The Pharma Innovation Journal 2022; 11(12): 2870-2873

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 2870-2873

www.thepharmajournal.com
Received: 15-09-2022
Accepted: 18-10-2022

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Effect of high temperature on commercial traits of silkworm, *Bombyx mori* L.

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Abstract
In the present investigation, effect of high temperature on the commercial traits of twelve bivoltine silkworm breeds was studied at Silkworm Research Laboratory of SKUAST-Jammu during Spring 2022. The silkworm larvae were reared at recommended rearing conditions until 2nd day of fifth instar. From 3rd day onwards the larvae were divided into two batches and subjected to high temperatures *viz.*, 30±1 °C and 35±1 °C for six hours, respectively every day until spinning, along with control batch which were reared at ambient temperature (25±1 °C). Highly significant differences were recorded in silkworm breeds in the treated groups with respect to larval weight, pupation rate and cocoon yield. On the basis of results recorded, four silkworm breeds i.e., U-3, U-4 and ND_5 were found having the potential for thermotolerance.

Keywords: High temperature, commercial traits, silkworm, *Bombyx mori* L.

1. Introduction
Temperature is considered as a foremost factor in establishing the growth, reproduction and distribution of organisms in most environments. Organisms employ diverse adjustments at multiple levels of biological organization to deal with the variable nature of the thermal environment (Bhattacharjee, 2008) [2]. The ability of organisms to acquire thermotolerance to normally lethal temperature is an ancient and conserved adaptive response (Hong and Vierling, 2000) [3]. Being poikilothermic in nature silkworm, *Bombyx mori* L. (Lepidoptera: Bombycidae) is vulnerable to high temperature (Benchamin and Jolly, 1986) [1]. Due to continuous domestication silkworm has lost its natural tolerance to environmental fluctuations and become prone to number of diseases which results in severe loss in cocoon production.
Temperature has a direct correlation with the growth of silkworm. The rise in temperature fastens the physiological development and decrease in temperature results in retardation of physiological development of silkworm (Rahmathulla *et al.*, 2004) [10]. Increased temperature during rearing accelerated the larval growth and shortens the larval period especially in late instars. It is well known fact that the late age silkworm larvae prefers relatively lower temperature than young age and fluctuation of temperature during different stages of larval development is more favourable for growth and development of larvae than constant temperature. Sarkar *et al.*, 2018[11] suggested that 24-28ºC temperature is ideal for the growth of silkworm larvae. He also added that silkworm larvae require comparatively higher temperature in first two instars. It is reported that silkworm larvae consume only 1 per cent of mulberry leaves during first and second instar. Due to less consumption of mulberry leaves during first and second instar, the activity of enzymes involved in breakdown of food slows down that resulted in less generation of heat in the silkworm body. Therefore, it is essential to provide optimum temperature for successful cocoon crop production. However, in case of fourth and fifth instar silkworm larvae reverse trend was observed where silkworms consumed almost 94 per cent of total mulberry leaves (Krishnaswami, 1978) [5] and subsequently it increased the body temperature of silkworm larvae and amount of CO_2 gas excreted also increased with the rise of the temperature. Therefore, it is important to maintain comparatively lower temperature in the rearing room during late instar stages.
Based on voltinism, silkworm breeds are classified as univoltine, bivoltine and multivoltine. Being tropical in origin multivoltine can tolerate high temperature conditions and produce poor quality silk whereas bivoltine of temperate origin are prone to high temperature conditions but able to produce silk of good quality.

Several attempts have been made to spread temperate silkworm strains throughout the sericulture belt of India but resulted in extensive crop loss due to hot and humid climatic conditions of subtropics. At high temperature, many quantitative characters tends to decline, thus it is necessary to develop stress and disease tolerant breeds along with high yielding attributes which can survive very well by overcoming environmental stress. The present study was intended to investigate the level of tolerance of selected silkworm breeds to high temperature during fifth instar larval stage.

2. Methodology

The experiments were carried out to evaluate twelve bivoltine silkworm breeds *viz.*, WM, ND_5, NB_4D_2, U-4, PO_1, ND_3, U-6, CSR_2, SH_6, SPO, U-3 and NSP against high temperature treatments during spring 2021-22 at Sericulture Research Laboratory, Division of Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu. The silkworm eggs were incubated under optimum temperature of 25±1ºC with 80±5% of relative humidity. The newly hatched worms were reared as per rearing method suggested by Krishnaswami, 1978 [5]. The larvae were reared in three replications in Completely Randomised Design. In each replication, 100 larvae were maintained. All the batches were reared upto the second day of fifth instar in the recommended rearing conditions. From the third day of fifth instar, these breeds were subjected to high temperature treatments of 30±1 °C and 35±1 °C for six hours till spinning. A control batch was also maintained during the experiment which was reared at ambient temperature (25±1 °C). The biological oxygen demand (BOD) incubator was used to provide temperature as per the treatments. After thermal treatment, the treated silkworm larvae were shifted to the mountage for the spinning at normal temperature of 25±1 °C with relative humidity of 65±5%. Cocoons were harvested 6 days later after completion of cocoon spinning. The pupation rate was utilized as the measure of index for accessing thermotolerance by calculating the number of healthy live pupae obtained relative to the number of larvae at the beginning of the treatment both in treated and control groups.

