Determination of optimum stocking density for broiler rearing in a small poultry house

The ideal density at which to place broilers during grow-out is an ongoing debate. There is no definitive answer to this question. It is natural to assume that birds will perform better when given more space. However, it's not more space but the improved environment that the added space may provide that is important. The modern broiler house enables producers to have great control over the house environment. Birds can be placed at higher densities as long as the appropriate environment (temperature, ventilation and humidity) is provided. Factors to consider when determining stocking density include but are not limited to bird size are feeder space, waterer space, house dimensions, bird welfare, nutrition, breed, performance and economic returns.

The ultimate goal is to maximize pounds of chicken produced per square foot while preventing production losses due to overcrowding. In many cases, producers have to settle for slightly reduced performance to achieve a satisfactory economic return. Stocking density is a central issue of broiler
welfare. Animal activist groups request that broilers be given more space during grow-out and cite behavioral and physiological stress as the reason. It has been reviewed by many scientists that the influence of stocking density on growth rate and leg problems acts through its influence on litter and air quality. High moisture content of the litter enhances microbial activity, which in turn leads to increase in temperature and ammonia in broiler houses, and thus, high incidence of contact dermatitis. High stocking density impedes heat transfer from the litter surface to the ventilated room. This restricts the efficacy of conventional ventilation systems in alleviating heat stress.

Studies on stocking densities in broiler production have produced variable conclusions. Some studies show large benefits in reducing stocking density, while others show little or no differences. Bilgili and Hess (1995) conducted a study examining densities of 0.8, 0.9 or 1.0 square foot per bird. Body weight, feed conversion, mortality, carcass scratches and breast meat yield were significantly improved when birds were given more space. A study by Feddes et al. (2002) demonstrated that when bird density was reduced, live weight and carcass weights were decreased. However, bird uniformity was better at high densities. It was concluded that high yield per unit area and good carcass quality could be achieved at the increased stocking density when adequate ventilation rates were provided.

The impact that proper house environment has on broiler production at higher densities cannot be over emphasized. A recent study conducted by Dawkins et al. (2004) in the United Kingdom examined the effect of stocking densities on bird welfare in commercial facilities from ten different companies. Stocking densities of 6.1, 7.0, 7.8, 8.6, 9.4 pounds per square feet (30, 34, 38, 42, and 46 kg per square meter) were compared. In addition to recording environmental conditions in the broiler house (temperature, relative humidity, ammonia, light intensity, and litter moisture), bird welfare was monitored through mortality, corticosteroid levels (a stress hormone), behavior and health, with an emphasis on leg strength and walking ability. At higher stocking densities the
birds grew slower, were jostled more and had reduced walking ability. While stocking density significantly affected three of the measured variables, environmental management affected seventeen of the nineteen variables measured. It was concluded that while stocking density does affect broiler welfare, the management of the environment in the broiler houses was more important.

Tinoco et al. (2001) conducted an experiment to determine the effects of stocking density (14, 16 and 18 poultry per sq. m) on the performance of broiler chickens grown under water fogging, tunnel ventilation system and sprinkling, in hot summer conditions. They concluded that the thermal environment inside the building at poultry level was not affected (P>0.05) by densities of 14, 16 and 18 poultry per sq. m, although the environment tended to get worse with increasing density. The relative humidity inside the building did not differ (P>0.05) for the three densities; however, it showed values much inferior to those considered as limits for a good poultry raising performance. The bed humidity, weight gain, food conversion, live weight and mortality rate were similar for the studied densities.

While stocking density certainly influences broiler performance and welfare, research indicates that housing environment is extremely important. It might be possible to place broilers at higher densities, but that when this is done, broiler environmental management is crucial to optimize broiler performance and welfare.

Focusing research on adequate space requirements may lead to management changes that would diminish stress and subsequently lead to improved survivability and growth of birds. The optimum stocking density can be described as maximum density of birds in a specific area at which maximum production is achieved by minimum cost without showing any adverse effect on the environment of birds as well as their health. The optimum stocking density can be a useful tool to increase the production by maximizing weight gain, reducing feeding and other costs. The objective of the present study was to
determine the optimum stocking density for maximum growth and production of broiler through cost benefit analysis of small broiler rearing poultry house
Material and Methods

Experimental design

The experiment was performed with poultry house having dimensions of 10 x 5 sq ft, where the main construction material used was bamboo and wire net. The number of prepared poultry houses was fifteen. All equipments necessary for an ideal poultry house were provided to avoid any kind of environmental stress.

The stocking density used in the study were 20, 25, 33, 50 and 100 birds per poultry house (herein called poultry houses $SD_{20}$, $SD_{25}$, $SD_{33}$, $SD_{50}$ and $SD_{100}$) which is equivalent to 2.5, 2.0, 1.5, 1.0 and 0.5 sq ft space per bird. There were three replications of the experiment.

One-day-old chicken of broiler (70 ± 3.5 g) were brought from a local hatchery and introduced at the rate of 20, 25, 33, 50 and 100 birds per poultry house and reared for forty five days production cycle. Commercial feed was bought and given to birds according to normal feeding procedure. All birds were reared following the standard management practices in a poultry house. Growth and survival of birds were recorded at regular interval. Production data was collected at the final harvest.

