Study of 31 economically important traits in 20 silkworm *Bombyx mori* varieties

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Abstract: Aim of this experiment was study of 31 economically important traits in twenty silkworm *Bombyx mori* varieties. These varieties included 31, 1005, 113 (2029), 153 (Xihang-1), 5118×10133-3-3, F6×101, 1433-15, 1126 (111), 113-K, 1003-4, M2-6-18 (109), M2-6-22 (107), 151 (103×M-1-1), Xihang 2/3, M-1-1×103, 7409, 107-K, 103, T5-M, and 101433-1-4. Rearing in young silkworm duration was performed by chopped leaves and paraffin paper coverage and in the adult duration was performed with leaves and branches. It was used rice straw as cocoon making structure for cocoon spinning in each replication separately. After cocoon spinning development (seven days after starting of cocoon spinning), obtained cocoons gathered and sorted based on form, thickness, clarity etc to four classes include good, middle, double and low cocoons. It was calculated ratio of each class cocoon for each replication separately. The data were subjected to analysis of variance (ANOVA) to determine if the differences found between treatments and the differences between treatments were significant. For analysis of variance, Tukey's studentized range test in a complete randomized design was used at α=0.05. From obtained results, it is showed that among studied varieties, the highest level of Percentage of hatchability belonged to [107] (97.77%), and 4-1003 variety (63.07%) remained at lower level than other varieties. Other varieties were between these two groups ($P<0.05$). Meanwhile, among studied varieties, the highest level of good cocoon number belonged to Xihang-1 (328.33), and [109] variety (159.67) remained at lower level than other varieties ($P<0.05$). Also, the highest level of good cocoon weight belonged to 4-1003(341.83 gr), and [7409] variety (194.09 gr) remained at lower level than other varieties ($P<0.05$). Finally, it is showed that the highest level of cocoon shell percentage belonged to [111] 1126 (23.11%), and k-113 variety (18.10%) remained at lower level than other varieties ($P<0.05$).
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1. Introduction

Silkworm as an economical insect have large role in rural life in many countries. Silkworm produce silk as high quality fiber and silk fabrics have high attractive in people line. There are different lines and strains for silk production.

Production of cocoon and raw silk are affected by several factors such as genetic potential of commercial varieties, quality of silkworm egg, pests and diseases incidence, quality of mulberry leaves, weather, breeding and management plans and silk reeling methods (Bizhannia and Seidavi, 2008).

Researchers must be investigate and compare productive potential of various varieties and select the high productive lines in order to hybridization. Rahman and Rahman (1990) studied genetic potential of the 36 varieties during four rearing seasons, and found these varieties have high heritability and different genotypes have high genetic diversity that can be used for breeding programs. The importance and role of additive gene effects on phenotype selection in these traits were also emphasized.

Rayar et al (1989) studied the structure of genetic variation in 18 economical traits in 29 silkworm varieties and found larval weight, larval duration, cocoon shell weight and length of fiber have high heritability.

Since the amount of silk production parameters in silkworm varieties of Iran gene bank is unknown, thus aim of this experiment was study of 31 economically important traits in twenty silkworm *Bombyx mori* varieties.

2. Material and Methods

Twenty studied silkworm varieties were used in the present study. These varieties included 31, 1005, 113 (2029), 153 (Xihang-1), 5118×10133-3-3, F6×101, 1433-15, 1126 (111), 113-K, 1003-4, M2-6-18 (109), M2-6-22 (107), 151 (103×M-1-1), Xihang 2/3, M-1-1×103, 7409, 107-K, 103, T5-M, and 101433-1-4. This study was conducted in Islamic Azad University, Rasht Branch, Iran during 2010. This experiment was performed to study the productive and economical traits of these twenty silkworm varieties. Silkworm egg of twenty varieties was taken from Iran Silkworm Research Center (ISRC). Rearing was standard conducted following rearing technology. It was applied favorite conditions for larva rearing such as 25-28ºcentigrade and 75-85% relative humidity. After egg hatching, every group was breed separately and under standard

situations (ESCAP, 1993). Rearing in young silkworm duration was performed by chopped leaves and paraffin paper coverage and in the adult duration was performed with leaves and branches. It was used rice straw as cocoon making structure for cocoon spinning in each replication separately. After cocoon spinning development (seven days after starting of cocoon spinning), obtained cocoons gathered and sorted based on form, thickness, clarity etc to four classes include good, middle, double and low cocoons. It was calculated ratio of each class cocoon for each replication separately. Furthermore, it was investigated on health or disease of total obtained pupae and calculated ratio of each class cocoon disease for each replication separately. It was recorded cocoon weight for good and double cocoons. All records were conducted on 8th days of cocoon spinning. Recorded traits were compared between six studied native groups.

