



E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2015; 3(6): 219-222
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Received: 05-09-2015
Accepted: 07-10-2015

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Reeling performances of F₂ and backcross populations under high temperature condition

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Abstract

The aim of this study was to assess the performances of F₂ and backcross populations at 36 °C by measuring reeling traits in silkworm. Nistari and Cambodge (thermo tolerant multivoltines), CSR2 (thermo susceptible bivoltine), their F₁S, F₂S and backcross populations without reciprocal crosses were reared at 25 °C and 36 °C. Data on five reeling traits were collected. All the reeling parameters (except neatness) were significantly ($P < 0.05$) reduced at 36 °C compared to their respective control breeds/hybrids. Backcrosses performed better than the F₂ populations at 36 °C. CSR2 x (Nistari x CSR2) was one of the best performers in form of reeling traits and Nistari x (Nistari x CSR2) was most stable breed which demonstrated least percentage reduction in treated over control larvae in raw silk percent, and second lowest percentage reduction in reelability percent, filament length, denier and neatness. Therefore, these crosses are preferred for breeding according to the requirement of silkworm breeder.

Keywords: Silkworm, Thermo tolerant, Thermo susceptible, Reeling traits

1. Introduction

The success of sericulture industry is influenced by several factors among which the impact of biotic and abiotic factors is of prime importance. Among them, the temperature, an abiotic factor plays a major role on growth and productivity of silkworm, as it is a poikilothermic insect^[1]. It is also known that the late age silkworms prefer relatively lower temperature than young age and fluctuation of temperature during different stages of larval development was found to be more favourable for growth and development of the larvae than constant temperature. There is copious literature showing that good quality cocoons are produced within a temperature range of 22-27 °C and above these levels makes the cocoon quality poorer^[2].

Cocoon reeling traits play an important role on the quality of the raw silk. The cocoon properties are defined by a large number of parameters, some of them are important for the parent breed maintenance and others for cocoons reeling. For a reeling technologist, the technological parameters of the cocoon are significantly important, since they determine the quality, quantity and efficiency of the reeling process^[3]. Since the major quality contribution comes from the cocoon, it is very much essential for silkworm breeders to focus on quality specific characters like filament size, filament length, tenacity, elongation etc. Furthermore, the influence of different environmental conditions on commercially important reeling traits like filament length, denier, renditta and raw silk percent that are the main quantitative traits in judging the quality of silk are studied^[3,4]. The aim of this study is to determine the effects of high temperature on reeling traits of F₂ and backcross populations under high temperature.

2. Materials and methods

Silkworm rearing

Two multivoltine (Nistari and Cambodge) and one bivoltine breeds (CSR2) were selected to develop F₁, F₂ and backcross populations. Silkworm rearing was conducted according to^[2]. On 3rd day of 5th instar, the larvae were subjected to high temperature treatment at 36 °C for 6 hours every day till they started spinning. The treatment was carried out in a special chamber for uniform temperature and humidity called Sericatron (CHUO, Japan). The larvae were fed with fresh mulberry leaves twice a day. The ripened larvae were allowed to spin cocoons on plastic mountages. Untreated larvae reared throughout the larval stage at 25 °C were considered as control. The experiment was performed in duplicate with 100 larvae for each replication. Healthy cocoons were harvested and maintained until the emergence of moths. Male moths of CSR2 breed were mated with the females of Nistari and Cambodge separately.

These F₁ hybrids were selfed to raise F₂ or crossed with one of their parents to develop backcross population.

Collection of data on reeling parameters

For assessment of reeling traits the cocoons from each replication of each combination were dried in hot oven. The drying chamber was heated up to 120 °C. The cocoons were then put into drying chamber to remove moisture then mixed with the air inside the cocoon at faster rate, so that inner layer sericin is not affected. The cocoons were subjected to drying schedule of 115 °C (one hour) → 100 °C (one hour) → 85 °C (one hour) → 70 °C (one hour) → 55 °C (one hour). Hot air dried cocoons were conditioned for a minimum period of 2 to 7 days in atmospheric conditions. The length of the filament was measured using eppovette fitted with meter. Other reeling parameters were studied following standard procedures as mentioned by [5].

