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Full Length Research Paper

Analysis of genetic divergence for classification and evaluation of 37 productive performances in 54 oval cocoon strains of Iran silkworm germplasm

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The purpose of this experiment was to analyse the genetic divergence for the classification and evaluation of 37 productive performances in all 54 oval cocoon strains of Iran silkworm *Bombyx mori* (Lepidoptera: Bombycidae) germplasm. The newly hatched larvae of all strains were reared for experiment under same standard conditions. Studied strains are ranked based on the average of evaluation index method and sub-ordinate function method. From the obtained results, it was clear that different strains of silkworm *B. mori* showed different performances based on productive traits. The analysis of variance regarding the studied traits showed that different strains have significant difference for traits (P < 0.01). Totally, W2-11-19-2[110] (2030.234), W2-11-19-3 (2025.089), BH-4 (1981.516), 104×110 (1963.656) and 17 (1935.046) showed higher evaluation index values. W2-11-19-3 (19.868), W2-11-19-2 [110] (2030.234), BH-4 (18.857), 104×110 (18.560) and 17 (17.917) showed higher sub-ordinate function values. All strains with the same origin did not group together because they had different biological and development performance. The main groups were also divided into separate sub-groups. Three sub-groups included various strains. Several strains were grouped together and far from other silkworm strains, indicating that they might be suitable for future crossings, maintenance of parental strains and hybridizations with peanut cocoon strains so as to maximize heterosis and to avoid depression inbreeding. After evaluation by two statistical methods (evaluation index method and sub-ordinate function method), some oval type strains that stood within high ranks were identified as potential parents for further breeding programme.

Key words: Hierarchical agglomerative clustering, oval cocoon, silk, germplasm bank, performance.

INTRODUCTION

Sericulture should be considered as one of the important potential agro-industry in East European and Ex-Soviet union Central Asian countries, situated around Black and Caspian seas region especially now that increasing number of farmers (approximately 500,000 households) are involved in sericulture industry development activities in order to generate their income resources (Tzenov, 2005). Genetic resources are not distributed uniformly between the different countries. It could be concluded that if compared with the sericulture genetic resources maintained in other advanced countries such as China, Japan, Korea and India, the total number of mulberry and silkworm accessions preserved in the countries of Eastern Europe and Central Asia is also huge. Moreover, there was a good germplasm exchange system established between most of those countries in the near past (Tzenov, 2005).

Islamic Republic of Iran has valuable silkworm genetics resources. There are reports regarding peanut cocoon strains of Iran silkworm germplasm bank (Salehi et al.,

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2009, 2010a, b, c). However, there is no report about oval cocoon strains of Iran silkworm germplasm bank, especially from the point of cocoon production characteristics. The purpose of this experiment was to analyse the genetic divergence for the classification and evaluation of 37 productive performances in all 54 oval cocoon strains of Iran silkworm *Bombyx mori* (Lepidoptera: Bombycidae) germplasm.

MATERIALS AND METHODS

This study was conducted at Iran silkworm research center (ISRC) and Islamic Azad University, Ghaemshahr Branch, Iran during 2008 to 2010. Fifty four (54) silkworm strains were used in this study. The strains included: (1) 6/4-6/6, (2) 104, (3) 124-K, (4) 120-K, (5) 108-K, (6) W2-11-19-2(110), (7) W2-11-19-3, (8) 1002-4-C-5, (9) 1002-E-8-3, (10) Guilan-Orange, (11) Khorasan-Orange, (12) Shown, (13) T1-P, (14) T5-P, (15) CS120(7409), (16) BH-4, (17) BH-3, (18) 104×110, (19) 110×104(152), (20) 32×110, (21) 110×32, (22) 18-1, (23) 1538-8-2(114), (24) 1538-14-9(112), (25) 4-4, (26) 32, (27) Tokaee-202, (28) 106, (29) 17, (30) Shaki A×D, (31) 124-16-9(116), (32) Mose.Black-Plain(2), (33) 726(118), (34) 1627-14-4-3, (35) Koming-1(154), (36) 1627-14-2-8, (37) Mos.Black-Black(2), (38) 823, (39) 1640, (40) 102(Shown), (41) W2-13-9(108), (42) 1001, (43) W1-2-7, (44) CS120(N19), (45) Koming-2-5, (46) W2-13-4, (47) Y-5, (48) 127-17, (49) Lemon Khorasan, (50) Lemon Haratee, (51) White Haratee, (52) Yellow Haratee, (53) Pink Khorasan and (54) Baghdadi.

All studied silkworm strains were reared in annual and routine germplasm conservation program at Iran silkworm research center (ISRC). Their silkworm rearing technique included single batch rearing system. Feeding and other conditions of larval rearing were conducted following the standard procedure (ESCAP, 1993) and all germplasm strains were reared under standards protocols in all rearing steps. After hatching the eggs based on ESCAP (1993), and neonates were brushed and reared separately on fresh leaves of mulberry (*Morus alba*). Each batch of strains which consisted of about 500 eggs were prepared (disease free) and reared at standard conditions. But at the beginning of the 4th instar, the number of larvae in each repeats were equaled to 250 larvae by counting. The silkworm eggs were incubated in the controlled environment chamber. When there were 95% of eggs having little black dots on the surface of eggs, they were shaded with black gobo to prevent the light irradiation for about 48 h to make the larvae emerge form the eggs at one time. After hatching, most eggs and the silkworm larvae were fed mulberry leaves. Brushing was done carefully and the larvae were reared. The young larvae (1^{st} to 3^{rd} instars) were reared at 27 to 28°C with 85 to 90% relative humidity and the late age larvae (4^{th} and 5^{th} instars) were maintained at 24 to 26°C with a relative humidity of 70 to 80%. The feeding of larvae was done three times a day. After pupae and emersion of moths, the obtained male and female moths mated, and then female moths laid egg individually in each replication.