Recorded traits for this study were number of produced eggs, number of the health eggs, number of the unfertilized and dead eggs, number of the dead hatched eggs, percentage of hatchability, good cocoon number, good cocoon weight, good cocoon percentage, good cocoon mortality, middle cocoon number, middle cocoon percentage, middle cocoon mortality, low cocoon number, low cocoon percentage, low cocoon mortality, double cocoon number, double cocoon weight, double cocoon percentage, double cocoon mortality, total mortality, female cocoon weight, female cocoon shell weight, female cocoon shell percentage, male cocoon weight, male cocoon shell weight, male cocoon shell percentage, average of cocoon weight, sum of cocoon weight for male and female, average of shell cocoon weight, sum of shell cocoon weight, and cocoon shell percentage.

These parameters were measured using standard protocols (ESCAP, 1993). Furthermore data above 70% or below 30%, undergone inverse sin transformation ($Z=\text{Arcsin } P_{ij}^{1/2}$) and data between 0-1, undergone square transformation ($P^{1/2}$). The data were subjected to analysis of variance (ANOVA) to determine if the differences found between treatments and the differences between treatments were significant. For analysis of variance, Tukey's studentized range (HSD) test in a complete randomized design was used at $\alpha=0.05$.

3. Results and Discussion

Obtained results are summerised in Tables 1-5.

Number of produced eggs

From obtained results, it is showed that amount of number of produced eggs in twenty studied varieties included between 307.00-574.91. Among studied varieties, the highest level of number of produced eggs belonged to 1005 (574.91), and 4-1003 variety (307.00) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant ($P>0.05$).

Number of the health eggs

From obtained results, it is showed that amount of number of the health eggs in twenty studied varieties included between 387.87-515.78. Among studied varieties, the highest level of number of the health eggs belonged to [2029] 113 (515.78), and 1005 variety (387.87) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant ($P<0.05$).

Number of the unfertilized and dead eggs

From obtained results, it is showed that amount of number of the unfertilized and dead eggs in twenty studied varieties included between 3.00-74.39. Among studied varieties, the highest level of number of the unfertilized and dead eggs belonged to [151] (74.39) and Xihang-1 variety (3.00) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant ($P>0.05$).

Number of the dead hatched eggs

From obtained results, it is showed that amount of number of the dead hatched eggs in twenty studied varieties included between 3.67-31.67. Among studied varieties, the highest level of number of the dead hatched eggs belonged to M-1-1×103 (31.67), and 15-1433 variety (3.67) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant ($P>0.05$).

Percentage of hatchability

From obtained results, it is showed that amount of Percentage of hatchability in twenty studied varieties included between 63.07-97.77%. Among studied varieties, the highest level of Percentage of hatchability belonged to [107] (97.77%), and 4-1003 variety (63.07%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant ($P<0.05$).

Good cocoon Number

From obtained results, it is showed that amount of good cocoon number in twenty studied varieties included between 159.67-328.33. Among studied varieties, the highest level of good cocoon number belonged to Xihang-1 (328.33), and [109]

variety (159.67) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Good cocoon weight

From obtained results, it is showed that amount of good cocoon weight in twenty studied varieties included between 194.09-341.83 gr. Among studied varieties, the highest level of good cocoon weight belonged to 4-1003(341.83 gr), and [7409] variety (194.09 gr) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Good cocoon percentage

From obtained results, it is showed that amount of good cocoon percentage in twenty studied varieties included between 62.77-86.30%. Among studied varieties, the highest level of good cocoon percentage belonged to 31 (86.30%), and K-107 variety (68.77%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant (P>0.05).

Good cocoon mortality

From obtained results, it is showed that amount of good cocoon mortality in twenty studied varieties included between 0.73-27.93%. Among studied varieties, the highest level of good cocoon mortality belonged to [2029] 113 (27.93%), and K-107 variety (0.73%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant (P>0.05)

Middle cocoon Number

From obtained results, it is showed that amount of middle cocoon number in twenty studied varieties included between 30.67-99.67. Among studied varieties, the highest level of middle cocoon number belonged to K-107 (99.67), and [2029] 113 variety (30.67) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Middle cocoon mortality

From obtained results, it is showed that amount of middle cocoon mortality in twenty studied varieties included between 1.00-8.67. Among studied varieties, the highest level of middle cocoon mortality belonged to [111] 1126 (8.67 mg/dl), and [31] variety (1.00 mg/dl) remained at lower level than other varieties. Other varietie s were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant (P>0.05).

Middle cocoon percentage

From obtained results, it is showed that amount of middle cocoon percentage in twenty studied varieties included between 1.00-8.67. Among studied varieties, the highest level of middle cocoon mortality belonged to [111] 1126 (8.67 mg/dl), and [31] variety (1.00 mg/dl) remained at lower level than other varieties. Other varietie s were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant (P>0.05).

Low cocoon Number

From obtained results, it is showed that amount of low cocoon percentage in twenty studied varieties included between 0.63-16.05. Among studied varieties, the highest level of low cocoon percentage belonged to F6×101 (16.05), and [7409]variety (0.63) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant (P>0.05).