Feed conversion index

Net weight gain and total feed consumption were recorded at every five days interval. Utilizing this data, Feed conversion index (FCI) was determined according to the following methods.

\[
FCI \, (\%) = \frac{NWG}{TFC} \times 100
\]

Where, NWG = Net weight gain
\[TFC = \text{Total feed consumed}\]
Cost-benefit analysis

Cost benefit analysis (CBA) of production of bird was performed using the method described by Jolly and Clont (1993) as follows.

\[ Y = Y_1 - (a x_1 + b x_2 + c x_3 + d x_4) \]

Where, \( Y = \) Net profit
\( Y_1 = \) Total revenue
\( x_1 = \) Stocking cost
\( x_2 = \) Rearing cost
\( x_3 = \) land rental cost
\( x_4 = \) Interests on input costs

Statistical analysis

A one way ANOVA was used for production data of the birds. If the main effect was found significant, the ANOVA was followed by a LSD (least significance difference) test. All statistical tests were performed at a 5% (\( P < 0.05 \)) probability level using statistical package M-STAT.
Results

Growth
The average weight of bird ranged from 0.44 to 2.40 kg in all stocking densities. The average growth was maximum in SD_{20} (2.25 kg) followed by SD_{25}, SD_{33}, SD_{50}, and SD_{100}. The daily growth rates varied between 0.09 and 0.049 gm per day in different stocking densities employed. The daily growth rate was markedly higher in SD_{20} (Table IX).

Survival
Survival of bird varied largely ranging from eighty five to one hundred percent in five stocking densities employed. No mortality was encountered when the stocking density remained between SD_{25} and SD_{33}, but ninety and eighty five percent mortality were observed in SD_{50} and SD_{100}, respectively (Table IX).

Production
Maximum production of bird (sixty eight kg) obtained in the stocking density of SD_{33} was twenty nine to forty seven percent higher than that observed in the lower stocking density (SD_{20} and SD_{25}) (Table IX). Generally, production of bird tended to rise as a direct function of the stocking density till the density of SD_{33}, further rise in stocking density (SD_{50} and SD_{100}) resulted in thirty three to forty one percent decline of bird production due to over density of bird population and mortality of birds (Figure 12).

Feed conversion index (FCI)
The values of FCI for birds tended to decrease as the stocking density increased. The values ranged from 0.247 to 0.638 (Table IX).

Cost-benefit analysis of production
The construction cost for poultry houses remained the same in all cases of stocking densities. The total production cost increased sharply from Rs. 1820.00 to 5100.00 with increasing stocking density of birds. The total revenue, on the
other hand, increased gradually till SD33 but declined sharply with further rise in density of bird, resulting in no revenue at SD50 and SD100 due to low growth rate and mortality (Figure 13). As a consequence, net profit became maximum at SD33 but showed loss of profit at the next two higher rearing densities of birds (SD50 and SD100).

**Table IX:** Mean (± S.E.) of growth and production criteria of bird in different stocking density employed. Same script among treatments (rows) revealed lack of significant difference.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Stocking densities</th>
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<tbody>
<tr>
<td></td>
<td>SD20</td>
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<tr>
<td>Initial weight (kg)</td>
<td>0.071</td>
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<tr>
<td></td>
<td>±0.0011</td>
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<tr>
<td>Final weight (kg)</td>
<td>2.3 ±0.023</td>
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<tr>
<td>Daily growth rate (kg d⁻¹)</td>
<td>0.049 ±0.002 A</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>100</td>
</tr>
<tr>
<td>Feed conversion index</td>
<td>0.638 ±0.008 A</td>
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<tr>
<td>Production (kg)</td>
<td>46 ±1.7 BC</td>
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</tbody>
</table>
Conclusion

Result of the study clearly revealed that the maximum production was encountered in the SD\textsubscript{33} (1.5 sq ft per bird) density of birds for forty-five days production cycle of broiler rearing. This density of bird rearing appeared to be far more practical according to the working principle for carrying capacity and management of poultry farming because over population causes severe hazards in the environment of the poultry house affecting the health of birds. According to Cravener et al. (1992) the production of broiler varies with population density of birds.

The relationship of production of bird with daily growth rate and food conversion index (FCI) indicated highest production at SD\textsubscript{33} when daily growth rate and food conversion index (FCI) remained 0.044 kg per d and 0.614, respectively, but growth of bird tended to decrease or mortality occurred with increasing density. Bolton et al. (1972) reported that growth performance is related with stocking density of bird.

Critical appraisal of the cost benefit data clearly showed the four levels of response to density of birds (Figure 14). Low growth of profit from SD\textsubscript{20} to SD\textsubscript{25} – low growth of profit density (LGPD), high growth of profit from >SD\textsubscript{25} to SD\textsubscript{33} – high growth of profit density (HGPD), reduced growth of profit from >SD\textsubscript{33} to SD\textsubscript{43} – reduced growth of profit density (RGPD) and negative growth of profit or loss from >SD\textsubscript{43} to SD\textsubscript{100} – negative growth of profit density (NGPD).

Basically the production function is stated as the relationship of a single product and a single resource describing the output level observed as the level of input is varied (Jolly and Clont, 1993). Examination of cost-benefit ratio for production of bird indicated linear increase in the total production cost of bird as a direct function of the density of bird, the total revenue and profit being maximum at the density of birds of 33 (SD\textsubscript{33}). The profit after the level of thirty-three density of birds tended to reduce with increasing density of birds exhibiting zero profit at
density of forty-three birds and loss tended to increase steadily as the number of
birds increased further (Bandyopadhyay et al. 2006a).

Figure 12: Relationship between production and stocking densities of bird
employed.
Figure 13: Cost-benefit analysis in different stocking densities of broiler reared in small poultry house.
Figure 14: Profit curve showing the four levels of response for different stocking densities.