Statistical analysis

The data on five reeling parameters viz., reelability percent (%), filament length (m), denier (d), raw silk (%) and neatness (%) were collected by standard procedure. Significant differences between the means of the control and treated larvae were analysed by applying independent t test (two-sample t test).

3. Results

Performances of breeds at 36 °C

All the reeling parameters (except neatness) were significantly reduced at 36 °C compared to their respective control breeds / hybrids. Data was collected on reelability percent, filament length, denier, raw silk percent and neatness percent in breeds, their F₁, F₂ and backcross populations at 25 °C and 36 °C (Table 1, 2). Reelability percent was higher in Nistari (84.12 %) followed by Cambodge (82.15 %) and CSR2 (79.15 %) with an average of 81.79 % (Table 2). Filament length was ranging between 316.9 m for Nistari and 827.38 m for CSR2 with an average of 492.81 m. Mean denier value was 2.61 d ranging between 2.43 d for CSR2 and 2.69 d for Cambodge. CSR2 (15.8 %) produced highest raw silk percent followed by Cambodge (9.62 %) and Nistari (9.43 %) with a mean value of 11.62 %. The neatness percent of the silk was higher in CSR2 (90 %) followed by Cambodge (85 %) and Nistari (84 %) with a mean value of 86.33 % (Table 1, 2).

Performances of F₁ hybrids at 36 °C

Among the hybrids Nistari x CSR2 showed highest denier (2.92 d) and raw silk percent (12.55 %) at 36 °C. Highest

reelability percent (89.13%), filament length (654.27 m), and neatness percent (86%) was observed in Cambodge x CSR2. Average reelability percent, filament length, denier, raw silk percent and neatness percent for hybrids were 85.6%, 609.21%, 2.65 d, 12.5% and 85%, respectively (Table 1, 2).

Performances of F₂ and backcross populations at 36 °C

Reelability percent was varying between 71.32% (Nistari x CSR2-F₂) and 84.5 % (Cambodge x (Cambodge x CSR2)) with an average of 79.29 %. Filament length was varying between 482 (Cambodge x (Cambodge x CSR2)) and 655 m (CSR2 x (Nistari x CSR2)) with an average of 596.3 m. Silk denier was varying between 2.02 d (Nistari x CSR2-F₂) and 2.41 d (Cambodge x (Cambodge x CSR2)) with an average of 2.21 d. Raw silk percent was ranging between 8.59 % (Cambodge x (Cambodge x CSR2)) and 14.39 % (CSR2 x (Nistari x CSR2)) with an average of 11.8 %. Neatness percent was highest in CSR2 x (Nistari x CSR2) and CSR2 x (Cambodge x CSR2) (90 %) and lowest in Cambodge x CSR2 -F₂, Nistari x (Nistari x CSR2) and Cambodge x (Cambodge x CSR2) (82 %) with an average of 85 % (Table 1, 2).

Percentage reduction in treated over control larvae of breeds

The negative sign in the percent change over control in treated larvae indicates a reduction over control and the value near to zero suggests a better performance of the breed / hybrid. Highest reduction in reelability percent was in Nistari (-2.89 %) followed by Cambodge (-2.42 %) and CSR2 (-2.33 %). Highest reduction in filament length was found with Cambodge (-17.09 %) followed by Nistari (-10.89 %) and CSR2 (-10 %). Nistari was the best performer with respect to denier with lowest reduction of -3.39 % followed by Cambodge (-5.12 %) and CSR2 (-7.6 %). Highest reduction in raw silk percent and silk neatness was observed in Nistari (-12.65 %) and CSR2 (-4.26 %), respectively. Lowest reduction in raw silk percent and silk neatness percent was observed in CSR2 (-6.43 %) and Cambodge (-1.16 %), respectively (Table 3).

Percentage reduction in treated over control larvae of F₁ hybrids

Treated larvae of Nistari x CSR2 hybrid showed lowest reduction over control in denier (-3.79 %). Lowest reduction in reelability percent (-2.43 %), filament length (-10.14 %), raw silk percent (-13.87 %) and neatness percent (0%) was in the cocoons spun by Cambodge x CSR2 hybrid (Table 3).