Low cocoon percentage

From obtained results, it is showed that amount of low cocoon mortality in twenty studied varieties included between 0.63-5.27%. Among studied varieties, the highest level of low cocoon mortality belonged to F6×101 (5.27%), and [7409]variety (0.63%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Low cocoon mortality

From obtained results, it is showed that amount of low cocoon mortality in twenty studied varieties included between 0.6-4.13%. Among studied varieties, the highest level of low cocoon mortality belonged to [111] 1126 (4.13%), and [7409] variety (0.60%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant (P<0.05).

Double cocoon Number

From obtained results, it is showed that amount of double cocoon number in twenty studied varieties included between 0.60-9.00. Among studied varieties, the highest level of double cocoon number belonged to [111] 1126 (9.00), and [7409] variety (0.60) remained at lower level than other varieties. Other varieties were between these two groups.

Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Double cocoon weight

From obtained results, it is showed that amount of double cocoon weight in twenty studied varieties included between 2.14-35.12 gr. Among studied varieties, the highest level of weight belonged to [151] (12.66 gr), and 5118 variety (2.14gr) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Double cocoon percentage

From obtained results, it is showed that amount of double cocoon percentage in twenty studied varieties included between 0.13-3.33%. Among studied varieties, the highest level of double cocoon percentage belonged to White Haratee (3.33%), and Yellow Haratee variety (0.13%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Double cocoon mortality

From obtained results, it is showed that amount of double cocoon mortality in twenty studied varieties included between 0.00-2.83%. Among studied varieties, the highest level of double cocoon mortality belonged to [7409] (2.83%), and 4-1-101433 variety (0.00%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Total mortality

From obtained results, it is showed that amount of total mortality in twenty studied varieties included between 4.30-17.55%. Among studied varieties, the highest level of total mortality belonged to [7409] (17.55%), and 4-1-101433 variety (4.30%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were not significant (P>0.05).

Female cocoon weight

From obtained results, it is showed that amount of female cocoon weight in twenty studied varieties included between 1.13-1.37%. Among studied varieties, the highest level of female cocoon weight belonged to 4-1-101433 (1.37%), and [2029] 113 variety (1.13%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Female cocoon shell weight

From obtained results, it is showed that amount of female cocoon shell weight in twenty studied varieties included between 0.16-0.35 gr. Among studied varieties, the highest level of female cocoon shell weight belonged to [111] 1126 (0.16 gr), and M-1-1×103 variety (0.16 gr) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Female cocoon shell percentage

From obtained results, it is showed that amount of female cocoon shell percentage in twenty studied varieties included between 16.75-21.62%. Among studied varieties, the highest level of female cocoon shell percentage belonged to [111] 1126(18.09%) and k -113 variety (11.43%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Male cocoon weight

From obtained results, it is showed that amount of male cocoon weight in twenty studied varieties included between 1.13-1.37 gr. Among studied varieties, the highest level of male cocoon weight belonged to 4-1-101433 (1.13 gr), and [2029] 113 variety (1.37 gr) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Male cocoon shell weight

From obtained results, it is showed that amount of male cocoon shell weight in twenty studied varieties included between 0.18-0.32 gr. Among studied varieties, the highest level of male cocoon shell weight belonged to 4-1-101433 (0.18 gr), and k-113 variety (0.32 gr) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Male cocoon shell percentage

From obtained results, it is showed that amount of male cocoon shell percentage in twenty studied varieties included between 19.69-32.05%. Among studied varieties, the highest level of male cocoon shell percentage belonged to 1005 (19.69%), and k- 113 variety (32.05%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Average of cocoon weight

From obtained results, it is showed that amount of average of cocoon weight in twenty studied varieties included between 1.21-1.52. Among studied varieties, the highest level of average of cocoon weight belonged to 4-1-101433 (1.52), and M-1-1×103 variety (1.21) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Sum of cocoon weight for male and female

From obtained results, it is showed that amount of sum of cocoon weight for male and female in twenty studied varieties included between 2.56-3.05 gr. Among studied varieties, the highest level of sum of cocoon weight for male and female belonged to 4-1-101433 (3.05 gr), and Lemon Khorasan variety (2.56 gr) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Average of shell cocoon weight

From obtained results, it is showed that amount of average of shell cocoon weight in twenty studied varieties included between 0.24-0.33 gr. Among studied varieties, the highest level of average of shell cocoon weight belonged to [111] 1126 (0.29 gr) and some other varieties remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Sum of shell cocoon weight

From obtained results, it is showed that amount of sum of shell cocoon weight in twenty studied varieties included between 0.32-0.67 gr. Among studied varieties, the highest level of sum of shell cocoon weight belonged to [111] 1126 (0.67 gr), and Lemon Haratee variety (0.32 gr) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Cocoon shell percentage

From obtained results, it is showed that amount of cocoon shell percentage in twenty studied varieties included between 18.10-23.11%. Among studied varieties, the highest level of cocoon shell percentage belonged to [111] 1126 (23.11%), and k-113 variety (18.10%) remained at lower level than other varieties. Other varieties were between these two groups. Meanwhile statistical differences between studied varieties for this trait were significant (P<0.05).

