Turkey is a robust large bird raised mostly for meat production. The turkey meat, famous for its leanness and delicacy, is one of the favoured white meats as compared to other commercial avian species. The turkey diets require a narrower energy to protein ratio and to be strictly balanced for sustaining rapid growth and better feed efficiency as compared to chicken (Tyagi 2001). The requirement of protein and energy varies with the strain of turkey, stage of growth and also the environmental temperature. The dietary protein (28% and 26%) and energy (2800 and 2900 kcal/kg diet) values, recommended by NRC (1994) for starting (0–4 week) and grower phase (4–8 week), respectively are much higher than those for chicken. The higher protein levels are required to let birds grow properly though their feed intake is lower initially. Thus turkey rations are costlier and the readymade feed in not available in the market. However, maintaining this level of energy and protein is not possible without the addition of vegetable oil.

Employing the lower protein levels in diets of turkey poults will help reduce the cost of turkey feed as well the reduction of ammonia production which will result in better welfare of birds. On the other hand as result of increasing welfare certifications in poultry industry, welfare considerations pertaining to turkey production are becoming increasingly important (Kijowski et al. 2005). The stocking density is considered as a main factor reflecting on turkey welfare (Marchewka et al. 2013). For commercial turkeys reared for meat, the recommendation is that stocking density should not exceed 34 kg/m² (Pattison et al. 2008). Under high stocking density conditions, the birds suffer from heat stress because the ventilation at the level of the birds gets compromised resulting in lower body heat dissipation from the birds. Though, there are a few inconclusive and contrasting reports pertaining to effects of stocking density on turkey (Majumdar et al. 2003, Abdel-Rahman 2005, Bessei and Gunthner 2006) there has been hardly any systematic research on turkey management in tropical countries like India. Thus, there is a dearth of information on the influence of stocking density of turkey. To our knowledge there is no literature available pertaining to the
effects of floor space vis-a-vis dietary protein supply on the performance of turkey poults under Indian conditions. Keeping in view these facts, the present study was conducted to examine the effects of floor space and dietary protein levels on growth performance, immune-competence and cost economics of growing turkey poults.

**MATERIALS AND METHODS**

The experimental procedures carried out on the birds were approved by Institute Animal Ethics Committee (402/01/ab/CPCSEA). Following a 3x3 factorial design, a total of 288 straight run day-old Beltsville Small White poults of uniform body weight were randomly distributed into 9 experimental groups with 4 replicate in each group in the experimental period. The ingredient and chemical composition of different experimental diets for pre-starter and starter phases are given in Table 1 (NRC 1994).

Table 1. Ingredients and nutrient composition of pre-starter and starter ration of turkey poults

| Feed ingredient   | Pre-starter (0–4 week) | Pre-starter (4–10 week) | Starter (0–4 week) | Starter (4–10 week) |
|-------------------|-------------------------|-------------------------|--------------------|---------------------|
| Maize             | 51.81                   | 46.73                   | 39.64              | 51.99               |
| DORB              | 1.70                    | 0.00                    | 0.00               | 0.00                |
| Soybean           | 42.40                   | 48.90                   | 55.30              | 43.20               |
| Oil               | 0.00                    | 0.50                    | 1.45               | 1.20                |
| Limestone         | 1.00                    | 1.00                    | 1.00               | 1.00                |
| DCP               | 1.95                    | 1.95                    | 1.85               | 1.70                |
| Salt              | 0.30                    | 0.30                    | 0.30               | 0.30                |
| DL-methionine     | 0.15                    | 0.12                    | 0.10               | 0.05                |
| TM. pre-mix*      | 0.10                    | 0.10                    | 0.10               | 0.10                |
| Vit. premix 2**   | 0.15                    | 0.15                    | 0.15               | 0.15                |
| B complex***      | 0.015                   | 0.015                   | 0.015              | 0.015               |
| Ch. chloride      | 0.05                    | 0.05                    | 0.05               | 0.05                |
| Toxin binder      | 0.05                    | 0.05                    | 0.05               | 0.05                |
| Total             | 100                     | 100                     | 100                | 100                 |

*Each g contained 15 mg copper, 250 mg iron, 6 mg iodine, 300 mg manganese and 300 mg zinc. **Each g contained 2.5 IU vitamin B6, 80 g vitamin B12, 80 mg vitamin E, 120 mg niacin and 80 mg calcium pantothenate.

