D-5973
[1-6]

RESEARCH ARTICLE Agricultural Science Digest, Volume Issue : ()

Influence of Seasons on Production Performance of Commercial Layer Chicken in Southern Region of Telangana

V. Kumaravel[1], M. Govardhan Reddy[1], P. Vasanthakumar[1]

10.18805/ag.D-5973

ABSTRACT

Background: Effective management strategies and feeding practices are essential for mitigating the challenges presented by the extreme temperatures of the summer season and the increased humidity and disease risk during the wet season. Adapting to these seasonal variations is crucial for maintaining a successful and profitable layer chicken farming.

Methods: Influence of seasons (summer, rainy and winter) on production performance of layer chickens in different production cycles (Phase I, II, III and IV) was studied. The commercial layer chicken farms from southern Telangana region were selected with bird capacities ranging from 1.0 to 1.5 lakhs, rearing BV-300 breeds, aged 19-83 weeks, housed in elevated cage systems were randomly chosen. The data was collected from farm records, pre-structured questionnaires and personal interviews.

Result: Summer (Phase I: 19-30 weeks) showed decreased egg production (70.57%), increased broken eggs (1.50%) and lower livability (99.95%). Egg production showed improved performance during the winter (90.22%) and rainy seasons (89.40%) in Phase II (31-50 weeks), highlighting the importance of seasonal adjustments for enhancing productivity. Phase III (51-72 weeks) also demonstrated rainy and winter seasons consistently yielding better results, with rainy season notably excelling in higher egg production (89.70%). Phase IV (72 weeks and above) highlighted winter's superiority in egg production (79.70%) and reduced broken eggs (0.57%), emphasizing the importance of adapting poultry farming practices to mitigate the climatic variability.

Key words: Layer chicken, Poultry, Production performance, Season.

INTRODUCTION

The poultry industry in India has emerged as the most dynamic and rapidly expanding segment of livestock economy as evident from the production level touching about 138.38 billion eggs during 2022-23 registered a growth of 33.31% over the past 5 years as compared to the estimates of 103.80 billion numbers during 2018-19. In terms of annual growth rate is 6.77% during 2022-23 over 2021-22 (BAHS, 2023). The total egg production comes from Andhra Pradesh with a share of 20.13% of total egg production followed by Tamil Nadu (15.58%), Telangana (12.77%), West Bengal (9.94%) and Karnataka (6.51%).

The poultry industry in the Telangana region of India has undergone substantial growth and transformation, becoming a fundamental component of the regional economy (Nasreen and Ahmed, 2017). Commercial layer chickens, specialized for egg production, constitute an indispensable segment of this industry. However, their performance is intricately linked to seasonal variations and the specific feeding management practices employed in the region. The Southern Telangana region experiences distinct seasonal changes, each of which significantly influences the feeding practices and production performance of commercial layer chicken farms. These seasons include summer, rainy and winter, each presenting a unique set of challenges and opportunities for commercial layer chicken farming.

During the hot summer months, elevated temperatures and low humidity levels pose numerous challenges for commercial layer chicken farms. To mitigate the adverse effects of heat stress, farmers must make adjustments to their feeding practices. Providing a well-balanced diet with appropriate nutrient proportions is crucial for supporting egg production while minimizing heat-induced stress. High temperatures can lead to reduced egg production due to heat-related stress and egg quality may also be compromised (Kim *et al*., 2024). Slower chicken growth due to decreased feed intake can affect the farm's overall profitability. Selecting appropriate broiler strains during the tropical summer is crucial to maximizing their potential. In addition, selecting the right poultry strains during the tropical summer is vital for achieving their maximum potential (Singh *et al*., 2018).

The rainy season brings heavy rainfall and increased humidity, creating favourable conditions for diseases. Maintaining robust biosecurity and disease prevention practices is imperative during this period. The higher humidity levels can adversely affect eggshell quality by

[1]Department of Animal Nutrition,Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Namakkal-637 002, Tamil Nadu, India.