Satenahalli et al (1988) were studied variation among seven silkworm pure lines and their hybrids based on larval weight, cocoon weight, cocoon shell weight, and length of cocoon fibers and reported that the hybrid Saniish-18×NB7 was superior based on cocoon weight (2.49 grams) and cocoon shell weight (0.469 grams).

On the other hand, Saha et al (2002) also studied the temperature and humidity suitable for silkworm embryo development, and they have developed a method that silkworm egg hatching rate in hot and dry summer seasons as much as much increase and improve production efficiency per unit will be followed. Their studies found that different temperature and relative humidity required to achieve

Table 1- Mean comparison (±SEM) of productive parameters in twenty studied silkworm varieties

No	Variety	Parameters					
		Number of produced eggs	Number of the health eggs	Number of the unfertilized and dead eggs	Number of the dead hatched eggs	Percentage of hatchability	Good cocoon Number
		-	-	-	-	%	-
1	31	428.67±45.32^{ab}	412.67±43.90^{abc}	3.67±1.76^{c}	12.33±2.03^{c}	97.10±0.17^{a}	291.67±31.22^{ab}
2	1005	574.67±28.54^{a}	494.67±42.78^{ab}	12.00±8.02^{c}	68.00±38.03^{ab}	88.23±6.55^{a}	164.67±18.27^{c}
3	113 (2029)	553.33±39.19^{a}	515.33±36.86^{a}	5.00±1.00^{c}	33.00±8.14^{bc}	95.67±1.56^{a}	221.67±13.57^{abc}
4	153 (Xihang-1)	480.33±43.94^{ab}	455.67±53.80^{abc}	3.00±2.08^{c}	21.33±10.04^{c}	95.07±2.75^{a}	328.33±102.81^{a}
5	5118×10133-3-3	481.33±71.95^{ab}	436.00±71.04^{abc}	13.33±4.91^{c}	32.00±3.61^{bc}	93.00±0.50^{a}	225.00±12.49^{abc}
6	F6×101	532.77±32.38^{a}	479.09±47.66^{abc}	6.52±0.87^{c}	47.16±14.43^{abc}	90.70±3.36^{a}	291.47±49.95^{ab}
7	1433-15	470.33±89.70^{ab}	436.67±94.27^{abc}	3.67±2.03^{c}	30.00±3.00^{c}	92.83±1.68^{a}	224.00±14.11^{abc}
8	1126 (111)	468.00±37.32^{ab}	414.33±42.27^{abc}	13.67±5.17^{c}	40.00±3.61^{abc}	90.97±1.41^{a}	166.33±20.48^{c}
9	113-K	514.67±26.35^{ab}	460.33±30.37^{abc}	18.00±6.08^{c}	45.33±14.17^{abc}	91.00±3.02^{a}	205.33±36.15^{ab}
10	1003-4	307.00±158.80^{b}	283.67±146.3^{c}	7.00±3.79^{c}	16.33±8.76^{c}	63.07±31.53^{b}	266.67±38.99^{abc}
11	M2-6-18 (109)	384.67±14.62^{ab}	366.00±13.61^{abc}	6.67±0.33^{c}	12.00±1.53^{c}	96.80±0.35^{a}	159.67±25.83^{c}
12	M2-6-22 (107)	428.00±16.04^{ab}	412.33±14.77^{abc}	19.00±11.14^{c}	10.33±2.85^{bc}	97.77±0.68^{a}	177.33±9.39^{ab}
13	151 (103×M-1-1)	458.43±1.33^{ab}	309.64±0.90^{bc}	74.39±0.22^{a}	74.39±0.22^{a}	81.03±0.23^{ab}	173.92±0.50^{ab}
14	Xihang 2/3	448.67±61.58^{ab}	401.67±63.17^{abc}	16.33±9.06^{c}	30.67±10.17^{c}	93.23±1.78^{a}	250.00±23.97^{abc}
15	M-1-1×103	460.00±12.90^{ab}	381.00±0.58^{abc}	31.67±5.46^{b}	44.67±10.17^{abc}	89.00±1.59^{a}	253.00±18.01^{abc}
16	7409	468.67±26.64^{ab}	441.67±20.17^{abc}	7.00±2.65^{c}	20.67±5.93^{c}	95.90±1.40^{c}	201.00±49.80^{ab}
17	107-K	447.33±65.05^{ab}	420.33±65.86^{abc}	6.33±1.33^{c}	20.67±1.20^{c}	95.07±0.80^{a}	177.00±2.65^{ab}
18	103	446.67±44.18^{ab}	418.00±42.55^{abc}	6.33±2.85^{c}	22.33±6.17^{c}	94.93±1.36^{a}	230.67±11.14^{abc}
19	T5-M	459.67±62.61^{ab}	432.00±64.58^{abc}	9.67±0.88^{c}	18.33±3.53^{c}	95.57±1.49^{a}	216.00±38.43^{abc}
20	101433-1-4	382.33±66.79^{ab}	331.00±63.10^{abc}	6.33±1.86^{c}	21.00±10.60^{c}	92.57±4.80^{a}	204.68±13.30^{bc}

*Means in each row followed by the same letters are not significantly different at α=0.05.

