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Changes in qualitative and quantitative traits in the bivoltine silkworm hybrid of Bombyx mori L. due to changing environmental conditions

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Summary : The authorized commercial bivoltine silkworm hybrid namely, CSR2 x CSR4 was chosen for the present study. The hybrid was subjected to different temperature and humidity treatments i.e., 25±1°C and RH 65±5% (control), 30±1°C, with combinations of low relative humidity (RH 65±5%) and high RH (85±5%) at different stages during rearing and spinning of silkworm larvae. The larvae of after 3rd moult were subjected to different thermal and humidity stress till the assessment of cocoon traits. The comparative rearing performance clearly indicated that the deleterious effect of high temperature and high RH was more pronounced for the majority of traits such as survival, cocoon yield, shell weight, and shell percentage, reelability, filament length, raw silk percentage and filament size than other temperature and RH treatments. The characters can be improved by providing ideal environmental conditions even during spinning stage of larvae affected with high temperature and RH.

Key words : *Bombyx mori* L, bivoltine silkworm hybrids, different environmental effect, qualitative and quantitative traits.

INTRODUCTION

It is well established fact that under tropical condition unlike polyvoltines silkworm breeds, bivoltines are more vulnerable to various stresses. One of the important stresses faced in a tropical country is high temperature conditions coupled with high pathogen load. The main aim of the breeder is to recommend to farmers silkworm hybrids which are stable under different environmental conditions and minimize the risk of falling below a expected yield level. Temperate zone has ideal temperature and humidity coupled with good quality leaf during favourable season for bivoltine sericulture. While in tropical countries, the prevailing climatic conditions are favourable predominantly for rearing of polyvoltine x bivoltine hybrids. Since sericulture helps in poverty alleviation, small-scale farming groups are attracted towards sericulture in these countries. Cocoon quality parameters play an important role on the quality of the raw silk reeled. The cocoon properties are defined by a large number of parameters, some of which important for the parent cocoons race maintenance some are important for cocoon reeling.

There are ample literature showing that good quality cocoons are produced within a temperature range of 22-27°C and above these levels makes the cocoon quality worse (Krishnaswami,*et al*., 1973). Limited information is available on the combined effect of different temperature and humidity on qualitative and quantitative traits at different stages during rearing and spinning of silkworm larvae which in turn will provide valuable information to the technology developers who are engaged in the improvement of quality and quantity of silk acceptable to the level of international standard. With an objective to understand the influence of different environmental condition on qualitative and quantitative traits, the present study was carried out.

Material and methods

In the present study, the popular commercial and authorized bivoltine hybrid viz., CSR2 x CSR4 was utilized. The silkworm rearing was carried out in five replications following the standard method (Krishnaswami, 1978). After 3rd moult, the larvae were subjected to different environmental conditions in SERICATRON chamber with precise and automatic control facilities for uniform maintenance of temperature and relative humidity (Chuo Company, Japan). The details of the rearing and spinning environmental conditions at different stages of silkworm larvae were in Table 1.

Harvesting of cocoon was carried out after pupation i.e, on 7th day from the mounting time. The cocoons with live pupae only were considered for calculation of survival. Twenty five

cocoons each of female and male used for assessment of cocoon weight, shell weight and shell percentage. Reeling of cocoons were carried out on multiend reeling machine using 100 meters/ minute speed, 40°C reeling basin water temperature and 8 cm crosier length. The parameters namely cocoon reelability, filament length, raw silk %, filament size (denier) and filament neatness were recorded.

Results

The effect of different temperature and humidity treatments on various qualitative and quantitative traits of the popular and commercial bivoltine hybrid, CSR2 x CSR4 was presented in Table 2. It could be observed that majority of parameters *viz*., survival, cocoon yield, cocoon weight, shell weight, shell percentage, reelability, filament length raw silk per centage and filament size are adversely affected by different temperature and humidity treatments.

Larval duration: Significant difference was observed among the treatments and ranged from 486 hrs (T1) to 510 hrs (T5, T6 and T7).