The body weight (BW) and feed intake (FI) were recorded on biweekly basis to arrive at overall weight gain, feed intake and feed conversion ratio (FCR). Daily monitoring of birds was done to record the mortality as and when it occurred. The performance index (PI) of birds during 0–4 week and 4–10 week of age was calculated as per the following formula (Bird 1955):

$$PI = \frac{\text{Body weight gain}^2}{\text{Feed intake}}$$

The cell mediated immune (CMI) response (foot web index to Phytohaemagglutinin, lectin from Phaseolus Vulgaris- PHAP) and humoral immune response (haemagglutination- HA titer to Sheep red blood corpuscles-SRBC) were studied at 31st and 44th day of age by using 10 poults from each treatment. At the end of experimental period, 10 birds from each treatment were selected randomly and slaughtered after 12 h of fasting with ad lib. drinking water for evaluation of immune organ weight on % live weight basis. The feed cost per bird, per kg weight gain, per kg meat produced, and profit potential per meter square (PPM) constituted the cost economic analysis of turkey production. The PPM was calculated as follows:

$$\text{PPM (₹)} = (\text{Cost of meat produced} – \text{Initial cost of poults} – \text{Cost of feed consumed})/\text{m}^2$$

The data obtained from the study were subjected to 2 way ANOVA (Snedecor and Cochran 1989) using SPSS software package (v17.0). The significant mean differences were tested by Duncan’s multiple range test (Duncan 1955).

**RESULTS AND DISCUSSION**

**Growth performance:** The results (Table 2) of body weight gain (BWG), feed intake (FI), and feed conversion (FCR) revealed no significant interaction effect between the stocking density and the dietary protein levels except for the FI of 0–4 week of age, where the combination of 0.8 ft²/bird with 26% protein and 1.0 ft²/bird with 24% and 26% resulted in highest FI of birds. In general, significantly (P<0.01) higher BWG and FI was observed at the floor space of 1.0 ft²/bird, lowest at 0.6 ft²/bird, and intermediate at 0.8 ft²/bird. Similar trend was observed in BWG and FI with respect to different dietary protein levels. However, no effect of either floor space or dietary protein levels was observed on the FCR of turkey poults.

The higher BWG of poults kept at 1.0 ft² floor space may be due to greater space which provides more opportunity for free movements of birds for feeding and watering. High stocking density could increase the ambient temperature, ammonia level and reduce ventilation and heat dissipation from birds (Houshmand et al. 2012). These factors could contribute to lower growth performance of birds. Thus high stocking density causes lower BWG in...
Table 2. Effect of floor space vis-à-vis dietary protein supply on growth performance of growing turkey poults