Table 2- Mean comparison (±SEM) of productive parameters in twenty studied silkworm varieties

No	Variety	Parameters					
		Good cocoon weight	Good cocoon percentage	Good cocoon mortality	Middle cocoon Number	Middle cocoon percentage	Middle cocoon mortality
		gr	%	%	-	%	%
1	31	339.52±23.43^{a}	86.30±0.57^{de}	12.73±3.21^{cde}	36.33±7.17^{cd}	10.50±1.08^{de}	1.00±0.30^{a}
2	1005	237.69±4.13^{bcd}	78.17±0.85^{abc}	9.23±1.53^{de}	39.00±2.52^{cd}	18.77±1.24^{bcde}	7.47±1.23^{a}
3	113 (2029)	241.36±15.97^{bcd}	85.93±4.37^{a}	27.93±5.56^{a}	30.67±9.74^{d}	11.93±3.83^{cde}	4.07±0.95^{a}
4	153 (Xihang-1)	283.75±24.83^{ab}	78.00±5.52^{abc}	6.63±1.69^{e}	71.00±4.04^{abc}	19.60±4.67^{bcde}	2.83±1.44^{a}
5	5118×10133-3-3	277.14±16.71^{abc}	78.77±6.90^{a}	20.80±5.37^{abcd}	59.00±26.63^{bcd}	19.13±6.8^{bcde}	2.83±0.54^{a}
6	F6×101	337.77±41.09^{a}	84.88±2.15^{e}	15.15±1.62^{bcde}	32.11±1.74^{cd}	9.88±0.95^{e}	2.86±0.43^{a}
7	1433-15	229.88±4.36^{bcd}	79.93±0.92^{abc}	23.00±4.32^{abc}	45.67±5.84^{cd}	16.20±1.54^{cde}	5.93±1.33^{a}
8	1126 (111)	218.77±20.06^{bcd}	76.87±2.35^{abc}	24.60±6.35^{abc}	40.33±7.17^{cd}	18.30±1.12^{bcde}	8.67±3.97^{a}
9	113-K	228.61±38.37^{bcd}	68.23±1.19^{a}	13.90±1.40^{abcde}	84.67±12.14^{ab}	28.43±0.58^{ab}	2.40±0.98^{a}
10	1003-4	341.15±34.56^{a}	84.47±3.32^{ab}	8.33±1.52^{de}	39.67±20.58^{cd}	10.63±5.33^{de}	1.77±1.11^{a}
11	M2-6-18 (109)	198.99±30.04^{cd}	65.03±4.91^{a}	12.07±0.43^{cde}	71.00±11.14^{abc}	29.47±4.54^{ab}	5.90±2.16^{a}
12	M2-6-22 (107)	223.67±4.01^{bcd}	77.23±4.71^{bcde}	14.60±0.2^{bcde}	47.00±12.10^{bcd}	19.67±3.84^{bcde}	3.40±0.46^{a}
13	151 (103×M-1-1)	242.92±0.70^{bcd}	73.39±0.21^{bcd}	18.50±0.05^{abcde}	54.29±0.16^{bcd}	22.92±0.07^{bc}	2.51±0.01^{a}
14	Xihang 2/3	276.94±22.85^{abc}	79.73±1.47^{abc}	27.93±4.05^{a}	61.00±10.54^{bcd}	19.17±1.37^{bcde}	5.80±0.17^{a}
15	M-1-1×103	288.78±11.52^{ab}	84.07±1.71^{ab}	6.43±3.83^{e}	37.67±8.4^{cd}	12.50±2.5^{cde}	1.73±0.78^{ab}
16	7409	194.41±21.16^{d}	74.07±6.61^{a}	26.23±7.71^{ab}	53.33±6.36^{bcd}	21.63±5.12^{bcd}	7.13±2.13^{a}
17	107-K	227.09±10.69^{bcd}	62.77±5.05^{a}	5.67±2.88^{e}	99.67±24.10^{a}	34.00±5.35^{a}	3.17±0.47^{a}
18	103	272.49±19.32^{abcd}	75.03±1.10^{bcde}	13.40±3.53^{bcde}	65.33±8.37^{abcd}	21.20±2.33^{bcde}	3.90±1.82^{a}
19	T5-M	229.49±35.97^{bcd}	82.80±3.63^{ab}	15.67±6.32^{abcde}	34.33±1.33^{cd}	14.07±2.72^{cde}	4.07±1.87^{a}
20	101433-1-4	287.03±24.14^{ab}	83.63±0.51^{ab}	5.87±0.84^{e}	34.62±2.60^{cd}	14.10±0.21^{cde}	2.11±0.92^{a}

*Means in each row followed by the same letters are not significantly different at α=0.05.