2.1 Observation recorded on commercial traits

During the study, data on larval weight (g), pupation rate (%), cocoon yield by weight (kg) for 10,000 larvae, were recorded following Kumari *et al.*, 2011[9].

2.1.1 Larval weight (g): Mean larval weight (g) recorded for 10 randomly selected larvae at the peak of growth of fifth instar larvae from each replication and average weight was recorded on digital balance in each breed.

2.1.2 Pupation per cent: The live pupa present inside the cocoon during metamorphosis of larvae into pupa expressed as a percentage. (Pupation per cent = Number of good cocoons + (Number of double cocoons×2)/Total number of larvae retained after third moult×100).

2.1.3 Cocoon yield by weight (Kg) per 10,000 larvae: The mean weight of the cocoon harvested in kilogram (kg) for every 10,000 larvae by weight. (Cocoon yield by weight = Cocoon yield in kg/ Total number of larvae retained after third moult×10,000).

3. Results

Significant variations were recorded for larval weight (g), pupation rate (%) and cocoon yield by weight (Kg) per 10,000 larvae in twelve silkworm breeds at high temperature.

3.1 Larval weight (g)

At 25±1 °C, the mature larval weight ranged from 35.97 to 39.21g. U-3 breed recorded significant highest larval weight (39.21g) followed by U-4 (38.89g) and ND_5 (38.79g) and lowest larval weight was observed in PO_1 (35.97g). At 30±1 °C, the larval weight ranged from 28.13 to 33.58g, the maximum (33.58g) was observed in U-3 breed followed by U-4 (33.15g) and ND_5 (33.02g) and the minimum larval weight was recorded in PO_1 (28.13g). At 35±1 °C it ranged from 21.68 to 29.45g and the highest larval weight was found in breed U-3 (29.45g) followed by U-4 (29.25g) and ND_5 (29.14g), while the lowest larval weight was observed in PO_1 (21.68g). Significant decrease in larval weight of silkworm breeds was recorded with the increase in temperature (Fig. 1).

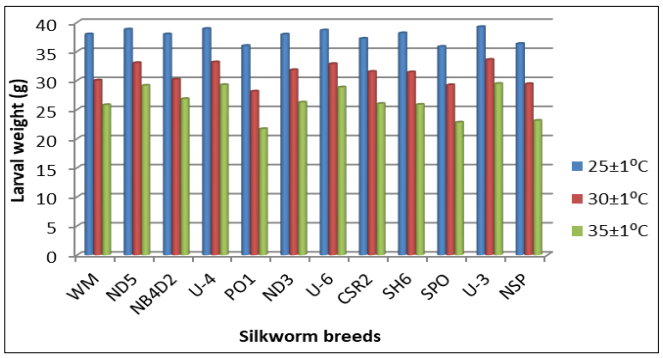

Fig 1: Larval weight of silkworm breeds at different temperatures

3.2 Pupation per cent

At 25±1 °C, the pupation per cent ranged from 91.25 to 93.31 per cent and the highest pupation per cent was recorded in U-3 breed (93.31%) followed by U-4 (93.22%) and ND_5 (93.19%) and the lowest pupation per cent was observed in breed PO_1 (91.25%). At 30±1 °C, it ranged from 70.25 to 77.20 per cent, the maximum pupation per cent was found in U-3 breed (77.20%) followed by U-4 (76.81%) and ND_5 (76.44%), whereas the minimum pupation per cent was observed in PO_1 (70.25%). At 35±1 °C, pupation per cent was ranged from 53.72 to 72.16 per cent and the highest was recorded in U-3 breed (72.16%) followed by U-4 (71.95%) and ND_5 (71.84%) and lowest was found in PO_1 (53.72%) (Fig. 2)