| Interaction effect | Protein level (%) | Body weight gain (g/b) | Feed intake (g/b) | Feed conversion ratio |
|--------------------|-------------------|------------------------|-------------------|----------------------|
| Floor space (sq. ft) | 0–4 week | 4–10 week | 0–10 week | 0–4 week | 4–10 week | 0–10 week | 0–4 week | 4–10 week | 0–10 week |
| 0.6                | 22              | 234.3                | 1317.1             | 1551.4              | 481.3<sup>a</sup> | 3139.2              | 3800.5              | 2.06           | 2.52           | 2.45           |
|                    | 24              | 291.6                | 1310.2             | 1601.8              | 628.2<sup>b</sup> | 3293.0              | 3921.2              | 2.16           | 2.51           | 2.45           |
|                    | 26              | 308.5                | 1379.4             | 1688.0              | 616.3<sup>c</sup> | 3524.2              | 4140.5              | 2.00           | 2.56           | 2.45           |
| 0.8                | 22              | 215.2                | 1397.4             | 1612.5              | 465.5<sup>a</sup> | 3150.5              | 3976.0              | 2.15           | 2.51           | 2.47           |
|                    | 24              | 293.3                | 1439.3             | 1732.6              | 605.1<sup>b</sup> | 3608.4              | 4213.5              | 2.06           | 2.51           | 2.43           |
|                    | 26              | 326.7                | 1520.8             | 1847.5              | 704.1<sup>c</sup> | 3678.5              | 4382.5              | 2.16           | 2.42           | 2.37           |
| 1.0                | 22              | 262.8                | 1452.2             | 1715.0              | 536.9<sup>b</sup> | 3627.2              | 4164.1              | 2.04           | 2.50           | 2.43           |
|                    | 24              | 333.2                | 1475.1             | 1808.3              | 707.1<sup>c</sup> | 3907.1              | 4614.2              | 2.12           | 2.66           | 2.56           |
|                    | 26              | 344.2                | 1526.6             | 1870.8              | 751.9<sup>c</sup> | 3959.9              | 4711.8              | 2.18           | 2.60           | 2.52           |
| Pooled SEM         |                 | 8.84                 | 19.13              | 24.72               | 19.28               | 47.26               | 61.41               | 0.02           | 0.02           | 0.02           |

Values bearing different superscripts within the column differ significantly; NS, Non-significant.
interaction effect was observed on the PI of poults. Agrawal et al. (2003) reported the better performance index of quail at 5th week of age reared at higher floor space. However, in contrast to this, Majumdar et al. (2003) reported better PI of poults reared at lower floor spaces (<1.0 sq. ft) during pre-starter period but not during the starter period. No literature is available pertaining to the effect of dietary protein levels on the PI of turkey poults.

**Immunity:** The results of immune organ weights and immune response as affected by stocking density and dietary protein levels in turkey poults are given in Table 3. The immune response (cell mediated as well as humoral) revealed no significant effect of stocking density, protein levels or their interaction. Similarly, Heckert et al. (2002), Thomas et al. (2004), and Buijs et al. (2009) reported that stocking density have no effect on immune organ weights of broiler chicken. Kidd et al. (2001) and Cheema et al. (2003) also reported that the relative lymphoid organ weights are not significantly affected by high dietary protein diets (22%) in broilers. Houshmand et al. (2012) reported that stocking density or interaction action between protein level and stocking density had no significant effect on bursa and spleen weights.

**Cost economics:** The results pertaining to the cost economics of turkey production are presented in Table 4. The feed cost per bird significantly (P<0.01) increased linearly with increasing floor space and dietary protein levels. Similarly, the feed cost per kg weight gain and feed cost per kg meat produced significantly (P<0.01) increased linearly with increasing dietary protein levels and no effect of stocking density was observed on them. Further, the profit potential per meter square (PPM) was significantly (P<0.01) highest at floor space 0.6 ft²/bird followed by 0.8 ft²/bird and lowest at 1.0 ft²/bird and no effect of dietary protein level was observed on PPM. None of these cost economics parameters have revealed any interaction effect between stocking density and dietary protein levels. Similar to the results of the present study, Jackson et al. (1982) reported that feed cost per kilogram live weight and returns over
increasing stocking density. Thus, the study recommends
level, the profit potential per meter square increases with
decreasing stocking density and increasing dietary protein
and immunity. Though, the feed cost increases with
without affecting their feed efficiency, mortality pattern,
weight gain, feed intake and performance index of poults
and decreasing the dietary protein level increase the body

