6.9 ft^2, regardless of topping strategy. On d 117, after all topping strategies were performed, pens of pigs initially stocked at 6.9 ft^2 ($P < 0.05$) had reduced CVs for pig BW compared to pens stocked at 9.7 ft^2. This agrees with previous research that has shown reductions in the variation of BW within a pen as the heaviest pigs are removed.

Overall from d 0 to 117, pigs in pens stocked at 9.7 ft^2 had greater ($P < 0.05$) ADG than pigs in pens on the *2:4* or *6* topping strategies. Also, pigs in pens on the *2:2:2* topping strategy had greater ($P < 0.05$) ADG than that of pigs in pens on the *6* topping strategy. Average daily feed intake was increased ($P < 0.05$) for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2, regardless of topping strategy. Meanwhile, F/G was poorer ($P < 0.05$) for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens on either the *2:2:2* or the *2:4* topping strategy. Pigs in pens on the *2:2:2* topping strategy had improved ($P < 0.05$) F/G compared to pigs in pens on the *6* topping strategy. However, if the F/G is adjusted to the same final BW (of pigs remaining in the pen on d 117), then the adjusted F/G was not influenced by treatment. Final BW of pigs in pens stocked at 9.7 ft^2 was heavier ($P < 0.05$) than those pigs in pens initially stocked at 6.9ft^2. Additionally, when the weighted average BW of pigs marketed was calculated, pigs in pens stocked at 9.7ft^2 were heavier than pigs in pens initially stocked at 6.9 ft^2. Pigs in pens on the *2:2:2* topping strategy had lighter ($P < 0.05$) BW than pigs in pens on the *6* topping strategy, which would be expected due to topping pigs from the *2:2:2* strategy earlier in the study and at lighter weights. Mortality and morbidity were not influenced by treatment.

In summary, ADG of pigs at heavy weights followed suggested trends from prediction equations developed by Gonyou et al. (2006). This was evident in the lack of significant difference in ADG of pigs in pens stocked at 9.7 ft^2 compared to pigs in pens on the *2:2:2* topping strategy, which was designed to remove pigs and keep the remaining pigs above the predicted space needs. Alternatively, ADFI should have been similar as well for the two treatments (based on the ADFI prediction equations); however, ADFI of pigs on the *2:2:2* topping strategy was different compared with the ADFI of pigs initially provided 9.7 ft^2 of floor space. This may be due to the removal of the heaviest pigs per pen at each topping point, resulting in lighter weight pigs remaining in the pen with lower voluntary feed intake rates. Additionally, when partitioned by BW groups, it appeared that early on (d 0 to 64) heavyweight pigs with additional floor space benefitted more than light- or medium-weight pigs. This would be expected because their requirement for space would be greater than for lightweight pigs. But, after the removal of the heaviest pigs from the pen, it generally appeared that all pigs remaining had improved growth rates, regardless of BW grouping. This may be due to the reduction in pen weight CV and lower weight variation among the pigs remaining, which was also achieved with the topping strategies.