Table 1: Reeling performances of breeds, hybrids, F₂ and backcross populations at 25 °C and 36 °C

Breed/hybrid	Reelability (%)		Filament length (m)		Denier (d)	
	25 °C	36 °C	25 °C	36 °C	25 °C	36 °C
CSR2	81.01 ^{NS}	79.11 ^{NS}	919.3 ^{**}	827.4 ^{**}	2.63 [*]	2.43 [*]
Nistari	86.63 ^{NS}	84.12 ^{NS}	355.6 [*]	316.9 [*]	2.81 ^{NS}	2.71 ^{NS}
Cambodge	84.20 ^{**}	82.16 ^{**}	403.1 [*]	334.2 [*]	2.83 ^{NS}	2.69 ^{NS}
Nistari x CSR2-F ₁	87.15 ^{**}	82.08 ^{**}	794.0 ^{**}	564.2 ^{**}	3.04 ^{NS}	2.92 ^{NS}
Cambodge x CSR2-F ₁	91.34 ^{NS}	89.13 ^{NS}	728.1 ^{**}	654.3 ^{**}	2.62 [*]	2.37 [*]
Nistari x CSR2-F ₂	87.09 [*]	71.32 [*]	777.8 [*]	584.5 [*]	2.08 ^{NS}	2.02 ^{NS}
Cambodge x CSR2 -F ₂	87.98 ^{**}	72.25 ^{**}	717.2 ^{**}	651.5 ^{**}	3.04 [*]	2.16 [*]
Nistari x (Nistari x CSR2)	84.41 ^{NS}	81.00 ^{NS}	697.8 ^{NS}	616.0 ^{NS}	2.32 ^{NS}	2.20 ^{NS}
Cambodge x (Cambodge x CSR2)	89.44 [*]	84.50 [*]	637.5 ^{NS}	482.0 ^{NS}	2.95 [*]	2.41 [*]
CSR2 x (Nistari x CSR2)	83.86 ^{NS}	82.15 ^{NS}	809.7 [*]	655.0 [*]	2.69 [*]	2.28 [*]
CSR2 x (Cambodge x CSR2)	90.41 [*]	84.50 [*]	722.3 [*]	589.0 [*]	2.56 [*]	2.22 [*]

* Significant difference at $P < 0.05$

** Significant difference at $P < 0.01$

^{NS} No significant difference

Percentage reduction in treated over control larvae of F₂ and backcross populations

Highest reduction in reelability percent (-18.18%) and filament length (-24.85%) was in Nistari x CSR2-F₂. Lowest reduction in reelability percent (-2.04%) and filament length (-9.16%) was in CSR2 x (Nistari x CSR2) and Cambodge x CSR2 -F₂, respectively. Highest and lowest reduction in denier was in

Cambodge x CSR2 -F₂ (-28.95%) and Nistari x CSR2-F₂ (-2.65%), respectively. Highest (-19.09%) and lowest (-7.31%) raw silk percent reduction was in CSR2 x (Nistari x CSR2) and Nistari x (Nistari x CSR2), respectively. Highest (-5.26%) and lowest (0%) reduction in silk neatness percent was in CSR2 x (Cambodge x CSR2) and Nistari x CSR2-F₂, respectively (Table 3).

Table 2: Reeling performances of breeds, hybrids, F₂ and backcross populations at 25°C and 36°C