| Interaction effect | Floor space (sq. ft) | Protein levels (%) | Feed cost/ bird | Feed cost/ kg wt. gain | Feed cost/ kg meat | PPM |
|--------------------|---------------------|--------------------|-----------------|------------------------|-------------------|-----|
| 0.6                | 22                  | 101.72             | 65.56           | 83.35                  | 2729.72           |     |
|                    | 24                  | 111.04             | 69.36           | 88.53                  | 2718.47           |     |
|                    | 26                  | 125.28             | 74.22           | 94.63                  | 2763.51           |     |
| 0.8                | 22                  | 106.44             | 66.01           | 85.21                  | 2218.66           |     |
|                    | 24                  | 119.34             | 68.94           | 87.71                  | 2434.58           |     |
|                    | 26                  | 132.57             | 71.75           | 92.52                  | 2490.81           |     |
| 1.0                | 22                  | 111.45             | 65.07           | 84.60                  | 1792.64           |     |
|                    | 24                  | 130.67             | 72.45           | 91.83                  | 1981.72           |     |
|                    | 26                  | 142.53             | 76.26           | 97.24                  | 1853.85           |     |
| Pooled SEM         |                     | 2.60               | 0.82            | 0.99                   | 75.33             |     |

Table 4. Effect of floor space vis-à-vis dietary protein supply on cost economics of turkey production

Main effect

| Floor space (sq. ft) | Protein levels (%) | Feed cost/ bird | Feed cost/ kg wt. gain | Feed cost/ kg meat | PPM |
|----------------------|--------------------|-----------------|------------------------|-------------------|-----|
| 0.6                  | 1.0                | 112.68<sup>ab</sup> | 69.71                 | 88.84             | 2737.23<sup>abc</sup> |     |
| 0.8                  | 1.0                | 119.45<sup>ab</sup> | 68.90                 | 88.48             | 2381.35<sup>b</sup> |     |
| 1.0                  | 1.0                | 128.22<sup>a</sup>  | 71.26                 | 91.23             | 1792.64<sup>b</sup> |     |

Protein levels (%)

| Protein levels (%) | Feed cost/ bird | Feed cost/ kg wt. gain | Feed cost/ kg meat | PPM |
|--------------------|-----------------|------------------------|-------------------|-----|
| 22                 | 106.54<sup>a</sup> | 65.55<sup>a</sup>    | 84.39<sup>a</sup>  | 2247.00 |     |
| 24                 | 120.35<sup>a</sup> | 70.25<sup>a</sup>    | 89.36<sup>a</sup>  | 2369.39 |     |
| 26                 | 132.46<sup>a</sup> | 74.07<sup>a</sup>    | 94.80<sup>a</sup>  | 2369.39 |     |

Significance

| Significance | Floor space | Protein level | Interaction |
|--------------|-------------|---------------|-------------|
| Main effect  | P<0.01      | NS            | NS          |
| P<0.01       | NS          | NS            | NS          |
| P<0.01       | NS          | NS            | NS          |

Values bearing different superscripts within the column differ significantly; NS, Non-significant.

feed costs per bird were significantly (P<0.01) affected by dietary protein and energy levels. The lower final body weight is compensated by the production of more number of birds or higher quantity of meat per unit area. Thus the high stocking density results in more profit than the low stocking density (Agrawal et al. 2003, Yausef Al-Ribdawi et al. 2003, Houshmand M, Azhar K, Zulkifli B I M and Kamyab A. 2012, Beg M A H, Baqui M A, Sarker N R and Hossain M M. 2011).

The study concluded that increasing the stocking density and decreasing the dietary protein level increase the body weight gain, feed intake and performance index of poults without affecting their feed efficiency, mortality pattern, and immunity. Though, the feed cost increases with decreasing stocking density and increasing dietary protein level, the profit potential per meter square increases with increasing stocking density. Thus, the study recommends either the floor space of 0.8 ft<sup>2</sup>/bird with 26% dietary protein level or the floor space of 1.0 sq<sup>2</sup>/bird with 24% dietary protein level for better performance of growing turkey poults without compromising the welfare of birds.

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