Total weight gain per pen was greater ($P < 0.05$, Table 8) for pens initially stocked at 6.9 ft^2 compared to pens stocked at 9.7 ft^2. Alternatively, total weight gain per pig was greater for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. Pigs in pens on the *2:2:2* topping strategy had less weight gain ($P < 0.05$) than pigs in pens on the *6* topping strategy. Similar to weight gain, revenue expressed on a pen basis was less ($P < 0.05$) for pens stocked at 9.7 ft^2 due to fewer pigs in the pen; however, when expressing the revenue on a pig basis, it was greater for pigs in pens stocked at 9.7 ft^2 than for pigs in pens initially stocked at 6.9 ft^2. Pigs in pens on the *2:2:2* topping strategy brought less ($P < 0.05$) revenue, either on a pen or pig basis, than pigs in pens on the *2:4* or *6* topping strategy. Feed usage and feed cost per pen were reduced for pens stocked at 9.7 ft^2 compared to those initially stocked at 6.9 ft^2; however, per-pig feed usage and feed cost were greater ($P < 0.05$) for pigs in pens stocked at 9.7 ft^2 compared to pigs in pens initially stocked at 6.9 ft^2. Pigs in pens on the *2:2:2* topping strategy had less ($P < 0.05$) feed usage and reduced feed cost, either on a pen or pig basis, than those on the *2:4* or the *6* topping strategy. Interestingly, there was a tendency ($P < 0.10$) for pigs in pens on the *2:4* topping strategy to show less feed usage and lower feed cost than pigs in pens on the *6* topping strategy. Income over feed and facility cost was the least ($P < 0.05$), either on a pen or pig basis, for pigs in pens stocked at 9.7 ft^2. Pigs in pens on the *2:2:2* topping strategy had less ($P < 0.05$) IOFFC when revenue was high and feed cost was low compared to pigs on the *2:4* or *6* topping strategy. These results suggest the most economic strategies were to stock the pens initially at 6.9 ft^2 and perform either the *2:4* or the *6* topping strategy. As expected, the benefit in growth performance resulting from additional floor space up to 9.7 ft^2 was overcome by the additional facility cost and feed cost per pig and the reduction in total revenue from marketing fewer pigs. Also, pigs in pens on the *2:2:2* topping strategy had improved performance, but the discounts from pigs marketed at lighter weights reduced total revenue. Between the topping strategies, it is more favorable to perform the *2:4* strategy (multiple toppings) when feed cost is high in order to remove pigs sooner and increase potential feed savings. When revenue is high, it is more economical to keep pigs in the pens to heavier market weights and perform a single topping strategy prior to removing all pigs in the barn, as observed for pigs on the *6* topping strategy.

In conclusion, this study shows producers the benefits in performance resulting from topping the heaviest pigs in the pen to relieve stocking density and provide additional floor space, but the ideal topping strategy should be evaluated on an economic basis to limit potential revenue reduction.

Table 1. Topping strategies based on experimental treatments[1]

	Initial floor space, ft² and topping strategy[2]			
	9.7	6.9	6.9	6.9
	none	2:2:2	2:4	6
Number of pigs removed from the pen[3]				
d 0	0 (15)	0 (21)	0 (21)	0 (21)
d 64	0 (15)	2 (19)	0 (21)	0 (21)
d 76	0 (15)	2 (17)	2 (19)	0 (21)
d 95	0 (15)	2 (15)	0 (19)	0 (21)
d 105	0 (15)	0 (15)	4 (15)	6 (15)
d 117	15 (0)	15 (0)	15 (0)	15 (0)

[1] A total of 1,092 pigs (PIC 359 × Genetiporc F25 females; initially 80.1 lb) were used in a 117-d study to determine the influence of initial floor space allowance and topping strategy on growth performance. There were either 15 or 21 pigs per pen and 14 pens (7 barrow and 7 gilt pens) per treatment.
[2] Pigs initially provided 6.9 ft² of floor space were marketed using three different strategies: 2:2:2 signifies pens where the 2 heaviest pigs on d 64, 76, and 95 were removed; 2:4 represents pens where the heaviest 2 pigs were removed on d 76 and the 4 heaviest pigs were removed on d 105; and 6 represents pens where the heaviest 6 pigs were removed on d 105.
[3] Values in parentheses represent the calculated number of pigs left following the experimental topping strategies.