Table 3- Mean comparison (±SEM) of productive parameters in twenty studied silkworm varieties

No	Variety	Parameters					
		Low cocoon Number	Low cocoon percentage	Low cocoon mortality	Double cocoon Number	Double cocoon weight	Double cocoon percentage
		-	%	%	-	gr	%
1	31	6.00±1.73^{bc}	1.80±0.50^{bc}	1.77±0.48^{abc}	4.33±0.33^{bcde}	10.28±0.88^{abcd}	1.33±0.28^{bcd}
2	1005	5.00±1.53^{bc}	2.37±0.67^{bc}	2.33±0.68^{abc}	1.67±1.20^{cde}	4.54±2.95^{cd}	0.73±0.47^{cd}
3	113 (2029)	2.67±0.33^{bc}	1.03±0.12^{c}	1.00±0.10^{abc}	2.67±1.20^{bcde}	6.19±2.56^{cd}	1.03±0.45^{bcd}
4	153 (Xihang-1)	6.67±3.48^{bc}	1.87±1.28^{bc}	1.87±1.28^{abc}	2.00±1.15^{cde}	4.87±2.85^{cd}	0.50±0.36^{cd}
5	5118×10133-3-3	5.67±1.33^{bc}	1.97±0.49^{bc}	1.83±0.38^{ab}	0.33±0.33^{e}	0.83±0.83^{d}	0.13±0.13^{cd}
6	F6×101	16.05±1.73^{a}	5.27±1.30^{a}	3.76±2.17^{abc}	1.00±0.58^{de}	1.87±1.08^{d}	0.25±0.14^{cd}
7	1433-15	6.33±0.88^{bc}	2.30±0.44^{bc}	2.27±0.46^{a}	4.33±1.20^{bcde}	8.61±2.02^{bcd}	1.53±0.42^{bcd}
8	1126 (111)	10.00±4.04^{ab}	4.17±1.27^{ab}	4.13±1.24^{abc}	1.67±1.67^{cde}	4.28±4.28^{cd}	0.62±0.62^{cd}
9	113-K	8.33±2.85^{bc}	2.90±0.95^{abc}	1.87±0.30^{abc}	1.33±0.88^{de}	3.56±2.65^{d}	0.37±0.23^{cd}
10	1003-4	4.67±4.67^{bc}	1.13±1.13^{c}	1.10±1.10^{abc}	2.33±1.86^{cde}	6.83±5.71^{cd}	0.67±0.57^{cd}
11	M2-6-18 (109)	7.33±0.88^{bc}	3.00±0.35^{abc}	3.00±0.35^{abc}	6.00±0.58^{abc}	15.14±1.84^{abc}	2.43±0.03^{abc}
12	M2-6-22 (107)	6.00±3.21^{bc}	2.43±1.26^{bc}	2.40±1.23^{abc}	1.33±0.88^{de}	3.73±2.42^{cd}	0.67±0.48^{cd}
13	151 (103×M-1-1)	3.02±0.01^{bc}	1.31±0.00^{bc}	1.21±0.00^{abc}	7.04±0.02^{ab}	20.06±0.06^{a}	3.02±0.01^{ab}
14	Xihang 2/3	2.67±1.33^{bc}	0.87±0.45^{c}	0.87±0.45^{abc}	0.67±0.67^{e}	1.92±1.92^{d}	0.20±0.20^{cd}
15	M-1-1×103	9.00±3.79^{bc}	2.97±1.16^{abc}	3.00±1.14^{abc}	1.33±0.67^{de}	2.99±1.50^{d}	0.40±0.20^{cd}
16	7409	1.67±0.33^{c}	0.63±0.15^{c}	0.60±0.15^{abc}	9.00±2.89^{a}	18.56±8.17^{ab}	3.60±1.52^{a}
17	107-K	5.67±1.20^{bc}	1.92±0.26^{bc}	1.90±0.26^{abc}	3.33±1.45^{bcde}	8.40±4.03^{bcd}	1.23±0.58^{bcd}
18	103	6.00±1.53^{bc}	1.97±0.50^{bc}	1.73±0.66^{abc}	5.33±2.60^{abcd}	11.88±6.50^{abcd}	1.80±0.87^{bcd}
19	T5-M	5.00±2.00^{bc}	2.23±1.23^{bc}	2.23±1.23^{abc}	2.33±1.86^{cde}	2.09±1.26^{d}	0.83±0.69^{cd}
20	101433-1-4	5.02±1.73^{bc}	2.16±0.84^{bc}	1.81±1.04^{abc}	1.00±0.58^{de}	3.04±1.75^{d}	0.35±0.20^{cd}

*Means in each row followed by the same letters are not significantly different at α=0.05.