Studied quantitative characteristics included number of total produced cocoons, number of good produced cocoons, number of alive good produced cocoons, number of dead good produced cocoons, number of middle produced cocoons, number of alive middle produced cocoons, number of dead middle produced cocoons, number of low produced cocoons, number of alive low produced cocoons, number of dead low produced cocoons, number of double produced cocoons, number of alive pupae in double cocoons, number of dead pupae in double cocoons, pupae vitality percentage (%), cocoon weight (g), shell cocoon weight (g), shell cocoon percentage (%), male cocoon weight (g), male shell cocoon weight (g), male shell cocoon percentage (%), female cocoon weight (g), female shell cocoon weight (g), female shell cocoon percentage (%), good cocoon weight of 250 larvae (g), middle cocoon weight of 250 larvae (g), middle cocoon weight (g), low cocoon weight of 250 larvae (g), low cocoon weight (g), double cocoon weight of 250 larvae (g), double cocoon weight (g), total cocoon weight of 250 larvae (g), total cocoon weight of 10000 4^{th} instar larvae (g), cocoon number per liter, cocoon weight per liter (g), male pupae weight (g) and female pupae weight (g). Recorded characteristics of cocoon and pupae weight were performed using a precision digital balance.

Data analysis from CRD model, GLM approach and SAS software was used. Under model was used for data analysis for each strain: $y_{ij} = \mu + G_i + e_{ij}$ where, y_{ij} was record or observation from trait; μ was trait average; G_i was the group effect (strain) and e_{ij} was the residual effects. Furthermore, appropriate transformation like angle transformation was used for those data which did not follow normal distribution. DNMRT method was used for average comparisons (SAS, 1997).

Also, evaluation index value and sub-ordinate function value were calculated for performance indices. Evaluation index value (EI) for silkworm strains performance were calculated by using the following formula: $EI = [(A-B)/C] \times 10 + 50$ (Mano et al., 1993; Rao et al., 2003), where, A is the mean of the particular trait in a strain; B is the overall mean of a particular trait in all strains; C is the standard deviation of a trait in all strains; 50 is the constant.

Sub-ordinate function is calculated by utilizing the following formula: $Xu = (Xi-Xmin)/(Xmax-Xmin)$ based on other references (Gower, 1971; Rao et al., 2003) where, Xu is the sub-ordinate function; Xi is the measurement of trait of tested strain; Xmin is the minimum value of the trait among all the tested strains and Xmax is the maximum value of the trait among all the tested strains.

The evaluation index (Table 2) and sub-ordinate function values (Table 3) for the all traits were calculated separately and average index value was obtained. Then studied silkworm strains are ranked based on the average of evaluation index method and sub-ordinate function method (Table 4).

Hierarchical agglomerative clustering was done by using NTSYS-pc, version 2.02e (Rohlf, 1998) based on complete, single, UPGMA, UPGMC, FLEXI approaches and SAS-pc (SAS, 1997) based on WARD and average approaches. However, method of average linkage between groups (Romesburg, 1984) under UPGMA (unweighted pair-group method using arithmetic average) was considered as the major and final protocol for data conclusion (Sneath and Sokal, 1973) and the resulting clusters were expressed as dendrograms. This method employed for grouping, UPGMA, uses the average distance among all the equal genotypes for the formation of each group (Cruz and Regazzi, 2001; Zanatta et al., 2009). The clustering was based on the squared Euclidean distance. The average linkage between two groups is considered as the average of distance between all pairs of cases with one number from each group. Hierarchical clustering analysis was carried out by considering all studied parameters together.

RESULTS

Obtained results are summarized in Tables 1 to 4. From the obtained results, it was clear that different strains of silkworm *B. mori* showed different performance based on productive traits. The analysis of variance regarding studied traits, showed that different strains have significant different for traits ($P < 0.01$).

From the obtained results, it is shown that the number of total produced cocoons of the W2-11-19-3 (245.000), 1627-14-4-3 (243.667), 726[118] (243.333), 110×32

Table 1. Mean (± standard deviation) performance of cocoon traits in studied silkworm pure lines of gene bank.