Table 2. Diet composition[1]

	Dietary phase and BW range, lb			
	1	2	3	4
	80 to 130	130 to 180	180 to 220	220 to 310
Ingredient, %				
Corn	55.22	59.62	61.54	63.39
Soybean meal, 46.5% CP	19.20	14.90	13.15	11.40
DDGS[2]	20.00	20.00	20.00	20.00
Fat, A-V blend	3.50	3.50	3.43	3.35
Calcium carbonate	0.96	0.95	0.95	0.95
Sodium chloride	0.44	0.44	0.44	0.44
Lysine sulfate, 46.5%	0.44	0.37	0.36	0.34
DL-methionine	0.01	---	---	---
Phytase[3]	0.023	0.018	0.013	0.005
Copper sulfate	0.05	0.05	---	---
VTM premix[4]	0.15	0.15	0.12	0.12
Total	100.00	100.00	100.00	100.00
Calculated analysis				
SID[5] amino acids, %				
Lys	1.10	0.90	0.80	0.70
TSAA:Lys	0.58	0.58	0.58	0.58
Thr:Lys	0.62	0.62	0.64	0.68
Trp:Lys	0.18	0.18	0.18	0.18
NE, Mcal/lb	1.18	1.20	1.20	1.21
SID Lys:NE, g/Mcal	4.23	3.40	3.02	2.62
Ca, %	0.46	0.46	0.44	0.43
P, %	0.40	0.40	0.38	0.37
Available P, %	0.28	0.27	0.25	0.21
Ca:P	1.15	1.15	1.16	1.16

[1] Each dietary phase was fed until the pen consumed its total feed budget for the respective diet. The per pig feed budgets were 115, 130, and 86 lb for phases 1, 2, and 3, respectively. Phase 4 was fed until all pigs were marketed.
[2] Dried distillers grains with solubles.
[3] Optiphos (HuvePharma, St. Louis, MO) provided 255, 199, 141 and 57 FTU/lb, releasing an estimated 0.11, 0.10, 0.07, and 0.04 % available P for phases 1, 2, 3, and 4, respectively.
[4] VTM= Vitamin and trace mineral premix. The premix provided 6,620 ppm Cu, 150 ppm I, 73,490 ppm Fe, 20,210 ppm Mn, 200 ppm Se, 73,490 ppm Zn, and 260 ppm Co per lb of premix. The premix also provided 1,335,000 IU vit. A, 335,000 IU vit. D_3, 6,667 IU vit. E, 667 mg vit. K, 1,000 mg riboflavin, 8,330 mg niacin, 5,000 mg pantothenic acid, and 6.67 mg vit. B_{12} per lb of premix.
[5] Standardized ileal digestible.

Table 3. Main effect of gender on growth of finishing pigs[1,2]

	Gender			Probability, *P* <
	Barrow	Gilt	SEM	Gender
d 0 to 64				
ADG, lb	1.99	1.82	0.015	0.001
ADFI, lb	4.75	4.30	0.043	0.001
F/G	2.39	2.36	0.014	0.162
d 64 to 76				
ADG, lb	2.18	2.22	0.029	0.309
ADFI, lb	6.77	6.25	0.050	0.001
F/G	3.12	2.82	0.032	0.001
d 76 to 95				
ADG, lb	2.07	2.16	0.042	0.098
ADFI, lb	6.60	6.45	0.057	0.068
F/G	3.21	3.00	0.057	0.016
d 95 to 105				
ADG, lb	1.88	1.90	0.071	0.849
ADFI, lb	6.60	6.35	0.072	0.018
F/G	3.63	3.48	0.122	0.389
d 105 to 117				
ADG, lb	1.87	2.10	0.044	0.001
ADFI, lb	6.87	6.63	0.102	0.103
F/G	3.72	3.16	0.069	0.001
d 0 to 117				
ADG, lb	2.00	1.95	0.012	0.002
ADFI, lb	5.57	5.19	0.034	0.001
F/G	2.78	2.67	0.012	0.001
Adj. F/G[3]	2.80	2.73	0.014	0.001

[1] A total of 1,092 pigs (PIC 359 × Genetiporc F25 females; initially 80.1 lb) were used in a 117-d study to determine the influence of initial floor space allowance and topping strategy on growth performance. There were either 15 or 21 pigs per pen and 14 pens (7 barrow and 7 gilt pens) per treatment.

[2] Different superscripts (a,b,c) within row, $P < 0.05$. Differing superscripts (x,y,z) within row, $P < 0.10$.