Corresponding Author: V. Kumaravel, Department of Animal Nutrition, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Namakkal-637 002, Tamil Nadu, India. Email: drkumaravelv@gmail.com

How to cite this article: Kumaravel, V., Reddy, M.G. and Vasanthakumar, P. (2024). Influence of Seasons on Production Performance of Commercial Layer Chicken in Southern Region of Telangana. Agricultural Science Digest. doi: 10.18805/ag.D-5973.

Submitted: 19-02-2024 **Accepted:** 01-08-2024 **Online:** 02-09-2024

softening the shells (Raju Jakkula, 2019). Farms must diligently monitor egg quality during the monsoon and implement measures to prevent soft-shelled eggs. Additionally, monsoon rains can create muddy and wet conditions on farms, posing challenges for both the birds and the farmers.

The winter season introduces a different set of challenges, primarily due to increased humidity and the associated disease risk. Farmers must adapt their feeding practices accordingly. Elevated humidity can lead to mould growth in feed, necessitating proper feed storage to prevent contamination. High humidity levels may also impact eggshell quality and the disease risk can result in decreased egg production (Li *et al*., 2020). Ammonia concentration in poultry houses can impact the growth performance of poultry during the winter season (Proch *et al*., 2018). Moreover, seasonal factors (Patra Kumar *et al*., 2017) and appropriate nutrient management (Kumaravel *et al*., 2023) must be carefully considered when raising improved backyard and native birds to achieve optimal production performance.

Understanding the complex dynamics of feeding management and its impact on layer chicken productivity in varying seasons holds paramount significance. Studies on seasonal variations will help elucidate best practices, seasonal adaptations and potential enhancements in feeding management strategies aimed at optimizing the production performance. Hence, the present study was aimed to explore the production performance of commercial layer chickens in different seasons in southern region of Telangana.

MATERIALS AND METHODS

This present study was carried out in the southern region of Telangana state, encompassing the districts of Medchal-Malkajgiri, Wanaparthy, Yadadri Bhuvanagiri, Jogulamba Gadwal, Mahabubnagar, Nagarkurnool, Nalgonda, Suryapet, Narayanpet, Rangareddy and Vikarabad. The area experiences an annual rainfall ranging from 610 to 850 mm, with winter and summer temperatures ranging between 20°C-26°C and 32°C-38°C, respectively (TSDPS and DES, 2022).

Climatic condition and seasons

The southern Telangana region undergoes distinct seasonal changes, including hot summers and a monsoon season. The highest mean maximum temperature (40.9°C) occurs in May, while the lowest (30.5°C) is observed in December. The average relative humidity across the year is 62%, with the highest at 89% and the lowest at 39%. The year is divided into summer (March-June), rainy (July-October) and winter season (November-February).

Birds and housing

Ten commercial layer chicken farms, seven from Mahabubnagar and three from Rangareddy district, were selected randomly for this study. These farms have an average capacity ranging from 1.0 to 1.5 lakhs birds and they reared BV-300 breeds. The data collection was carried out for layer birds aged 19-83 weeks during the year 2022-23. The birds were housed in elevated cage systems and relied mainly on natural daylight, with supplemental lighting provided using 60 W bulbs. Routine vaccination and preventive measures were implemented following standard protocols.

Feeding management

The feeding regimen involved maize and soybean meal-based chick crumble feed for day-old chicks to 9 weeks of age. Grower or developer feed was provided from 10 to 15 weeks of age, followed by pre-lay feed from 16th to 18th

Table 1: Nutrient composition of diets followed in different phases.