Survival and Cocoon yield: Survival and cocoon yield were significantly altered by different environmental conditions. Minimum survival (48%) and cocoon yield (7.9 kg) was observed in high temperature and RH (T1) than other treatments. While maximum survival (94.5%) and cocoon yield (17.6 kg) was recoded in T7 (control) when compared to other treatments. Significant improvement was observed when the spinning larvae were shifted to optimum conditions of temperature and RH (T2 and T4). High temperature and high RH (T5) has great effect on these traits than high temperature and low RH (T6) at spinning stage.

Cocoon weight: Cocoon weight was significantly altered by different environmental conditions. Minimum cocoon weight (1.445 g) was observed in high temperature and low RH (T3) Maximum cocoon weight (1.978 g) was recoded in T7 (control) when compared to other treatments. Marginal improvement in cocoon weight was observed when the spinning larvae were shifted to optimum conditions of temperature and RH (T2 and T4). High temperature and low RH (T6 – 1.845 g) has great effect on cocoon weight than high temperature and high RH (T5 – 1.927g) at spinning stage.

Shell weight : Minimum shell weight (0.317 g) was observed in high temperature and high RH (T1). Maximum shell weight (0.458 g) was recoded in T7 (control). Marginal improvement in shell weight was observed when the spinning larvae were shifted to optimum conditions of temperature and RH (T2 and T4). High temperature and high RH (T5 – 0.427g) has more effect on shell weight than high temperature and low RH (T6 – 0.450g) at spinning stage.

Shell percentage : Minimum shell percentage (20.0%) was observed in high temperature and high RH (T1). Maximum shell percentage (24.4) was recoded in T6. High temperature and high RH (T5 – 22.2%) has great effect on shell percentage than high temperature and low RH (T6 – 24.4%) at spinning stage.

Reelability percentage : Minimum cocoon reelability (35%) was observed in high temperature and high RH (T1) than other treatments. Maximum cocoon reelabilty (88 %) was recoded in T7 (control) when compared to other treatments. Significant improvement in reelability was observed when the spinning larvae were shifted to optimum conditions of temperature and RH (T2 and T4). The results also indicate that high temperature and high RH (T5 - 51%) has great effect on reelability than high temperature and low RH (T6 - 86.5%) at spinning stage.

Filament length : Filament length was significantly affected by different environmental conditions. Minimum filament length (666 m) was observed in high temperature and high RH (T1) than other treatments. Maximum filament length (1181m) was recoded in T7 (control) when compared to other treatments. Significant improvement in filament length was observed when the spinning larvae were shifted to optimum conditions of temperature and RH (T2 and T4). High temperature and high RH (T5 – 831m) has grate effect on filament length than high temperature and low RH (T6 – 1129 m) at spinning stage.

Raw silk percentage : Minimum raw silk (9.6%) was observed in high temperature and high RH (T1) than other treatments. Maximum raw silk (19.7%) was recoded in T7 (control) when compared to other treatments. Marginal improvement in raw silk percentage was observed when the spinning larvae were shifted to optimum conditions of temperature and RH (T2 and T4). High temperature and high RH (T5 - 10.0%) has great effect on this trait than high temperature and low RH (T6 – 19.5%) at spinning stage.

Filament size (denier) : Minimum filament size (2.05 d) was observed in high temperature and high RH (T1) than other treatments. Maximum filament size (3.10 d) was recoded in T7 (control) when compared to other treatments. Marginal improvement in filament size was observed when the spinning larvae were shifted to optimum conditions of temperature and RH (T2 and T4). High temperature and high RH (T5 – 2.51 d) has great effect on this trait than high temperature and low RH (T6 – 3.10 d) at spinning stage.

Filament neatness : Non significant difference was observed among the all treatments for this character.