Breed/hybrid	Raw silk (%)		Neatness (%)	
	25°C	36°C	25°C	36°C
CSR2	16.89**	15.80**	94 ^{NS}	90 ^{NS}
Nistari	10.79**	9.43**	86 ^{NS}	84 ^{NS}
Cambodge	10.58 ^{NS}	9.62 ^{NS}	86 ^{NS}	85 ^{NS}
Nistari x CSR2-F ₁	16.59**	12.55**	85 ^{NS}	84 ^{NS}
Cambodge x CSR2-F ₁	14.46*	12.45*	86 ^{NS}	86 ^{NS}
Nistari x CSR2-F ₂	13.11*	11.24*	84 ^{NS}	84 ^{NS}
Cambodge x CSR2 -F ₂	11.22 ^{NS}	10.33 ^{NS}	86 ^{NS}	82 ^{NS}
Nistari x (Nistari x CSR2)	14.02 ^{NS}	13.00 ^{NS}	85 ^{NS}	82 ^{NS}
Cambodge x (Cambodge x CSR2)	9.35 ^{NS}	8.60 ^{NS}	84 ^{NS}	82 ^{NS}
CSR2 x (Nistari x CSR2)	17.79**	14.39**	94 ^{NS}	90 ^{NS}
CSR2 x (Cambodge x CSR2)	15.08 ^{NS}	13.22 ^{NS}	95 ^{NS}	90 ^{NS}

* Significant difference at $P < 0.05$

** Significant difference at $P < 0.01$

^{NS} No significant difference

Table 3: Percentage reduction in reeling traits of breeds, hybrids, F₂ and backcross populations in treated over control larvae

Breed / hybrid	Reelability (%)	Filament length (m)	Denier (d)	Raw silk (%)	Neatness (%)
CSR2	-2.33	-10.00	-7.60	-6.43	-4.26
Nistari	-2.89	-10.89	-3.39	-12.65	-2.33
Cambodge	-2.42	-17.09	-5.12	-9.03	-1.16
Nistari x CSR2-F ₁	-5.82	-28.94	-3.79	-24.33	-1.18
Cambodge x CSR2-F ₁	-2.43	-10.14	-9.54	-13.87	0
Nistari x CSR2-F ₂	-18.10	-24.85	-2.65	-14.27	0
Cambodge x CSR2 -F ₂	-17.87	-9.16	-28.95	-7.93	-4.65
Nistari x (Nistari x CSR2)	-4.03	-11.72	-5.18	-7.31	-3.53
Cambodge x (Cambodge x CSR2)	-5.52	-24.39	-18.47	-8.03	-2.38
CSR2 x (Nistari x CSR2)	-2.04	-19.11	-15.27	-19.09	-4.26
CSR2 x (Cambodge x CSR2)	-6.53	-18.46	-13.28	-12.37	-5.26

4. Discussion

All the studied reeling traits of silkworms tend to be decreased at 36 °C. These results are acceptable with the results of [6]. The quality of raw silk depends upon the ideal temperature and humidity coupled with good leaf quality. Low reeling performance in treated larvae is attributed to the structural changes in the sericin (gumming substance in cocoons), which degenerates due to high temperature thereby reducing reelability and raw silk percent.

Filament length is considered as most important reeling trait to assess silk quality. To obtain uniform filament size in auto and semiautomatic reeling units, cocoon size uniformity is very important [7]. High temperature causes significant changes in cocoon shape and size in silkworms resulting in variations in filament size as well as the quality of the reeled thread [8]. It is also known that when reeling is carried out with such non-uniform cocoons will result in thread breakage, hindrance due to slugs, poor reelability, poor cooking, decreased raw silk recovery, variation in raw silk denier and poor neatness [9]. Kumar *et al.* [10] also pointed out the deleterious effect of high temperature on the cocoon shape and size of all the pure races, segregating populations, single and double hybrids.

In this study, cocoons produced by CSR2 x (Nistari x CSR2) had highest filament length (655 m), raw silk percent (14.39%), and neatness percent (90%) with fine denier (2.3 d) and good reelability percent (82.15%) indicating that the silk

produced is of better quality than other tested populations at 36 °C. Hence, CSR2 x (Nistari x CSR2) is the better performer in terms of silk fibre quality at 36 °C. Percentage reductions in treated over control larvae of F₂ and backcross populations were determined. The results indicate that the backcross population Nistari x (Nistari x CSR2) had lowest percentage reduction over their control in raw silk percent (-7.31%), and second lowest percentage reduction in all other studied traits like reelability percent (-4.03%), filament length (-11.72%), denier (-5.18%) and neatness percent (-3.53%). According to the requirement, the silkworm breeder can choose F₂ or backcross population to initiate breeding in it.

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