Table 4- Mean comparison (±SEM) of productive parameters in twenty studied silkworm varieties

No	Variety	Parameters					
		Double cocoon mortality	Total mortality	Female cocoon weight	Female cocoon shell weight	Female cocoon shell percentage	Male cocoon weight
		%	%	gr	gr	%	gr
1	31	0.67±0.44^{bc}	16.17±3.07^{e}	1.42±0.13^{bcd}	0.27±0.01^{bcd}	19.38±1.38^{bc}	1.20±0.03^{abc}
2	1005	0.27±0.27^{bc}	19.30±2.32^{cde}	1.60±0.06^{abc}	0.30±0.02^{abc}	18.77±0.77^{bcde}	1.34±0.04^{ab}
3	113 (2029)	0.63±0.63^{bc}	33.63±3.96^{abcd}	1.35±0.02^{d}	0.25±0.01^{cd}	18.68±0.49^{bcde}	1.13±0.01^{c}
4	153 (Xihang-1)	0.20±0.20^{bc}	11.57±3.54^{e}	1.43±0.10^{abcd}	0.26±0.02^{cd}	17.95±0.42^{bcdef}	1.18±0.07^{bc}
5	5118×10133-3-3	0.13±0.13^{bc}	7.57±7.37^{e}	1.42±0.13^{bcd}	0.27±0.04^{bcd}	19.04±0.87^{bcde}	1.21±0.11^{abc}
6	F6×101	0.25±0.14^{bc}	22.02±0.84^{bcde}	1.45±0.07^{abcd}	0.28±0.02^{bcd}	19.32±0.32^{bcd}	1.23±0.08^{abc}
7	1433-15	1.20±0.80^{bc}	32.40±5.89^{abcd}	1.32±0.07^{d}	0.23±0.01^{d}	17.64±0.27^{cdef}	1.11±0.06^{c}
8	1126 (111)	0.83±0.83^{bc}	38.23±8.25^{a}	1.62±0.06^{ab}	0.35±0.01^{a}	21.62±0.22^{a}	1.27±0.03^{abc}
9	113-K	0.10±0.10^{bc}	18.27±2.64^{de}	1.41±0.06^{bcd}	0.24±0.01^{d}	16.75±0.43^{f}	1.19±0.05^{bc}
10	1003-4	0.17±0.09^{bc}	8.33±5.17^{e}	1.44±0.09^{abcd}	0.25±0.02^{cd}	17.63±0.47^{cdef}	1.25±0.07^{abc}
11	M2-6-18 (109)	1.63±0.41^{ab}	22.57±3.01^{bcde}	1.43±0.07^{abcd}	0.27±0.02^{bcd}	19.15±0.33^{bcd}	1.22±0.03^{abc}
12	M2-6-22 (107)	0.33±0.33^{bc}	20.73±1.23^{cde}	1.43±0.05^{abcd}	0.26±0.01^{cd}	18.44±0.30^{bcdef}	1.20±0.05^{c}
13	151 (103×M-1-1)	0.40±0.00^{bc}	22.62±0.07^{bcde}	1.62±0.00^{ab}	0.31±0.00^{abc}	19.17±0.06^{bcd}	1.34±0.00^{ab}
14	Xihang 2/3	0.10±0.10^{bc}	34.70±4.51^{abc}	1.39±0.05^{bcd}	0.25±0.01^{cd}	18.16±0.31^{bcdef}	1.09±0.02^{c}
15	M-1-1×103	0.30±0.30^{bc}	11.47±2.90^{e}	1.30±0.06^{d}	0.26±0.01^{cd}	19.74±0.16^{b}	1.11±0.01^{c}
16	7409	2.83±0.82^{a}	36.80±5.88^{ab}	1.32±0.08^{d}	0.26±0.02^{cd}	19.71±0.35^{b}	1.09±0.05^{c}
17	107-K	0.47±0.12^{bc}	11.20±3.16^{e}	1.44±0.04^{abcd}	0.25±0.01^{cd}	17.45±0.16^{def}	1.23±0.04^{abc}
18	103	0.57±0.43^{bc}	19.13±5.85^{cde}	1.37±0.04^{cd}	0.23±0.00^{d}	17.16±0.35^{ef}	1.17±0.02^{bc}
19	T5-M	0.83±0.69^{bc}	22.53±9.17^{bcde}	1.27±0.05^{d}	0.24±0.02^{d}	18.41±0.81^{bcdef}	1.16±0.08^{bc}
20	101433-1-4	0.00±0.00^{bc}	9.78±0.95^{e}	1.66±0.03^{a}	0.33±0.01^{ab}	19.64±0.22^{b}	1.37±0.05^{a}

*Means in each row followed by the same letters are not significantly different at α=0.05.

Table 5- Mean comparison (±SEM) of productive parameters in twenty studied silkworm varieties