Nutrients (%)	Chick	Grower/Developer	Pre-layer	Phase I	Phase II	Phase III	Phase IV
ME Kcal/kg	2900	2700	2700	2575	2545	2545	2435
Crude protein	19.00	17.00	17.00	16.63	15.75	15.23	14.58
Crude fibre	5.17	6.20	5.48	5.41	5.44	5.39	5.89
Ether extract	2.80	2.18	2.66	2.57	2.12	2.14	2.04
Calcium	1.04	1.02	2.49	3.86	4.00	4.21	4.16
Av. Phosphorus	0.47	0.42	0.45	0.40	0.35	0.32	0.28
Dig. Lysine	0.90	0.70	0.75	0.67	0.64	0.61	0.57
Dig. Methionine	0.41	0.31	0.30	0.36	0.30	0.27	0.24
Dig. Cystine	0.27	0.25	0.25	0.25	0.24	0.24	0.23
Dig. Met +Cyst	0.68	0.56	0.56	0.61	0.54	0.51	0.46
Dig. Threonine	0.63	0.51	0.53	0.51	0.48	0.46	0.43
Dig. Tryptophn	0.19	0.16	0.17	0.16	0.15	0.14	0.14
Sodium	0.20	0.18	0.18	0.17	0.16	0.16	0.15
Chloride	0.22	0.18	0.18	0.17	0.16	0.16	0.16
Potassium	0.98	1.04	0.96	0.93	0.91	89.00	93.00
Linoleic acid	0.16	1.27	1.52	1.45	1.22	1.23	1.17
Choline chloride g/kg	1.50	1.50	1.50	1.43	1.32	1.29	1.27

weeks of age (Table 1). The layer Phase-I, Phase-2, Phase-3 and Phase-4 mash feed were administered from 19-30, 31-50, 51-72 and 73 weeks of age and above, respectively, following the nutrient specifications of breeder (BV-300).

Production performance

The data on production performance of commercial layer chickens in various seasons (summer, rainy and winter) and different phases (Phase I, II, III and IV) was collected and analysed using the following metrics (Dilawar *et al*., 2021).

Hen day egg production

Hen day egg production (HDEP) was calculated as the percentage of the number of eggs laid to the number of hen days.

$$\text{HDEP (\%)} = \frac{\text{(Number of eggs laid}}{\text{Number of hen days)}} \times 100$$

Broken eggs

The number of broken eggs was calculated for each phase and expressed in percentage.

Feed intake

Feed intake was calculated as the difference between the initial feed offered to birds and the feed left over.

Egg weight

Egg weight was determined by weighing individual eggs collected with the use of electronic balance.

Livability

Livability of the birds was calculated based on the recorded mortality for each phase, expressed as a percentage.

Data collection and Statistical analysis

The data was collected from farm records, pre-structured questionnaires and personal interviews. All data were processed using generalized linear matrix procedure in SPSS, Version 22.0. Statistical analysis of the data was performed following the methodology outlined by Snedecor and Cochran (1994) and statistically differences among the groups were determined by Duncan's multiple range test. A probability of $p<0.05$ was considered significant.

RESULTS AND DISCUSSION

The influence of various seasons (summer, rainy and winter) on production performance of commercial layer chickens during phase I, phase II, phase III and phase IV are presented in Tables 2, 3, 4 and 5, respectively.

Influence of season on production performance of commercial layer chicken during phase I (19-30 weeks)

Data in Table 2 showed that the Hen day egg production (HDEP) was significantly lower during the summer season compared to the rainy and winter seasons. Furthermore, the incidence of broken eggs was higher and the lowest livability percentage was observed during the summer season. Though no significant difference in feed intake was observed during this phase, a reduction in feed intake (3.74%) was noted during the summer. In contrast, egg weight was higher in the rainy (58.74 g) and winter seasons (58.00g). Overall, production performance was notably superior in the rainy and winter seasons during this Phase I production cycle (19-30 weeks) of commercial layer chickens.

A reduction in feed intake has been documented to have significant implications for the availability of calcium in the blood for eggshell formation (Robert, 2004). Additionally, the decrease in the strength and thickness of eggshells in heat stressed hens can be associated to a reduction in the levels of free ionized calcium in the blood stream (Alexey and Viktor, 2021).