[3] Feed to gain ratios were adjusted to a common final BW of 310 lb by using an adjustment of 0.005 for every 1 lb difference in final BW.

Table 4. Main effects of initial floor space allowance and topping strategy on growth of finishing pigs[1,2]

	Initial floor space, ft² and topping strategy[3]					Probability, $P <$
	9.7	6.9	6.9	6.9		
	none	*2:2:2*	*2:4*	*6*	SEM	Initial floor space[4]
d 0 to 64						
No. of pigs per pen	15	21	21	21		
ADG, lb	1.96[a]	1.90[a,b]	1.88[b]	1.88[b]	0.021	0.003
ADFI, lb	4.71[a]	4.47[b]	4.45[b]	4.48[b]	0.061	0.001
F/G	2.40	2.35	2.36	2.39	0.020	0.164
d 64 to 76						
No. of pigs per pen	15	19	19	21		
ADG, lb	2.28[a]	2.30[a]	2.08[b]	2.16[a,b]	0.041	0.040
ADFI, lb	6.83[a]	6.53[b]	6.26[c]	6.43[b,c]	0.071	0.001
F/G	3.01[a,b]	2.85[b]	3.03[a]	2.99[a,b]	0.045	0.346
d 76 to 95						
No. of pigs per pen	15	17	19	21		
ADG, lb	2.27[a]	2.14[a,b]	2.04[b]	2.02[b]	0.059	0.005
ADFI, lb	6.96[a]	6.47[b]	6.33[b]	6.34[b]	0.081	0.001
F/G	3.10	3.03	3.14	3.16	0.081	0.912
d 95 to 105						
No. of pigs per pen	15	15	19	21		
ADG, lb	1.90[x,y]	2.03[x]	1.97[x,y]	1.66[y]	0.101	0.890
ADFI, lb	6.68[a]	6.66[a]	6.47[a,b]	6.09[b]	0.101	0.024
F/G	3.59	3.39	3.41	3.82	0.172	0.786
d 105 to 117						
No. of pigs per pen	15	15	15	15		
ADG, lb	1.94	1.99	2.03	2.00	0.062	0.340
ADFI, lb	7.04	6.70	6.67	6.57	0.145	0.022
F/G	3.67[x]	3.39[x,y]	3.32[y]	3.38[x,y]	0.097	0.009
d 0 to 117						
ADG, lb	2.04[a]	1.99[a,b]	1.95[b,c]	1.92[c]	0.017	0.001
ADFI, lb	5.69[a]	5.28[b]	5.26[b]	5.28[b]	0.049	0.001
F/G	2.79[c]	2.65[a]	2.70[a,b]	2.75[b,c]	0.017	0.001
Adj. F/G[5]	2.75	2.74	2.77	2.79	0.021	0.420

[1] A total of 1,092 pigs (PIC 359 × Genetiporc F25 females; initially 80.1 lb) were used in a 117-d study to determine the influence of initial floor space allowance and topping strategy on growth performance. There were either 15 or 21 pigs per pen and 14 pens (7 barrow and 7 gilt pens) per treatment.
[2] Different superscripts (a,b,c) within row, $P < 0.05$. Differing superscripts (x,y,z) within row, $P < 0.10$.
[3] Pigs initially provided 6.9 ft² of floor space were marketed using three different strategies: 2:2:2 signifies pens where the 2 heaviest pigs on d 64, 76, and 95 were removed; 2:4 represents pens where the heaviest 2 pigs were removed on d 76 and the 4 heaviest pigs were removed on d 105; and 6 represents pens where the heaviest 6 pigs were removed on d 105.
[4] Initial floor space compares the mean of pigs initially provided 9.7 or 6.9 ft².
[5] Feed to gain ratios were adjusted to a common final BW of 310 lb by using an adjustment of 0.005 for every 1 lb difference in final BW.