No	Variety	Parameters						
		Male cocoon shell weight	Male cocoon shell percentahe	Average of cocoon weight	Sum of cocoon weight for male and female	Average of shell cocoon weight	Sum of shell cocoon weight	Cocoon shell percentage
		gr	%	gr	gr	gr	gr	%
1	31	0.25±0.01^{cd}	21.00±0.50^{cd}	1.31±0.08^{bcd}	2.62±0.15^{bcd}	0.26±0.01^{bcd}	0.52±0.02^{cd}	20.03±0.96^{cd}
2	1005	0.31±0.02^{d}	23.05±1.05^{abc}	1.47±0.05^{ab}	2.93±0.10^{ab}	0.30±0.02^{ab}	0.61±0.04^{abc}	20.70±0.74^{abc}
3	113 (2029)	0.25±0.01^{cd}	22.21±0.66^{abcd}	1.24±0.02^{d}	2.48±0.03^{cd}	0.25±0.01^{cd}	0.50±0.02^{d}	20.23±0.52^{d}
4	153 (Xihang-1)	0.25±0.02^{cd}	21.22±0.51^{cd}	1.31±0.08^{bcd}	2.61±0.16^{bcd}	0.25±0.02^{bcd}	0.51±0.04^{cd}	19.43±0.41^{cd}
5	5118×10133-3-3	0.27±0.03^{abcd}	22.08±0.94^{bcd}	1.32±0.12^{bcd}	2.64±0.25^{bcd}	0.27±0.04^{bcd}	0.54±0.07^{cd}	20.43±0.87^{cd}
6	F6×101	0.28±0.02^{abcd}	22.37±0.54^{abcd}	1.34±0.08^{abcd}	2.68±0.15^{abcd}	0.28±0.02^{abcd}	0.56±0.04^{bcd}	20.72±0.44^{bcd}
7	1433-15	0.26±0.01^{bcd}	23.41±2.30^{abc}	1.22±0.06^{d}	2.43±0.13^{cd}	0.25±0.00^{cd}	0.49±0.00^{d}	20.27±1.07^{d}
8	1126 (111)	0.32±0.01^{ab}	25.07±0.39^{a}	1.45±0.05^{abc}	2.89±0.10^{abc}	0.33±0.01^{abc}	0.67±0.03^{a}	23.10±0.15^{a}
9	113-K	0.23±0.01^{d}	19.69±0.34^{d}	1.30±0.06^{bcd}	2.60±0.11^{bcd}	0.24±0.01^{bcd}	0.47±0.02^{d}	18.10±0.36^{d}
10	1003-4	0.26±0.02^{cd}	20.50±1.32^{cd}	1.35±0.08^{abcd}	2.69±0.15^{abcd}	0.26±0.02^{abcd}	0.51±0.05^{cd}	18.97±0.87^{cd}
11	M2-6-18 (109)	0.27±0.01^{abcd}	22.37±0.48^{abcd}	1.33±0.04^{bcd}	2.65±0.07^{bcd}	0.27±0.01^{bcd}	0.55±0.03^{bcd}	20.63±0.38^{bcd}
12	M2-6-22 (107)	0.26±0.01^{bcd}	21.67±0.33^{bcd}	1.32±0.05^{bcd}	2.63±0.10^{bcd}	0.26±0.01^{bcd}	0.52±0.02^{cd}	19.90±0.21^{cd}
13	151 (103×M-1-1)	0.30±0.00^{abc}	22.30±0.06^{abcd}	1.48±0.00^{ab}	2.96±0.01^{ab}	0.30±0.00^{ab}	0.61±0.00^{abc}	20.61±0.06^{abc}
14	Xihang 2/3	0.23±0.00^{d}	21.22±0.84^{cd}	1.24±0.02^{d}	2.49±0.04^{cd}	0.24±0.01^{cd}	0.49±0.02^{d}	19.47±0.38^{d}
15	M-1-1×103	0.27±0.02^{abcd}	24.45±1.27^{ab}	1.21±0.03^{d}	2.42±0.07^{cd}	0.26±0.01^{cd}	0.53±0.03^{cd}	21.90±0.52^{cd}
16	7409	0.24±0.01^{d}	21.92±0.65^{bcd}	1.21±0.06^{d}	2.42±0.13^{cd}	0.25±0.01^{cd}	0.50±0.03^{d}	20.70±0.25^{d}
17	107-K	0.26±0.02^{bcd}	21.38±0.68^{cd}	1.34±0.04^{abcd}	2.67±0.08^{abcd}	0.26±0.01^{abcd}	0.51±0.03^{cd}	19.27±0.61^{cd}
18	103	0.25±0.01^{cd}	21.11±0.18^{cd}	1.27±0.03^{cd}	2.53±0.06^{cd}	0.24±0.00^{cd}	0.48±0.01^{d}	18.97±0.18^{d}
19	T5-M	0.25±0.02^{cd}	21.73±1.12^{bcd}	1.22±0.02^{d}	2.43±0.04^{cd}	0.24±0.01^{cd}	0.49±0.03^{d}	20.00±0.92^{d}
20	101433-1-4	0.32±0.01^{a}	23.33±0.08^{abc}	1.52±0.04^{a}	3.04±0.08^{a}	0.32±0.01^{a}	0.64±0.02^{ab}	21.27±0.07^{ab}

*Means in each row followed by the same letters are not significantly different at α=0.05.

maximum yield silkworm egg hatching, is 25°C and 75-80 percentage respectively. They found that farmers often do not follow these factors and therefore the rate and uniformity of hatching larvae in villages far weaker than the standard level of production and these factors has reduced the production of cocoon yield. System developed by them was able using very low cost; in hot and dry summer conditions, the required amount of heat decreased as much as 6-7°C and relative humidity increase to 40 percentage. They reported that the development of this system leads to increased levels of cocoon production in villages. Effect of temperature and humidity has been proven on the emergence of silkworm moth.

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