In summer season, when poultry experiences heat stress, there is a decrease in their dietary calcium intake,

Table 2: Influence of season on production performance of commercial layer chicken during phase I (19-30 weeks).

Season	Number of hens	HDEP %	Broken egg %	Feed intake / bird (g)	Egg weight (g)	Livability (%)
Summer	24,136	70.57^{a}	1.50^{c}	93.93	48.51	99.95^{a}
Rainy	38,517	80.72^{b}	0.37^{a}	94.63	49.92	100.00^{c}
Winter	30,369	83.71^{b}	0.98^{b}	97.58	49.30	99.98^{b}
SEm±		0.940	0.050	0.700	0.250	0.002
P-value		0.001	0.001	0.069	0.182	0.001

Means with at least one common superscript in a column do not differ significantly (P>0.05).

Table 3: Influence of season on production performance of commercial layer chicken during phase II (31-50 weeks).

Season	Number of hens	HDEP %	Broken egg %	Feed intake / bird (g)	Egg weight (g)	Livability (%)
Summer	26,853	88.49^{a}	0.70^{a}	106.43	55.03^{a}	99.96^{a}
Rainy	31,879	89.40^{ab}	1.14^{b}	106.90	55.60^{b}	100.00^{c}
Winter	47,869	90.22^{b}	1.22^{b}	107.77	55.57^{b}	99.98^{b}
SEm±		0.250	0.022	0.297	0.054	0.001
P-value		0.022	0.001	0.176	0.001	0.001

Means with at least one common superscript in a column do not differ significantly (P>0.05).

leading to both bone resorption and the development of hypophosphatemia. In this condition inhibits the formation of calcium carbonate ($CaCO_3$) in the uterine glands of laying hens. This inhibition occurs because more blood is diverted to the skin for cooling, resulting in reduced blood flow to the uterus and a diminished supply of calcium to this organ (Chauhan and Roy, 2007). The end consequence is the production of eggs with sub optimal shell quality led to more broken eggs.

The elevation of corticosterone during bird stress is a well-documented phenomenon. In Leghorn birds, heat stress diminishes luteinizing hormone and hypothalamic gonadotropin-releasing hormone due to heightened prolactin levels. This sequence of events triggers ovarian regression (Rozenboim *et al*., 2007) and shifts lymphocyte counts, leading to a higher heterophil ratio. As a result, immunity levels in laying birds become compromised.

The present study results are concurrent with Abdullahi *et al*. (2021) revealed that cold season is the best production season for layer chickens at 20 weeks of age with better external and internal egg qualities.

Influence of season on production performance of commercial layer chicken during phase II (31-50 weeks)

The data showed that (Table 3) the HDEP, broken eggs, egg weight and livability per cent were shown significant (P<0.05) seasonal influence except feed intake during this phase II production cycle of commercial layer chickens. HDEP was higher significantly in winter (90.22%) than in rainy (89.40%) and summer (88.49%) seasons. Intriguingly, the incidence of broken eggs was reduced in the summer (0.70%) compared to other seasons. Egg weight and livability percentages were improved in the rainy (55.60 g and 100%) and winter (55.57% and 99.98%) seasons. The overall production performance was better in the winter and rainy seasons during this Phase II production cycle (31-50 weeks) of commercial layer chickens.

The present study demonstrated that feed intake, egg weight, feed conversion ratio and hen-day egg production were all significantly affected by changing seasons. During the rainy season (August-November), when temperatures were relatively lower, feed intake was observed to be higher, while the lowest values were recorded in the dry season, characterized by higher temperatures. The findings from present study supported with the research conducted by Bell, (2002) and Korankye *et al*. (2020).