Table 5. Effects of initial floor space and topping strategy on ADG of BW groups (light, medium, or heavy pigs within pens)[1]

Initial floor space, ft²	Topping strategy[2]	BW group[3]	ADG, lb d 0 to 64	d 64 to 76	d 76 to 95	d 95 to 105	d 105 to 117
9.7	none	Light	1.81	2.15	2.20	1.94	1.78
9.7	none	Medium	1.95	2.27	2.16	2.04	2.06
9.7	none	Heavy	2.14	2.27	2.25	1.92	1.92
No. of pigs per pen			15	15	15	15	15
6.9	2:2:2	Light	1.78	2.28	2.15	1.99	2.04
6.9	2:2:2	Medium	1.93	2.25	2.21	2.06	2.05
6.9	2:2:2	Heavy	2.00	2.34	2.17	2.10	1.98
No. of pigs per pen			21	19	17	15	15
6.9	2:4	Light	1.80	1.96	1.94	1.85	2.15
6.9	2:4	Medium	1.84	2.07	2.06	1.89	2.22
6.9	2:4	Heavy	2.01	2.15	2.12	1.92	2.34
No. of pigs per pen			21	21	19	19	15
6.9	6	Light	1.76	2.01	2.04	1.71	2.08
6.9	6	Medium	1.89	2.11	2.09	1.63	2.08
6.9	6	Heavy	2.02	2.15	2.04	1.65	1.86
No. of pigs per pen			21	21	21	21	15
SEM			0.088	0.058	0.097	0.120	0.099
			Probability, $P <$				
Interaction							
Treatment × BW group			0.048	0.347	0.085	0.511	0.035
Main effects							
Treatment			0.022	0.001	0.064	0.085	0.018
BW group			0.001	0.001	0.055	0.665	0.042

[1] A total of 1,092 pigs (PIC 359 × Genetiporc F25 females; initially 80.1 lb) were used in a 117-d study to determine the influence of initial floor space allowance and topping strategy on growth performance. There were either 15 or 21 pigs per pen and 14 pens (7 barrow and 7 gilt pens) per treatment.

[2] Pigs initially provided 6.9 ft² of floor space were marketed using three different strategies: 2:2:2 signifies pens where the 2 heaviest pigs on d 64, 76, and 95 were removed; 2:4 represents pens where the heaviest 2 pigs were removed on d 76 and the 4 heaviest pigs were removed on d 105; and 6 represents pens where the heaviest 6 pigs were removed on d 105.

[3] Pigs were ranked within pen as either: light, medium, or heavy weight prior to each growth period for evaluation.

Table 6. The effects of initial floor space and topping strategy on CV of the weight of finishing pigs[1,2]

	Initial floor space, ft² and topping strategy[3]					Probability, $P <$
	9.7	6.9	6.9	6.9		
	---	2:2:2	2:4	6	SEM	Initial floor space[4]
CV of BW within pen prior to removals						
d 0	15.5	14.8	15.2	14.1	0.67	0.295
d 64	12.6	11.1	11.6	11.8	0.56	0.107
d 76	11.5[b]	9.1[a]	10.8[a,b]	11.1[a,b]	0.56	0.067
d 95	9.8[b]	7.7[a]	9.0[a,b]	9.3[b]	0.42	0.022
d 105	9.3[b]	6.9[a]	8.2[a,b]	8.7[b]	0.40	0.004
d 117	9.0[b]	6.5[a]	6.5[a]	6.8[a]	0.40	0.001

[1] A total of 1,092 pigs (PIC 359 × Genetiporc F25 females; initially 80.1 lb) were used in a 117-d study to determine the influence of initial floor space allowance and topping strategy on growth performance. There were either 15 or 21 pigs per pen and 14 pens (7 barrow and 7 gilt pens) per treatment.

[2] Different superscripts (a,b,c) within row, $P < 0.05$.

[3] Pigs initially provided 6.9 ft² of floor space were marketed using three different strategies: 2:2:2 signifies pens where the 2 heaviest pigs on d 64, 76, and 95 were removed; 2:4 represents pens where the heaviest 2 pigs were removed on d 76 and the 4 heaviest pigs were removed on d 105; and 6 represents pens where the heaviest 6 pigs were removed on d 105.