Trait / Pure Line	Number of total produced cocoon	Number of good produced cocoon	Number of alive good produced cocoon	Number of dead good produced cocoon	Number of middle produced cocoon	Number of alive middle produced cocoon	Number of dead middle produced cocoon	Number of low produced cocoon	Number of alive low produced cocoon	Number of dead low produced cocoon	Number of double produced cocoon	Number of Alive Pupae in Double Cocoon
(1) 6/4-6/6	209.670^{ef}±15.502	94.000^{t}±17.058	94.000^{p}±17.058	0.000^{i}±0.000	72.000^{bc}±3.000	60.330^{bcd}±4.163	11.667^{a}±2.886	34.900^{a}±4.725	39.333^{a}±1.527	2.667^{a}±5.773	36.667^{nop}±0.577	1.333^{qr}±0.577
(2) 104	204.000^{ef}±11.135	158.000^{kl}±8.717	149.670^{lm}±11.239	8.333^{fg}±4.932	34.667^{g-m}±11.590	26.333^{kl}±10.124	8.333^{abc}±2.886	17.000^{bcd}±4.163	7.333^{c}±0.000	0.000^{bcd}±4.163	7.333^{n-p}±2.645	4.000^{op}±0.350
(3) 124-K	220.000^{ef}±25.514	163.330^{kl}±21.126	159.000^{ef}±21.566	4.333^{fg}±2.081	50.000^{fg}±15.000	44.333^{fg}±10.598	5.667^{ef}±4.725	22.667^{d-f}±0.577	3.667^{c}±0.000	0.000^{d-f}±0.577	3.667^{n-p}±0.000	3.000^{pqr}±1.527
(4) 120-K	183.670^{ghi}±14.153	122.670^{tr}±10.875	118.670^{lm}±8.962	4.000^{fg}±2.000	56.000^{fg}±3.605	54.333^{c-f}±2.516	1.167^{h-i}±1.154	30.533^{d-f}±2.081	3.667^{c}±0.577	0.333^{d-f}±2.309	3.333^{nop}±1.527	1.333^{qr}±2.000
(5) 108-K	227.670^{ef}±12.342	161.670^{kl}±17.039	156.670^{f-l}±16.623	5.000^{fg}±1.000	57.667^{fg}±9.291	49.667^{fg}±8.326	8.000^{bc}±1.000	25.300^{d-f}±6.350	3.667^{c}±0.000	0.000^{d-f}±6.350	3.667^{n-p}±2.081	4.667^{op}±3.464
(6) W2-11-19-2(110)	208.330^{ef}±10.392	131.330^{kl}±16.947	127.670^{lm}±12.220	3.667^{fg}±3.785	52.667^{fg}±5.859	44.667^{fg}±6.027	8.000^{bc}±7.211	25.267^{ef}±0.577	1.667^{c}±0.000	0.000^{d-f}±0.577	1.667^{a}±8.144	22.667^{ab}±14.147
(7) W2-11-19-3	245.000^{a}±7.594	146.000^{kl}±18.083	140.000^{lm}±19.519	6.000^{fg}±1.732	89.333^{a}±17.009	81.000^{a}±15.620	8.333^{abc}±2.309	36.467^{cd}±4.041	6.333^{c}±0.000	0.000^{c-d}±4.041	6.333^{n-p}±1.154	2.333^{op}±2.645
(8) 1002-4-C-5	182.330^{ghi}±28.936	98.333^{ef}±8.621	95.000^{p}±8.000	3.333^{fg}±1.527	72.333^{bc}±25.716	64.333^{abc}±23.755	8.000^{bc}±6.244	38.767^{bc}±7.023	8.333^{bc}±1.154	0.667^{bc}±6.110	7.667^{n-p}±1.527	3.333^{pqr}±2.645
(9) 1002-E-8-3	227.000^{ef}±11.357	169.670^{f-k}±8.621	165.000^{ef}±7.549	4.667^{fg}±1.154	52.667^{fg}±15.502	49.333^{fg}±13.012	3.333^{ef}±2.516	23.033^{def}±2.081	2.333^{c}±0.000	0.000^{d-f}±2.081	2.333^{n-p}±2.081	2.333^{op}±4.163
(10) Guilan-Orange	143.670^{j}±750.035	124.000^{o-t}±62.697	118.000^{lm}±61.294	6.000^{fg}±2.000	15.000^{m}±9.539	14.000^{m}±10.392	1.000^{hi}±1.000	9.700^{d-f}±4.932	4.333^{c}±0.000	0.000^{d-f}±4.932	4.333^{op}±0.577	0.333^{r}±1.154
(11) Khorasan-Orange	199.670^{ef}±21.939	164.330^{kl}±16.921	157.670^{ef}±16.563	6.667^{fg}±2.309	26.333^{j-m}±9.865	24.667^{kl}±10.124	1.667^{hi}±0.577	13.100^{ef}±1.154	0.667^{c}±0.000	0.000^{ef}±1.154	0.667^{fg}±2.081	8.333^{h-j}±4.582
(12) Shown	216.000^{ef}±8.717	182.000^{ef}±7.100	171.000^{ef}±7.211	11.000^{bcd}±2.000	27.000^{j-m}±0.440	25.333^{kl}±8.962	1.667^{hi}±2.081	12.467^{d-f}±2.645	4.000^{c}±0.000	0.000^{d-f}±2.654	4.000^{n-p}±2.645	3.000^{op}±5.291
(13) T1-P	234.670^{abc}±16.502	193.000^{bc}±8.888	185.670^{bc}±10.214	7.333^{fg}±1.527	39.333^{g-i}±8.736	36.667^{fg}±9.865	2.667^{ef}±2.081	16.663^{def}±0.577	2.333^{c}±0.000	0.000^{d-f}±0.577	2.333^{p}±0.000	0.000^{r}±0.000
(14) T5-P	215.670^{ef}±19.008	170.330^{ef}±8.378	159.000^{ef}±30.116	11.333^{bc}±2.081	37.333^{g-m}±17.925	35.333^{fg}±17.097	2.000^{f-h}±1.000	17.367^{d-f}±3.785	5.667^{c}±0.000	0.000^{d-f}±3.785	5.667^{n-p}±0.577	2.333^{op}±1.154
(15) CS120(7409)	234.000^{bc}±10.392	179.670^{ef}±8.326	168.330^{ef}±10.214	11.333^{bc}±4.041	48.667^{fg}±2.886	44.333^{fg}±4.932	4.333^{ef}±2.081	20.800^{d-f}±3.055	3.333^{c}±0.000	0.000^{d-f}±3.055	3.333^{n-p}±2.516	2.333^{op}±5.033
(16) BH-4	233.670^{bc}±4.932	189.330^{ef}±7.571	185.000^{bc}±11.135	4.333^{fg}±4.163	35.333^{g-m}±3.511	32.000^{gh}±3.000	4.333^{ef}±0.577	15.333^{d-f}±2.516	3.333^{c}±0.000	0.000^{d-f}±2.516	3.333^{n-p}±2.081	5.667^{op}±4.041
(17) BH-3	213.330^{ef}±21.213	15.330^{kl}±49.497	134.330^{lm}±19.798	11.000^{ab}±8.485	63.667^{bc}±2.121	54.000^{bc}±1.414	9.667^{ab}±0.707	30.000^{d-f}±4.242	3.667^{c}±0.000	0.000^{d-f}±4.242	3.667^{op}±0.707	0.667^{r}±0.707