Moreover, earlier research conducted by Nayak *et al*. (2015) emphasized the strong relationship between climatic conditions and egg production in broiler breeder poultry over 40 weeks. Factors such as wind velocity and afternoon relative humidity (RH) were found to create favourable conditions for birds, leading to increased egg production. Besides, longer periods of bright sunshine had a stimulating effect on laying hens, resulting in higher egg production, as noted by Sheridan (1990). Conversely, unfavourable factors including rainfall, morning RH, temperature and rainy days were less conducive for breeder hens during that period, potentially leading to reduced production. Higher rainfall and RH were also associated with increased disease incidence within the flock, negatively impacting production (Moreda *et al*., 2014).

Influence of season on production performance of commercial layer chicken during phase III (51-72 weeks)

During phase III production cycle of commercial layer chicken was significantly (*P<0.05*) influenced by various seasons of all studied parameters viz. HDEP, broken eggs, feed intake, egg weight and livability per cent (Table 4). The best performance was noted during rainy and winter than summer season. A broken number of eggs (1.49%) are

Table 4: Influence of season on production performance of commercial layer chicken during phase III (51-72 weeks).

Season	Number of hens	HDEP %	Broken egg %	Feed intake / bird (g)	Egg weight (g)	Livability (%)
Summer	29,963	82.27^{a}	0.94^{a}	106.90^{a}	55.06^{a}	99.96^{a}
Rainy	28,734	89.70^{c}	1.25^{b}	106.07^{a}	57.16^{b}	100.00^{c}
Winter	48,354	86.86^{b}	1.49^{c}	109.58^{b}	57.09^{b}	99.97^{b}
SEm±		0.179	0.019	0.333	0.098	0.001
P-value		0.001	0.001	0.001	0.001	0.001

Means with at least one common superscript in a column do not differ significantly (P>0.05).

Table 5: Influence of season on production performance of commercial layer chicken during phase IV (73 weeks and above).

Season	Number of hens	HDEP %	Broken egg %	Feed intake / bird (g)	Egg weight (g)	Livability (%)
Summer	47,251	71.57^{a}	1.71^{b}	95.58^{a}	56.46^{a}	99.95^{a}
Rainy	40,279	78.88^{b}	1.67^{b}	106.08^{b}	58.74^{c}	100.00^{c}
Winter	29,941	79.70^{b}	0.57^{a}	110.45^{c}	58.00^{b}	99.97^{b}
SEm±		0.597	0.086	0.709	0.094	0.001
P-value		0.001	0.001	0.001	0.001	0.001

Means with at least one common superscript in a column do not differ significantly (P>0.05).

also observed during winter season. The feed intake and egg weight were increased during winter (106.90 g and 57.16 g) and rainy season (106.07 g and 57.16 g) and livability were also higher during rainy (100%) season. The overall production performance was better noticeably in rainy season and deprived production performance was recorded in summer during this phase III production cycle (51-72 weeks) of commercial layer chickens.

The enhancement of egg production was reported when the birds housed under artificial LED lighting exhibited notable improvements in reproductive hormones and metabolic enzymes, including T_3, T_4, GnRH, LH, FSH, cortisol and catalase enzyme levels (Fazal *et al*., 2020).

Influence of season on production performance of commercial layer chicken during phase IV (72 weeks and above)

Data in Table 5 showed that the production performance during phase IV of production cycle of layer chickens in terms of HDEP, broken eggs, feed intake, egg weight and livability per cent were influenced significantly (*P<0.05*) by various seasons. HDEP was higher during winter (79.70%) followed by rainy (78.88%) than summer (71.87%) season. Interestingly broken eggs (0.57%) were reduced during winter season. The feed intake and egg weight were higher in winter and rainy season noticeably reduced feed intake (95.58g) and egg weight (56.46 g) were observed during summer season. The livability (99.95%) per cent was also lower during summer season.

The overall production performance was better during the winter season, with reduced performance observed in the summer during this Phase IV production cycle (72 weeks and above) of commercial layer chickens.