The per cent change computed for each character fore each treatment over control was depicted in Table 3. The effect ofhigh temperature and high RH conditions (T1) was more

pronounced for traits viz., survival (49.2 per cent reduction), cocoon yield (56.4 per cent reduction), cocoon shell weight (30.8 per cent reduction), cocoon shell percentage (13.8 per cent reduction), reelability (60.2 per cent reduction), filament length (43.6 per cent reduction), raw silk percentage (51.3 per cent reduction) and filament denier (33.9 per cent reduction) than other treatments as evidenced by the values of per cent change. However, larval duration and filament neatness did not much altered due to changing environmental conditions.

Discussion

The success of silkworm rearing depends upon several factors that include the environmental factors as the major one. Among environmental factors, there are biotic and abiotic factors. Among these abiotic factors, temperature plays a vital role on the growth and in the production potential of silkworm. (Benchamin and Jolly, 1986).

Silkworm breeds which are reared over a series of environments exhibiting less variation are considered stable. One of the main aims of the breeders is to recommend to farmers that are stable under different environmental conditions. In India, indigenous races are well adapted to fluctuating tropical climatic conditions characterized by high temperature, but they are poor in productivity. Keeping this in view, efforts over a decade to improve the quality of raw silk has resulted in the development of many productive and qualitatively superior bivoltine hybrids (Basavaraja, *et al*., 1995). These hybrids have been recommended to rear during favourable months and their unsuitability to rear during hot climatic condition prevailing, particularly in summer months. This situation has led to the development of robust hybrids tolerant to high temperature (Datta, *et al*., 2001). It was also observed that the lines selected at high temperature and high humidity perform better than the lines selected at normal temperature. When both parental strains and hybrids are raised in unfavourable environmental conditions, performance of hybrids will be much superior to both the parental strains (Nagaraju *et al.,* 1996).

The results of the present study clearly indicated the effect of high temperature and high RH (T1) on the majority of characters such as survival, cocoon yield, cocoon weight, shell weigh, shell percentage, rellability, filament length, raw silk percentage and filament size was more than other temperature and RH treatments. The effect of high humidity on reeling characteristics could be attributed to the structural changes in the sericin. Akahane and Tsubochi (1994) have pointed out that more water content in the cocoon shell layers during cocoon spinning will reduce the reelability of cocoons. The low reelability will in turn affect all related parameters namely filament length, raw silk percentage.

Reduction in survival, cocoon yield and other related parameters upon exposure of silkworm to high temperature may be attributed to low feeding activity of the silkworm and consequential physiological impact on growth and development (Takeuchi et*al.*, 1964).

The present investigation clearly indicates that the deleterious effect of high temperature and high RH was more pronounced on rearing of silkworm larvae than other temperature and RH treatments. The cocoon characters can be improved by providing ideal environmental conditions even during spinning stage of larvae affected with high temperature and RH. The study also suggests that high temperature and low humidity has greater effect during silkworm rearing stage than cocoon spinning stage.

Table 1. The details of the rearing and spinning environmental conditions at different stages of silkworm larvae

Treatment No.	Rearing conditions		Spinning conditions	
	Temperature (ºC)	Relative humidity (%)	Temperature (ºC)	Relative humidity (%)
T1	30 ± 1 throughout	85 ± 5	30 ± 1	85 ± 5
T2	30 ± 1 throughout	85 ± 5	24 ~25	65 ± 5
T3	30 ± 1 throughout	50 ± 5	30 ± 1	50 ± 5
T4	30 ± 1 throughout	50 ± 5	24 ~25	65 ± 5
T5	27 ~ 28 young age 24 ~ 25 late age	85 ± 5 65 ± 5	30 ± 1	85 ± 5
T6	27~28 young age 24 ~25 late age	85 ± 5 65 ± 5	30 ± 1	50 ± 5
T7 (Control)	27~28 young age 24 ~25 late age	85 ± 5 65 ± 5	24 ~25	65 ± 5