(18) 104×110	214.330^{ef}±9.451	150.330^{kl}±18.823	146.330^{lm}±21.385	4.000^{fg}±3.605	56.333^{fg}±12.503	53.667^{fg}±13.650	2.667^{ef}±1.154	26.467^{ef}±0.577	0.667^{c}±0.000	0.000^{ef}±0.577	0.667^{fg}±3.000	7.000^{op}±5.033
(19) 110×104(152)	208.000^{ef}±8.185	147.000^{kl}±2.000	140.670^{lm}±2.081	6.333^{fg}±0.577	37.333^{g-m}±3.785	35.000^{fg}±3.605	2.333^{f-h}±1.527	17.933^{ef}±0.577	0.667^{c}±0.000	0.000^{ef}±0.577	0.667^{a}±2.645	23.000^{a}±3.055
(20) 32×110	205.670^{ef}±10.692	118.330^{rt}±19.218	111.330^{nop}±16.563	7.000^{fg}±5.000	77.667^{abc}±15.373	72.667^{ab}±17.097	5.000^{ef}±1.732	37.833^{f}±0.577	0.333^{c}±0.000	0.000^{f}±0.577	0.333^{fg}±2.309	9.333^{j-o}±3.785
(21) 110×32	237.670^{ab}±13.576	154.670^{kl}±24.337	146.330^{lm}±28.041	8.333^{fg}±3.785	78.333^{ab}±31.643	72.667^{ab}±25.967	5.667^{ef}±5.686	32.667^{f}±0.577	0.333^{c}±0.000	0.000^{f}±0.577	0.333^{n-p}±1.527	4.333^{op}±2.309
(22) 18-1	210.000^{ef}±1.000	164.000^{kl}±8.000	160.000^{ef}±11.269	7.000^{fg}±5.567	37.667^{g-m}±9.018	34.667^{fg}±11.503	3.000^{ef}±2.645	17.933^{def}±1.527	1.333^{c}±0.000	0.000^{ef}±1.527	1.333^{n-p}±2.000	4.000^{op}±3.000
(23) 1538-8-2(114)	214.670^{ef}±20.744	159.330^{kl}±21.825	156.000^{f-l}±23.302	3.333^{fg}±2.516	41.667^{fg}±4.509	37.333^{fg}±4.932	4.333^{ef}±2.309	19.467^{ef}±1.527	1.333^{c}±0.000	0.000^{ef}±1.527	1.333^{d-f}±4.932	12.333^{cde}±8.717
(24) 1538-14-9(112)	180.670^{ghi}±14.011	127.330^{o-t}±8.144	119.000^{lm}±4.582	8.333^{fg}±5.033	45.333^{fg}±4.163	40.667^{fg}±4.509	4.667^{ef}±1.527	25.100^{c-d}±2.516	6.333^{c}±0.000	0.000^{c-d}±2.516	6.333^{n-p}±0.577	1.667^{pqr}±0.577
(25) 4-4	220.670^{ef}±28.884	173.670^{ef}±23.501	171.670^{ef}±24.542	2.000^{ghi}±2.000	37.333^{g-m}±10.263	35.000^{fg}±9.848	2.333^{f-h}±2.309	16.800^{d-f}±6.350	4.667^{c}±0.000	0.000^{d-f}±6.350	4.667^{n-p}±4.358	5.000^{op}±9.865
(26) 32	192.000^{ef}±7.000	123.670^{o-t}±4.618	121.000^{lm}±4.358	2.667^{ghi}±0.577	51.667^{fg}±2.309	47.000^{fg}±4.000	4.667^{ef}±2.000	26.900^{d-f}±2.516	3.333^{c}±0.000	0.000^{d-f}±2.516	3.333^{bcd}±3.511	13.333^{cde}±7.000
(27) Tokaee-202	215.000^{ef}±5.291	138.670^{kl}±8.386	136.000^{lm}±8.888	2.667^{ghi}±1.527	63.667^{c-f}±7.023	61.667^{bcd}±8.802	2.000^{f-h}±2.000	29.700^{d-f}±2.000	3.000^{c}±0.000	0.000^{d-f}±2.000	3.000^{fg}±3.214	9.667^{h-j}±6.082
(28) 106	204.330^{ef}±17.502	155.000^{kl}±21.377	148.670^{lm}22.188	6.333^{fg}±3.511	33.000^{m-j}±8.544	27.000^{kl}±7.549	6.000^{ef}±2.000	16.400^{d-f}±2.516	2.333^{c}±0.000	0.000^{d-f}±2.516	2.333^{bc}±2.000	14.000^{de}±5.686
(29) 17	181.330^{ghi}±20.599	135.670^{kl}±22.368	128.670^{lm}±25.146	7.000^{fg}±3.000	31.667^{m-j}±8.144	29.667^{h-k}±4.082	2.000^{f-h}±1.000	17.933^{def}±1.732	2.000^{c}±0.000	0.000^{d-f}±1.732	2.000^{fg}±6.557	12.000^{h-j}±8.082
(30) Shaki A×D	220.330^{ef}±8.020	171.330^{ef}±4.509	163.000^{ef}±8.544	8.333^{fg}±4.041	40.667^{g-i}±5.507	35.333^{fg}±5.686	5.333^{ef}±1.154	18.433^{d-f}±1.154	4.667^{c}±0.000	0.000^{d-f}±1.154	4.667^{n-p}±2.886	3.667^{op}±4.932
(31) 124-16-9(116)	212.000^{ef}±3.000	180.000^{ef}±6.557	170.330^{ef}±4.041	9.667^{d-f}±2.516	22.667^{klm}±5.507	19.333^{klm}±4.163	3.333^{ef}±2.081	1.070^{def}±1.527	2.667^{c}±0.000	0.000^{d-f}±1.527	2.667^{fg}±2.309	6.667^{op}±4.163
(32) Mose.Black-Plain(2)	219.670^{ef}±16.563	190.000^{c-e}±13.747	186.330^{abc}±10.408	3.667^{fg}±3.511	20.667^{lm}±2.309	18.000^{lm}±2.000	2.667^{ef}±1.154	9.400^{def}±1.527	2.667^{c}±0.000	0.000^{d-f}±1.527	2.667^{l-g}±0.577	6.333^{op}±1.527
(33) 726(118)	243.330^{a}±16.010	204.330^{a}±12.662	193.670^{ab}±14.571	10.667^{b-d}±2.516	27.667^{j-m}±3.511	24.000^{kl}±4.000	3.667^{ef}±0.577	11.367^{def}±2.516	2.333^{c}±0.000	0.000^{d-f}±2.516	2.333^{fg}±4.582	9.000^{op}±9.165
(34) 1627-14-4-3	243.670^{a}±21.079	202.670^{ab}±16.165	197.000^{a}±15.716	5.667^{fg}±4.932	36.000^{g-m}±8.000	31.000^{h-k}±7.000	5.000^{ef}±1.000	14.667^{def}±4.041	2.333^{c}±0.000	0.000^{d-f}±4.041	2.333^{n-p}±0.577	2.667^{op}±1.000
(35) Koming-1(154)	196.000^{ef}±6.244	160.000^{kl}±8.717	155.000^{lm}±5.196	5.000^{fg}±3.605	30.000^{j-m}±1.000	26.000^{kl}±0.000	4.000^{ef}±1.000	15.300^{ef}±1.154	0.667^{c}±0.000	0.000^{ef}±1.154	0.667^{n-p}±3.214	5.333^{op}±6.244
(36) 1627-14-2-8	210.330^{ef}±11.676	162.670^{kl}±14.502	159.330^{ef}±11.590	3.333^{fg}±3.214	37.000^{g-m}±5.196	31.000^{h-k}±5.000	6.000^{ef}±2.645	17.600^{d-f}±0.000	3.000^{c}±0.000	0.000^{d-f}±0.000	3.000^{fg}±4.163	7.667^{op}±7.637