Similarly, Kumar *et al*. 2007 reported that among different age groups, the influence of ambient temperature was more in aged (more than 60 weeks) and adult birds (41 to 60 weeks). Layer chickens aged, 21 to 40 weeks exhibited well tolerance to heat stress in terms of egg production but not in terms of livability %.

Feeding management practices should be focused on formulating and adjusting the nutritional composition of layer feed to better suit the changing needs of hens during different seasons. This includes modifying the energy, protein and mineral content of the feed to account for variations in temperature, daylight hours and egg production rates.

However, the effectiveness of these practices will vary with several factors including the duration and intensity of heat, relative humidity, air velocity, breed and age of birds. Hence, there is a need to strengthen the feeding and management strategies on how to reduce the effects of seasonal fluctuations on poultry production.

CONCLUSION

The study found that seasons significantly impact the production performance of layer chickens across different phases of their production cycle. In Phase I (19-30 weeks), summer led to reduced egg production, increased broken eggs and lower livability. In Phase II (31-50 weeks), winter and the rainy season improved performance, with the rainy season showing particularly good results in Phase III (51-72 weeks). Phase IV (72 weeks and above) favored winter for egg production and reduced breakage. The study emphasizes the importance of seasonally tailored feeding and management to optimize productivity. It also suggests that further research should consider regional climate differences and the economic implications of seasonal adjustments.

ACKNOWLEDGEMENT

The authors are grateful to Tamil Nadu Veterinary and Animal Sciences University, Chennai for the support to carry out this study.

Conflict of interest

The authors declare that there are no conflicts of interest.

REFERENCES

Abdullahi, A.U., Abubakar, A., Chafe, U.M., Aliyu, S., Bello, A. (2021). Influence of production seasons on egg quality characteristics of layers in semi-arid sokoto, north-western nigeria. Journal of Biotechnology and Bioengineering. 5: 13-18.

Alexey Kavtarashvili and Viktor Buyarov. (2021). The reasons for the deterioration of chicken eggshell quality at high temperatures: A review. E3S Web of Conferences 247, 01015. ICEPP-2021. https://doi.org/10.1051/e3sconf/202124701015.

BAHS, (2023). Basic Animal Husbandry Statistics, Government of India Ministry of Fisheries, Animal Husbandry and Dairying, https://dahd.nic.in/sites/default/filess/BAHS 2023.pdf.

Bell, D.D. (2002). Egg handling and egg breakage. In: Bell DD, Weaver W D Jr, editors. Commercial Chicken Meat and Egg Production. 5th ED. Spring City, New York, USA: Springer. 1091-1105.

Chauhan, H.V.S. and Roy, S. (2007). Nutritional Diseases. In: Poultry Diseases Diagnosis and Treatment. 3rd Ed. New Age International (P) Ltd., Publisher New Delhi 110002. 172.

Dilawar, M.A., Mun, H.S., Rathnayake, D., Yang, E.J, Seo Y.S, Park, H.S, Yang, C.J. (2021). Egg quality parameters, production performance and immunity of laying hens supplemented with plant extracts. Animals (Basel). 11(4): 975. doi: 10.3390/ani11040975. PMID: 33807460; PMCID: PMC8066455.

Fazal, R., Hussain, J., Mahmudi, A., Javed, K. (2020). Effect of light sources on productivity, welfare aspects and economic evaluation of commercial layers. Turkish Journal of Veterinary and Animal Sciences. 45: 176-190.

Kim, H.R., Ryu, C., Lee, S.D., Cho, J.H., Kang, H. (2024). Effects of heat stress on the laying performance, egg quality and physiological response of laying hens. Animals. 14(7): 1076. https://doi.org/10.3390/ani14071076.

Korankye, O., Kagya-Agyemang, J.K., Annor, S.Y., Asabere-Ameyaw, A. and Clement G.K. (2020). Effect of season and different dietary protein level on production and reproductive performance and egg characteristics of indigenous guinea fowl (Numida meleagris) in the middle belt of ghana. World Journal of Advanced Research and Reviews. 08: 317-329.