Table 2. Effect of different environmental condition on bivoltine hybrid

Tr[redacted]me[redacted]	[redacted]arv[redacted] pe[redacted]d (hrs)	Su[redacted]val (%)	[redacted]coo[redacted] yi[redacted]/ [redacted],00 la[redacted]e (kg)	[redacted]coo[redacted] we[redacted]t (g)	S[redacted]ll [redacted]eig[redacted]	S[redacted]l p[redacted]ent[redacted]	Re[redacted]- [redacted]lity	[redacted]lam[redacted] le[redacted]th	[redacted]w sil[redacted]	[redacted]ilar[redacted]t [redacted]ze	[redacted]lam[redacted]t ne[redacted]ess
[redacted]	[redacted]	[redacted]8.0	[redacted]	1.[redacted]	[redacted].31[redacted]	20.0	[redacted]5.0	[redacted]	9.[redacted]	2.05	[redacted]0
T[redacted]	[redacted]486	5[redacted]	[redacted]9.8	[redacted]635	0[redacted]8	2[redacted]	5[redacted]	[redacted]77[redacted]	[redacted]6	2.[redacted]	[redacted]94.[redacted]
[redacted]3	[redacted]	[redacted]2.5	1[redacted]	1.4[redacted]	[redacted].33	[redacted]3.1	[redacted]9.0	[redacted]	15.[redacted]	[redacted]31	[redacted]0
T4[redacted]	[redacted]496	8[redacted]	[redacted]4.9	[redacted]545	0[redacted]7	2[redacted]	7[redacted]	[redacted]103	[redacted]2	2.[redacted]	[redacted]94.[redacted]
[redacted]5	[redacted]	[redacted]0.0	1[redacted]	1.9[redacted]	[redacted].42	[redacted]2.2	[redacted]1.0	[redacted]	10.[redacted]	[redacted]51	[redacted]0
T[redacted]	[redacted]510	9[redacted]	[redacted]7.6	[redacted]845	0[redacted]0	2[redacted]	8[redacted]	[redacted]112	[redacted]5	2.9[redacted]	[redacted]95.[redacted]
[redacted]7 (C[redacted]trol	[redacted]	[redacted]4.5	1[redacted]	1.9[redacted]	[redacted].45	[redacted]3.2	[redacted]88	[redacted]1	19.[redacted]	[redacted]10	[redacted]0
C[redacted]t 5[redacted]	ns	4[redacted]	[redacted].91	[redacted]018	0[redacted]0	0[redacted]	1[redacted]	[redacted]27	[redacted]7	0.0[redacted]	ns[redacted]

Each value mean of 5 replications ± S.E

Table 3. Per cent change for different character over control (T7)

[redacted]	[redacted] period	[redacted]	[redacted] yield/ [redacted] [redacted]vae	[redacted] weight	[redacted] weight	[redacted] percentage	[redacted] bility	[redacted] length	[redacted] silk	[redacted] size	[redacted]
T1	[redacted].7	49.2	56.4	19.[redacted]	30.8	30.8	60.2	43.6	51.3	33.9	2.1
[redacted]	[redacted].7	39.[redacted]	[redacted].9	[redacted].3	28.[redacted]	13.[redacted]	36.4	[redacted].2	46.2	[redacted].0	[redacted].1
T3	2[redacted]	[redacted].7	27.[redacted]	26.9	[redacted].1	[redacted]4	2[redacted]	16[redacted]	[redacted].8	25.[redacted]	1.[redacted]
[redacted]	[redacted]2.7	9.[redacted]	[redacted].7	[redacted]9	24[redacted]	3.0	[redacted]7.0	[redacted]2	17[redacted]	[redacted].5	[redacted].1
T5	0[redacted]	[redacted].3	18[redacted]	2.6	[redacted].8	[redacted]8	4[redacted]	29	[redacted].2	19[redacted]	2[redacted]
[redacted]	[redacted]0.0	1.[redacted]	[redacted]8	[redacted]7	1[redacted]	-5.[redacted]	[redacted]1.7	[redacted]4	1.[redacted]	[redacted].5	[redacted]0

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