Table 1. Contd.

(37) Mos.Black-Black(2)	228.330^{c-e}±13.576	194.670^{abc}±13.613	192.670ab±14.364	2.000^{ghi}±1.000	27.667^{j-m}±5.507	26.667^{kl}±5.507	1.000^{hi}±0.000	12.133^{ef}±1.732	1.000^{c}±0.000	0.000^{ef}±1.732	1.000^{n-p}±3.785	4.667^{op}±7.571
(38) 823	183.000^{ghi}±13.453	144.000^{kl}±3.605	137.000 ^{lm}±4.582	7.000^{fg}±2.645	31.667^{j-m}±8.504	24.000^{kl}±9.165	7.667^{c-e}±4.725	17.133^{d-f}±1.000	4.000^{c}±0.000	0.000^{d-f}±1.000	4.000^{n-p}±2.309	3.333^{op}±4.618
(39) 1640	219.000^{ef}±40.595	177.330^{ef}±25.383	167.670^{ef}±24.440	9.667^{d-f}±2.081	35.000^{g-m}±16.000	31.333^{h-k}±16.502	3.667^{ef}±0.577	15.433^{def}±2.309	2.667^{c}±0.000	0.000^{d-f}±2.309	2.667^{n-p}±1.732	4.000^{op}±3.785
(40) 102(Shown)	211.000^{ef}±10.148	172.330^{ef}±4.725	168.330^{ef}±5.686	4.000^{fg}±1.000	21.667^{klm}±6.110	19.000^{klm}±5.291	2.667^{ef}±1.154	10.200^{ef}±1.000	1.000^{c}±0.000	0.000^{ef}±1.000	1.000^{b}±1.732	16.000^{cd}±3.000
(41) W2-13-9(108)	190.670^{ef}±12.583	156.000^{kl}±7.211	151.000^{lm}±10.148	5.000^{fg}±3.000	24.333^{klm}±6.806	23.000^{kl}±6.082	1.333^{hi}±1.154	12.700^{ef}±0.577	0.667^{c}±0.000	0.000^{ef}±0.577	0.677^{fg}±1.154	9.667^{h-j}±1.732
(42) 1001	208.670^{ef}±9.814	154.330^{kl}±10.115	149.670^{lm}±11.547	4.667^{fg}±1.527	41.667^{fg}±4.618	34.667^{fg}±2.5516	7.000^{ef}±5.000	20.033^{def}±1.154	2.333^{c}±0.000	0.000^{d-f}±1.154	2.333^{fg}±2.886	10.333^{e-h}±5.686
(43) W1-2-7	207.330^{ef}±29.535	168.000^{kl}±30.446	163.670^{ef}±34.947	4.333^{fg}±4.932	33.333^{j-m}±1.527	32.667^{fg}±2.081	0.677^{hig}±0.577	16.367^{def}±1.154	2.333^{c}±0.000	0.000^{d-f}±1.154	2.333^{n-p}±1.527	3.667^{op}±2.516
(44) CS120(N19)	193.330^{ef}±20.550	155.330^{kl}±0.000	144.000^{lm}52.000	11.333^{bc}±3.785	29.667^{j-m}±5.507	27.667^{h-k}±4.725	2.000^{f-h}±1.000	15.300^{d-f}±1.1732	6.000^{c}±0.000	0.000^{d-f}±1.732	6.000^{n-p}±2.516	2.333^{pqr}±4.582
(45) Koming-2-5	212.330^{ef}±38.798	182.000^{ef}±43.092	179.000^{c-e}±39.509	3.000^{fg}±3.605	22.333^{klm}±4.932	22.333^{kl}±4.932	0.000^{j}±0.000	10.933^{ef}±1.732	1.000^{c}±0.000	0.000^{ef}±1.732	1.000^{fg}±2.000	7.000^{op}±3.511
(46) W2-13-4	193.670^{ef}±14.640	129.67^{l-t}±14.843	126.330^{lm}±12.858	3.333^{fg}±2.886	43.667^{fg}±4.163	43.667^{fg}±4.163	0.000^{j}±0.000	22.700^{d-f}±2.081	3.333^{c}±0.000	0.000^{de}±2.081	3.333^{b}±1.732	17.000^{bc}±3.214
(47) Y-5	181.670^{ghi}±10.115	139.67^{kl}±9.451	122.000^{lm}±8.544	17.667^{a}±2.081	26.667^{j-m}±3.055	24.667^{kl}±2.081	2.000^{f-h}±1.732	14.667^{def}±1.732	2.000^{c}±0.000	0.000^{d-f}±1.732	2.000^{bcd}±1.527	17.333^{d-e}±2.081
(48) 127-17	191.000^{ef}±17.349	154.33^{kl}±18.147	147.000^{lm}±18520	7.333^{fg}±1.527	31.000^{j-m}±3.605	30.667^{h-k}±4.163	0.333^{ij}±0.577	16.400^{ef}±1.527	1.333^{c}±0.000	0.000^{ef}±1.527	1.333^{n-p}±4.932	4.333^{op}±7.571
(49) Lemon Khorasan	186.000^{f-h}±19.078	151.000^{kl}±25.534	147.330^{lm}±26.083	3.667^{ghi}±0.577	27.333^{j-m}±7.637	26.667^{kl}±7.094	0.667^{hij}±0.577	15.067^{d-f}±2.081	5.333^{c}±0.000	0.000^{d-f}±1.732	5.000^{n-p}±0.577	2.333^{op}±1.154
(50) Lemon Haratee	195.670^{ef}±15.011	113.000^{r-t}±18.520	111.670^{nop}±17.559	1.333^{hi}±1.154	67.667^{bc}±38.070	64.333^{abc}±35.557	3.333^{ef}±2.516	33.867^{d-f}±1.527	4.667^{b}±1.732	0.000^{d-f}±3.214	3.667^{fg}±6.658	10.333^{h-j}±9.237
(51) White Haratee	183.000^{ghi}±18.248	140.330^{kl}±4.932	133.670^{lm}±7.023	6.667^{fg}±3.785	32.333^{j-m}±16.165	30.000^{h-k}±15.394	2.333^{f-h}±1.527	17.200^{d-f}±2.000	5.000^{c}±0.000	0.000^{d-f}±2.000	5.000^{n-p}±3.055	5.333^{op}±1.033
(52) Yellow Haratee	166.330^{hij}±22.120	112.670^{rst}±14.294	109.000^{op}±15.394	3.667^{fg}±1.154	32.000^{j-m}±8.717	30.667^{h-k}±8.326	1.333^{h-i}±1.154	19.067^{b}±4.358	9.000^{c}±0.000	0.000^{b}±4.358	9.000^{cd}±2.516	12.667^{de}±1.055
(53) Pink Khorasan	182.330^{ghi}±5.507	143.330^{kl}±11.846	136.330^{lm}±8.504	7.000^{fg}±4.000	34.000^{j-m}±13.527	30.000^{h-k}±10.535	4.000^{ef}±1.464	18.700^{def}±3.214	2.333^{c}±0.000	0.000^{d-f}±3.214	2.333^{n-p}±1.527	2.667^{op}±1.055
(54) Baghdadi	162.330^{ij}±36.555	126.000^{o-t}±31.096	116.330^{mn}±38.811	9.667^{d-f}±8.082	26.333^{j-m}±13.868	25.000^{kl}±13.114	1.333^{h-i}±1.527	16.333^{def}±1.527	2.667^{c}±0.000	0.000^{d-f}±1.527	2.667^{fg}±2.516	7.333^{op}±5.131

Means in each column followed by the same letters are not significantly different at α = 0.01.