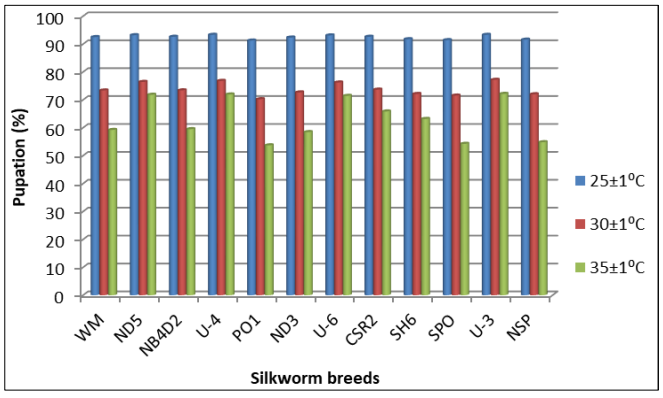

Fig 2: Pupation per cent of silkworm breeds at different temperatures

3.3 Cocoon yield by weight (kg) per 10,000 larvae

The cocoon yield by weight (Kg) per 10,000 larvae ranged from 13.71 to 17.24 Kg at 25±1 °C and the maximum yield was recorded significantly highest in U-3 breed (17.24 Kg) followed by U-4 (16.86 Kg) and ND_5 (16.82 Kg). At 30±1 °C, the cocoon yield was recorded in the ranged from 7.92 to 12.70 Kg and the highest cocoon yield was observed in breed U-3 (12.70 Kg) followed by U-4 (12.41 Kg). At 35±1 °C, the cocoon yield was observed in the range from 6.66 to 11.54 Kg and the maximum yield was observed in breed U-3 (11.54 Kg) followed by breed U-4 (11.19 Kg). The lowest yield was observed in PO_1 breed with the cocoon yield of 13.71, 7.92 and 6.66 Kg at 25±1 °C, 30±1 °C and 35±1 °C, respectively (Fig. 3).

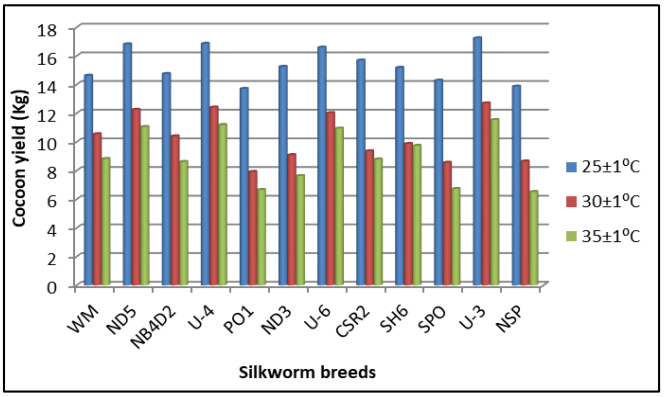

Fig 3: Cocoon yield (Kg) of silkworm breeds at different temperatures

Discussion

The abiotic and biotic factors have a considerable impact on the success of sericulture industry and thus they are of great importance (Kumar *et al.*, 2012) [7]. Among abiotic factors, temperature plays a key role in growth and productivity of silkworm, as it is a poikilothermic insect (Benchamin and Jolly, 1986) [1]. It is well known fact that the late age silkworms prefer relatively lower temperature than young age and fluctuation of temperature during different stages of larval development is more favourable for growth and development of larvae than constant temperature.

The effect of temperature higher than 30 °C on silkworm larvae was reported earlier by Shirota (1992) [12]. Tazima and Ohnuma (1995) [13] further confirmed the genetical nature of thermotolerance by selection based on pupation rate on silkworms reared under higher temperature conditions during fifth instar. The experiments conducted by Kato *et al.* (1989) [4] observed that the thermotolerance character in silkworm is heritable. Therefore, it is important to understand the performance of the breeds under a set of different high temperature. In this study the effect of high temperature on twelve silkworm breeds was assessed at three temperatures *viz.*, 25±1 °C, 30±1 °C and 35±1 °C and the maximum larval weight (39.21, 33.58 and 29.45g), pupation per cent (93.31, 77.20 and 72.16%) and cocoon yield (17.24, 12.70 and 11.54 Kg) at three temperatures, respectively were observed in U-3 breed followed by U-4 and ND_5 and these breeds can be used as potential breeding resources for the development of thermo tolerant silkworm breeds/ hybrids.

The results demonstrated the variation in rearing performance of silkworm breeds on being exposed to high temperatures. With the increase in temperature silkworm breeds showed a decline in larval weight, pupation rate and cocoon yield. The results obtained are in line with the findings of Kumar *et al.* (2002) [6] and Kumari *et al.* (2011) [9] they found that the commercial parameters of breeds showed a decline with the increase in rearing temperature above 25 °C. The decline in the rearing parameters was probably due to the low feeding activity of silkworms during high temperature. Kumar *et al.* (2012) [7] found that high temperature reduces the moisture content in the leaf through evaporation thereby drying the leaf sooner and making it inedible for larvae. As water is an essential requirement for metabolic activity and also for optimum growth of silkworm and at high temperature the evapo-respiration at body surface and respiratory epithelium of tracheal system increases significantly and cause the problem of water balance in silkworm which finally affects the growth and productivity of silkworm (Rahmathulla, 2004) [10].

Conclusion

From the study, it is concluded that the breeds U-3, U-4 and ND_5 performed well at 25±1 °C, 30±1 °C, and 35±1 °C with respect to larval weight, pupation per cent and cocoon yield among all the twelve breeds. Thus, these breeds have potential to withstand adverse environmental conditions and can be used as breeding resource for the development of thermo tolerant breeds/ hybrids.

Acknowledgement

The authors are thankful to Head and Staff of the Division of Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu for giving permission to carry out the work by providing facilities.

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