[4] Initial floor space compares the mean of pigs initially provided 9.7 or 6.9 ft².

Table 7. The effects of initial floor space and topping strategy on BW of finishing pigs[1,2]

	Initial floor space, ft² and topping strategy[3]					Probability, $P <$
	9.7	6.9	6.9	6.9		
	none	2:2:2	2:4	6	SEM	Initial floor space[4]
Avg BW of pen prior to removals, lb						
d 0	80.2	80.0	80.1	80.0	0.72	0.835
d 64	206.5[a]	202.8[a,b]	201.3[b]	202.0[a,b]	1.37	0.007
d 76	232.9[a]	226.9[a,b]	226.6[b]	228.0[b]	1.5	0.002
d 95	276.7[a]	264.3[b]	261.8[b]	267.4[b]	1.74	0.001
d 105	295.7[a]	281.2[b]	281.7[b]	284.4[b]	1.77	0.001
d 117	319.3[a]	305.1[b]	298.7[b]	297.6[b]	2.13	0.001
Avg BW of pigs removed, lb						
d 0	---	---	---	---	---	---
d 64	---	236.1	---	---	---	---
d 76	---	253.5	264.9	---	1.75	---
d 95	---	288.9	---	---	---	---
d 105	---	---	309.5	308.5	1.79	---
d 117	319.3[a]	305.1[b]	298.7[b]	297.6[b]	2.13	0.001
Avg BW of pigs in the pen after removals, lb						
d 0	---	---	---	---	---	---
d 64	---	199.2	---	---	---	---
d 76	---	223.6	222.5	---	1.4	---
d 95	---	260.9	---	---	---	---
d 105	---	---	273.6	274.2	1.97	---
d 117	---	---	---	---	---	---
Weighted avg BW of pigs marketed, lb	319.3[a]	291.6[c]	297.3[b,c]	301.1[b]	1.91	0.001
Mortality and morbidity, %[5]	2.9	2.9	3.6	5.4	1.32	0.503

[1] A total of 1,092 pigs (PIC 359 × Genetiporc F25 females; initially 80.1 lb) were used in a 117-d study to determine the influence of initial floor space allowance and topping strategy on growth performance. There were either 15 or 21 pigs per pen and 14 pens (7 barrow and 7 gilt pens) per treatment.

[2] Different superscripts (a,b,c) within row, $P < 0.05$.

[3] Pigs initially provided 6.9 ft² of floor space were marketed using three different strategies: 2:2:2 signifies pens where the 2 heaviest pigs on d 64, 76, and 95 were removed; 2:4 represents pens where the heaviest 2 pigs were removed on d 76 and the 4 heaviest pigs were removed on d 105; and 6 represents pens where the heaviest 6 pigs were removed on d 105.

[4] Initial floor space compares the mean of pigs initially provided 9.7 or 6.9 ft².

[5] Mortality and morbidity were analyzed as a binomial distribution and calculated as the number of pigs sent to market out of the total number of pigs placed within each pen.

Table 8. The effects of initial floor space and topping strategy on economic parameters[1,2]