Table 1. Contd.

Trait / Pure line	Number of dead pupae in double cocoon	Pupae vitality percentage (%) 33	Cocoon weight (g)	Shell cocoon weight (g)	Shell cocoon percentage (%)	Male cocoon weight (g)	Male shell cocoon weight (g)	Male shell cocoon percentage (%)	Female cocoon weight (g)	Female shell cocoon weight (g)	Female shell cocoon percentage (%)	Good cocoon weight of 250 larvae (g)
(1) 6/4-6/6	1.667^{cde}±1.000	1.000^{l}±5.105	76.233^{b}±0.000	1.330^{b}±0.004	0.160^{q}±0.321	1.147^{u}±0.011	0.159^{g}±0.005	13.800^{n}±0.300	1.507^{o}±0.015	0.166^{h}±0.003	11.000^{q}±0.346	118.507^{r}±20.885
(2) 104	5.667^{c-e}±1.527	2.333^{ijk}±3.914	87.067 ^{b}±0.064	1.733^{b}±0.012	0.410^{cf}±0.351	1.573^{ef}±0.064	0.405^{cd}±0.015	25.733^{c-e}±1.001	1.887^{ef}±0.058	0.415^{bc}±0.014	22.000^{ef}±0.264	264.553^{ef}±15.061
(3) 124-K	4.333^{c-e}±1.527	1.667^{ef}±0.321	93.567 ^{b}±0.500	1.657^{b}±0.018	0.375^{fg}±0.493	1.480^{mo}±0.045	0.379^{cd}±0.016	25.633^{c-e}±0.776	1.827^{ef}±0.055	0.370^{c-f}±0.030	20.233^{f-j}±1.301	267.523^{ef}±32.907
(4) 120-K	2.000^{cde}±1.154	0.667^{ef}±1.201	94.833 ^{b}±0.056	1.633^{b}±0.100	0.356^{fg}±0.173	1.500^{f-o}±0.045	0.351^{cd}±0.010	23.400^{e-g}±0.100	1.767^{ef}±0.075	0.361^{c-f}±0.013	20.400^{f-j}±0.264	201.627^{n-p}±18.009
(5) 108-K	8.000^{cde}±1.154	1.333^{ef}±3.501	92.133 ^{b}±0.028	1.693^{b}±0.005	0.368^{fg}±0.000	1.497^{f-o}±0.025	0.356^{cd}±0.004	23.767^{e-g}±0.152	1.883^{ef}±0.037	0.378^{c-f}±0.007	20.067^{f-j}±0.057	273.137^{ef}±28.942
(6) W2-11-19-2(110)	4.333^{a}±2.000	5.000^{ef}±4.309	92.033 ^{b}±0.160	1.700^{a}±1.730	1.358^{fg}±0.550	1.520^{ef}±0.153	0.353^{cd}±0.035	23.200^{e-g}±0.529	1.877^{ef}±0.172	0.363^{c-f}±0.039	19.300^{f-j}±0.529	220.200^{n-p}±20.444
(7) W2-11-19-3	6.000^{cde}±0.577	0.667^{ef}±2.025	91367 ^{b}±0.045	1.863^{b}±0.017	0.407^{fg}±0.435	1.673^{ab}±0.020	0.396^{cd}±0.007	23.677^{e-g}±0.577	2.050^{abc}±0.091	0.418^{bc}±0.026	20.367^{f-j}±0.351	266.053^{ef}±32.879
(8) 1002-4-C-5	4.000^{c-e}±0.577	2.667^{g-i}±3.980	88.467 ^{b}±0.017	1.680^{b}±0.100	0.377^{fg}±0.814	1.490^{f-o}±0.036	0.368^{cd}±0.011	24.667^{e-g}±0.602	1.870^{ef}±0.055	0.387^{c-f}±0.012	20.733^{ef}±1.011	162.810^{q}±14.832
(9) 1002-E-8-3	4.667^{e}±0.000	0.000^{c-e}±1.301	95.533 ^{b}±0.156	1.700^{b}±0.025	0.402^{bc}±0.700	1.487^{mo}±0.086	0.390^{cd}±0.010	26.233^{abc}±0.971	1.910^{ef}±0.233	0.414^{bc}±0.040	21.733^{ef}±0.650	285.847^{ef}±15.955
(10) Guilan-Orange	0.667^{e}±0.000	0.000^{ef}±3.803	90.967 ^{b}±0.045	1.503^{b}±0.015	0.261^{fg}±1.446	1.360^{qr}±0.065	0.270^{u}±0.029	19.967^{klm}±2.742	1.643^{mno}±0.032	0.584^{a}±0.577	15.233^{o}±0.305	183.627^{pq}±92.428
(11) Khorasan-Orange	16.000^{cde}±1.732	1.000^{ef}±0.608	95.20 ^{b}±0.075	1.500^{b}±0.142	0.196^{fg}±2.511	1.330^{qrs}±0.088	0.286^{fg}±0.036	21.700^{g-k}±4.348	1.670^{k-o}±0.095	0.297^{fg}±0.014	17.833^{mn}±1.193	249.037^{n-l}±25.705
(12) Shown	6.000^{e}±0.000	0.000^{ef}±1.662	92.367 ^{b}±0.121	1.820^{b}±0.016	0.429^{cf}±0.953	1.650^{bc}±0.070	0.391^{cd}±0.018	23.700^{e-g}±0.984	1.987^{bc}±0.173	0.465^{bc}±0.015	23.467^{abc}±1.415	329.500^{bc}±15.579
(13) T1-P	0.000^{e}±0.000	0.000^{ef}±1.258	94.667 ^{b}±0.047	1.663^{b}±0.018	0.416^{ab}±0.458	1.497^{f-o}±0.055	0.406^{bcd}±0.035	27.167^{ab}±2.203	1.830^{ef}±0.065	0.426^{bcd}±0.026	23.333^{bc}±1.800	318.043^{cde}±16.768
(14) T5-P	4.667^{e}±0.000	0.000^{ef}±3.066	91.133 ^{b}±0.047	1.783^{b}±0.036	0.415^{fg}±2.193	1.573^{ef}±0.089	0.371^{cd}±0.044	23.567^{e-g}±1.934	1.987^{bc}±0.011	0.459^{bc}±0.055	23.067^{c-e}±2.916	308.857^{ef}±35.075
(15) CS120(7409)	4.667^{e}±0.000	0.000^{ef}±1.752	92.000 ^{b}±0.700	1.430^{b}±0.009	0.293^{fg}±1.677	1.297^{rst}±0.085	0.271^{fg}±0.025	21.000^{kl}±3.340	1.563^{no}±0.065	0.315^{fg}±0.007	20.200^{f-j}±1.039	236.833^{n-p}±5.605
(16) BH-4	9.667^{c-e}±0.577	1.667^{ef}±1.417	94.700^{b}±0.050	1.807^{b}±0.016	0.394^{fg}±0.034	1.610^{ef}±0.045	0.383^{c-d}±0.014	23.767^{e-g}±0.305	1.993^{bc}±0.058	0.404^{bc}±0.018	20.233^{f-h}±0.351	343.077^{ab}±18.354
(17) BH-3	1.000^{cde}±0.707	0.333^{k}±0.000	88.433^{b}±0.021	1.530^{b}±0.012	0.341^{fg}±0.494	1.367^{o-q}±0.007	0.321^{fg}±0.012	23.467^{e-g}±0.707	1.690^{o-n}±0.035	0.340^{fg}±0.013	20.100^{f-j}±0.424	226.140^{n-p}±42.221