Kumar, V.R.S., Natarajan, A., Selvam, S., Chandrasekaran, D. (2007). Influence of ambient temperature on the performance of egg type chicken. Indian Journal of Poultry Science. 42: 174-178.

Kumaravel, V., Mohan, B., Natarajan, A., Murali, N., Selvaraj, P., Vasanthakumar, P. (2023). Effect on growth performance, carcass traits and myostatin gene expression in aseel chicken fed varied levels of dietary protein in isocaloric energy diets. Tropical Animal Health and Production. 55: 82(2023). https://doi.org/10.1007/s11250-023-03505-7.

Li, D., Tong, Q., Shi, Z., Zheng, W., Wang, Y., Li, B., Yan, G. (2020). Effects of cold stress and ammonia concentration on productive performance and egg quality traits of laying hens. Animals. 10(12): 2252. https://doi.org/10.3390/ani10122252.

Moreda, E., Singh, H., Sisaye, T., Johansson, A.M. (2014). Phenotypic characterization of indigenous chicken population in South West and South part of Ethiopia. British Poultry Science. 3: 15-19.

Nasreen Fatima and Badiuddin Ahmed. (2017). The role of poultry Industry-A study of telangana state. International Journal of Advanced Scientific Research and Management. 2(6): 27-29. https://ijasrm.com/wp-content/uploads/2017/06/IJASRM_V2S6_251_27_29.pdf.

Nayak, G.D., Behura, N.C., Sardar, K.K., Sardar, K.K., Mishra, P.K. (2015). Effect of climatic variables on production and reproduction traits of colored broiler breeder poultry. Veterinary World. 8:472-477.

Patra, K.M., Hajra, D.K., Das, R.K., Sarkar, P., Deka, C.B. (2017). Effect of season on growth and reproduction performance of improved backyard poultry in North Eastern Hill Region. Indian Journal of Animal Research. 52(7): 1071-1076. doi: 10.18805/ijar.v0iOF.9122.

Proch, A., Dalpat, M.S., Singh Y., Sandhu, S.K., Sharma, A., Sethi, A.P.S. (2018). Effect of litter and dietary amendments on ammonia concentration, broiler performance and litter quality in winter. Indian Journal of Animal Research. 53(7): 973-978. doi: 10.18805/ijar.B-3619.

Raju Jakkula. (2019). Management of layer birds in rainy season-role of feed acidifier. Indian Poultry Review. https://indianpoultryreview.com/2021/08/06/management-of-layer-birds-in-rainy-season-role-of-feed-acidifier.

Robert, J.L. (2004). Factors affecting egg internal quality and shell quality. Journal of Applied Science 41:161-177.

Rozenboim, I., Tako, E., Gal-Garber, O., Proudman, J.A. and Uni, Z. (2007). The effect of heat stress on ovarian function of laying hens. Poultry Science 86:1760-1765.

Sheridan, A.K. (1990). Genotype x environment interactions. In: Crawford R.D, editor. Poultry Breeding and Genetics. 1st ED. Amsterdam, The Netherlands: Elsevier Science Publishers, BV, Sara Burgerhartstraat. pp 897-909.

Singh, K.D., Singh, K.V., Paswan, K.V. (2018). Comparative production performance of hubbard, vencobb and Vencobb-400 broiler strains during tropical summer season. Indian Journal of Animal Research. 53(5): 685-688. doi: 10.18805/ijar.B-3553.

Snedecor, G.W. and Cochran, W.G. (1994). Statistical methods (eighth edition). Calcutta, India: Oxford and IBH Publishing Co.

Tsdps and Des. (2022). Weather and climatology of Telangana. Telangana State Development Planning Society (TSDPS) /Directorate of Economics and Statistics (DES). Khairathabad, Hyderabad-500 004. https://www.tsdps.telangana.gov.in.