	Initial floor space, ft^2 and topping strategy[3]					Probability, P <
	9.7	6.9	6.9	6.9		
	---	2:2:2	2:4	6	SEM	Initial floor space[4]
Total weight gain, lb/pen	3,534[b]	4,479[a]	4,592[a]	4,578[a]	60.4	0.001
Total weight gain, lb/pig	242.8[a]	219.9[c]	227.2[b,c]	230.7[b]	2.06	0.001
Revenue[5]						
Low, $/pen	1,705[c]	2,177[b]	2,247[a]	2,281[a]	10.6	0.001
High, $/pen	2,243[c]	2,844[b]	2,931[a]	2,977[a]	15.2	0.001
Low, $/pig[6]	113.69[a]	103.65[c]	106.98[b]	108.64[b]	0.51	0.001
High, $/pig[6]	149.55[a]	135.45[c]	139.57[b]	141.78[b]	0.74	0.001
Feed usage, lb/pen	10,003[c]	11,793[b]	12,271[a,x]	12,633[a,y]	101.5	0.001
Feed usage, lb/pig	666.9[a]	561.6[c]	584.4[b,x]	601.6[b,y]	5.1	0.001
Feed cost[7]						
Low, $/pen	1,000[c]	1,179[b]	1,227[a,x]	1,263[a,y]	10.2	0.001
High, $/pen	1,300[c]	1,533[b]	1,595[a,x]	1,642[a,y]	13.2	0.001
Low, $/pig[8]	66.69[a]	56.16[c]	58.43[b,x]	60.16[b,y]	0.51	0.001
High, $/pig[8]	86.70[a]	73.01[c]	75.97[b,x]	78.21[b,y]	0.67	0.001
IOFFC, $/pen[9]						
Low Rev-High Feed	152.15[b]	390.75[a]	398.57[a]	386.45[a]	10.51	0.001
Low Rev-Low Feed	452.25[b]	744.50[a]	766.71[a]	765.45[a]	8.94	0.001
High Rev-High Feed	690.15[b]	1,058.59[a]	1,083.06[a]	1,082.37[a]	11.93	0.001
High Rev-Low Feed	990.15[c]	1,412.38[b]	1,451.19[a,b]	1,461.37[a]	11.48	0.001
IOFFC, $/pig[9]						
Low Rev-High Feed	10.14[b]	18.60[a]	18.98[a]	18.40[a]	0.56	0.001
Low Rev-Low Feed	30.15[b]	35.45[a]	36.51[a]	36.45[a]	0.47	0.001
High Rev-High Feed	46.00[b]	50.41[a]	51.57[a]	51.54[a]	0.62	0.001
High Rev-Low Feed	66.01[c]	67.26[b,c]	69.10[a,b]	69.59[a]	0.58	0.001

[1] A total of 1,092 pigs (PIC 359 × Genetiporc F25 females; initially 80.1 lb) were used in a 117-d study to determine the influence of initial floor space allowance and topping strategy on growth performance. There were either 15 or 21 pigs per pen and 14 pens (7 barrow and 7 gilt pens) per treatment.

[2] Different superscripts (a,b,c) within row, P < 0.05. Differing superscripts (x,y,z) within row, P < 0.10.

[3] Pigs initially provided 6.9 ft^2 of floor space were marketed using three different strategies: 2:2:2 signifies pens where the 2 heaviest pigs on d 64, 76, and 95 were removed; 2:4 represents pens where the heaviest 2 pigs were removed on d 76 and the 4 heaviest pigs were removed on d 105; and 6 represents pens where the heaviest 6 pigs were removed on d 105.

[4] Initial floor space compares the mean of pigs initially provided 9.7 or 6.9 ft^2.

[5] Revenue was based on a low ($45/cwt) or high ($60/cwt) base price. To mimic premium and discounts associated with specific carcass weights a fixed yield of 75% was used to calculate HCW of pigs marketed, and the following regression equation was used to adjust premiums and discounts for varying HCW: Premium/discount, $/Cwt=0.00001 × HCW^3-0.01064 × HCW^2+3.01173*H-CW-257.58240.

[6] Revenue/pen divided by the initial placement of either 15 or 21 pigs per pen for pens initially stocked at 9.7 or 6.9 ft^2, respectively.

[7] Based on average diet costs of $200/ton for low and $260/ton for high.

[8] Feed cost/pen divided by the initial placement of either 15 or 21 pigs per pen for pens initially stocked at 9.7 or 6.9 ft^2, respectively.

[9] Income over feed and facility costs: calculated as revenue-feed cost-facility cost. A fixed facility cost of $0.11/7.4ft^2/day was used to calculate facility costs.