Table 1. Contd.

(18) 104×110	12.667^{cde}±1.154	1.333^{abc}±0.057	96.667^{b}±0.010	1.870^{b}±0.014	0.421^{fg}±0.700	1.660^{abc}±0.045	0.409^{bcd}±0.018	24.633^{e-g}±0.750	2.083^{ab}±0.050	0.432^{bc}±0.012	20.722^{ef}±0.665	283.167^{ef}±39.479
(19) 110×104(152)	46.333^{abc}±1.527	3.667^{ef}±0.251	94.367^{b}±0.045	1.567^{b}±0.006	0.348^{fg}±0.493	1.417^{o-q}±0.051	0.346^{c-d}±0.012	24.433^{e-g}±0.763	1.717^{k-m}±0.035	0.349^{fg}±0.001	20.333^{f-j}±0.321	232.807^{n-p}±11.441
(20) 32×110	15.667^{c-e}±1.000	3.000^{ef}±2.909	92.833^{b}±0.049	1.683^{b}±0.017	0.355^{fg}±0.862	1.530^{ef}±0.051	0.363^{c-d}±0.016	24.733^{e-g}±1.365	1.830^{ef}±0.043	0.346^{fg}±0.021	18.900^{klm}±0.866	198.423^{n-p}±26.476
(21) 110×32	7.333^{cde}±1.154	1.333^{ef}±3.212	93.733^{b}±0.090	1.723^{b}±0.039	0.387^{fg}±1.096	1.507^{ef}±0.073	0.376^{c-d}±0.038	24.867^{e-g}±1.327	1.937^{ef}±0.105	0.398^{bc}±0.040	20.500^{f-j}±1.044	265.74^{ef}±55.589
(22) 18-1	7.000^{cde}±1.000	1.000^{ef}±1.913	94.7233^{b}±0.020	1.790^{b}±0.009	0.394^{fg}±0.750	1.587^{ef}±0.028	0.379^{c-d}±0.001	23.867^{e-g}±0.493	1.987^{bc}±0.015	0.408^{bc}±0.017	20.533^{f-j}±1.006	293.510^{ef}±23.891
(23) 1538-8-2(114)	24.000^{cde}±1.154	0.667^{bc}±0.208	95.733^{b}±0.064	1.577^{b}±0.016	0.372^{cf}±0.907	1.377^{o-q}±0.050	0.361^{c-d}±0.015	26.200^{bc}±1.000	1.770^{ef}±0.078	0.384^{c-f}±0.019	21.700^{ef}±0.721	252.723^{f-n}±36.248
(24) 1538-14-9(112)	2.333^{cde}±1.000	1.000^{i-g}±3.308	89.330^{b}±0.035	1.597^{b}±0.002	0.351^{fg}±0.300	1.473^{mo}±0.050	0.348^{c-d}±0.013	23.600^{e-g}±1.000	1.713^{m-k}±0.049	0.353^{fg}±0.009	20.633^{f-j}±0.585	200.063^{n-p}±13.117
(25) 4-4	8.667^{cde}±1.154	1.333^{ef}±3.622	95.133^{b}±0.035	1.743^{b}±0.016	0.398^{fg}±0.493	1.523^{ef}±0.028	0.379^{c-d}±0.014	24.933^{e-g}±0.550	1.960^{cde}±0.060	0.416^{bc}±0.020	21.233^{ef}±0.416	286.133^{ef}±27.473
(26) 32	24.000^{c-e}±0.577	2.667^{ef}±1.705	93.500^{b}±0.091	1.740^{b}±0.030	0.396^{fg}±0.585	1.540^{ef}±0.091	0.383^{c-d}±0.037	24.833^{e-g}±0.907	1.937^{ef}±0.097	0.408^{bc}±0.024	21.033^{ef}±0.351	210.873^{n-p}±11.570
(27) Tokaee-202	18.000^{cde}±1.527	1.333^{bc}±3.053	95.967^{b}±0.026	1.770^{b}±0.010	0.401^{fg}±0.721	1.590^{ef}±0.020	0.390^{c-d}±0.015	24.533^{e-g}±1.040	1.950^{ef}±0.034	0.413^{bc}±0.005	21.167^{ef}±0.503	245.207^{n-l}±21.044
(28) 106	23.333^{ab}±2.081	4.667^{ef}±3.774	91.000^{b}±0.051	1.723^{b}±0.009	0.386^{fg}±0.929	1.517^{ef}±0.097	0.362^{c-d}±0.024	23.867^{e-g}±0.057	1.920^{ef}±0.043	0.410^{bc}±0.036	21.333^{ef}±1.709	267.707^{ef}±30.334
(29) 17	18.667^{a}±5.773	5.333^{ef}±4.059	91.600^{b}±0.020	1.800^{b}±0.035	0.477^{a}±2.084	1.623^{ef}±0.015	0.467^{b}±0.081	28.767^{a}±0.259	1.973^{bc}±0.041	0.486^{ab}±0.059	24.667^{a}±3.500	253.357^{f-n}±42.929
(30) Shaki A×D	7.333^{ed}±0.577	0.333^{ef}±2.040	91.667^{b}±0.056	1.793^{b}±0.013	0.347^{fg}±0.208	1.590^{ef}±0.079	0.339^{d-f}±0.012	21.300^{kl}±0.400	1.990^{bc}±0.060	0.355^{fg}±0.016	17.833^{mn}±0.288	308.093^{ef}±12.284
(31) 124-16-9(116)	1.667^{c-e}±1.154	2.667^{ef}±2.631	93.167^{b}±0.045	1.730^{b}±0.008	0.408^{cf}±0.986	1.553^{ef}±0.030	0.392^{cd}±0.005	25.233^{e-g}±0.850	1.903^{ef}±0.065	0.423^{bc}±0.012	22.233^{ef}±1.021	316.880^{cde}±17.028
(32) Mose.Black-Plain(2)	12.333$^{de\pm}$0.577	0.333^{bc}±2.281	95.967^{b}±0.104	1.720^{b}±0.025	0.389^{fg}±0.501	1.520^{ef}±0.095	0.370^{cd}±0.026	24.300^{e-g}±0.435	1.917^{ef}±0.107	0.408^{bc}±0.040	21.367^{ef}±2.466	321.800^{c-e}±18.374
(33) 726(118)	18.000^{e}±0.000	0.000^{ef}±1.852	93.300^{b}±0.045	1.680^{b}±0.016	0.364^{fg}±0.351	1.503^{ef}±0.056	0.353^{cd}±0.018	23.467^{e-g}±0.635	1.850^{ef}±0.072	0.375^{c-f}±0.015	20.267^{f-j}±0.321	332.877^{abc}±18.614
(34) 1627-14-4-3	5.000^{de}±0.577	0.333^{ef}±3.302	94.533^{b}±0.015	1.757^{b}±0.020	0.377^{fg}±1.040	1.583^{ef}±0.045	0.358^{cd}±0.009	22.633^{e-g}±0.351	1.923^{ef}±0.020	0.395^{bc}±0.032	20.567^{f-j}±1.871	356.610^{a}±33.098
(35) Koming-1(154)	8.000^{cde}±1.527	0.333^{ef}±1.159	93.867^{b}±0.052	1.880^{b}±0.010	0.455^{bcd}±059	1.693^{a}±0.046	0.452^{bc}±0.006	26.700^{abc}±0.346	2.063^{abc}±0.064	0.458^{bc}±0.024	22.233^{ef}±1.680	292.377^{ef}±19.816
(36) 1627-14-2-8	13.333^{c-e}±1.000	2.000^{ef}±1.001	93.400^{b}±0.089	1.757^{b}±0.014	0.406^{fg}±0.378	1.590^{ef}±0.060	0.402^{cd}±0.013	25.300^{cde}±0.100	1.920^{ef}±0.122	0.411^{bc}±0.015	21.400^{ef}±0.529	292.607^{ef}±26.764
(37) Mos.Black-Black(2)	9.333^{e}±0.000	0.000^{a}±0.351	98.267^{b}±0.077	1.503^{b}±0.020	0.325^{fg}±0.321	1.327^{qrs}±0.064	0.315^{fg}±0.018	23.733^{e-g}±0.305	1.680^{k-o}±0.091	0.336^{fg}±0.022	19.967^{f-j}±0.450	305.253^{ef}±15.000
(38) 823	6.667^{cde}±0.000	0.000^{f-j}±3.377	89.900^{b}±0.222	1.673^{b}±0.037	0.376^{fg}±0.737	1.513^{ef}±0.162	0.367^{cd}±0.033	24.300^{e-g}±0.360	1.833^{ef}±0.284	0.384^{c-f}±0.041	21.033^{ef}±0.960	239.877^{n-p}±39.036
(39) 1640	6.667^{cde}±0.577	1.000^{ef}±2.655	91.333^{b}±0.106	1.737^{b}±0.034	0.387^{fg}±0.611	1.580^{ef}±0.104	0.382^{cd}±0.040	24.167^{e-g}±1.234	1.887^{ef}±0.117	0.391^{c-f}±0.028	20.700^{f-j}±0.360	303.590^{ef}±25.474
(40) 102(Shown)	31.000^{cde}±1.732	1.000^{ef}±0.360	96.200^{b}±0.035	1.643^{b}±0.045	0.374^{fg}±2.324	1.453^{o-q}±0.035	0.363^{cd}±0.046	24.967^{e-g}±2.571	1.833^{ef}±0.041	0.385^{c-f}±0.045	20.967^{ef}±2.010	288.203^{ef}±4.111
(41) W2-13-9(108)	19.000^{de}±0.577	0.333^{bc}±1.464	96.267^{b}±0.097	1. 720^{b}±0.006	0.357^{fg}±0.568	1.563^{ef}±0.025	0.347^{cd}±0.006	22.233^{e-g}±0.577	1.873^{ef}±0.086	0.365^{c-f}±0.012	19.500^{f-j}±0.458	274.337^{ef}±8.406
(42) 1001	20.333^{cde}±1.000	1.000^{ef}±2.715	93.067^{b}±0.052	1.710^{b}±0.007	0.352^{fg}±0.550	1.570^{ef}±0.072	0.349^{cd}±0.004	22.233^{e-g}±1.184	1.847^{ef}±0.032	0.355^{fg}±0.011	19.233^{f-j}±0.416	277.400^{ef}±18.495
(43) W1-2-7	6.333^{cde}±1.000	1.000^{bc}±3.629	95.800^{b}±0.060	1.687^{b}±0.015	0.362^{fg}±0.416	1.510^{ef}±0.036	0.353^{cd}±0.011	23.367^{e-g}±0.404	1.867^{ef}±0.085	0.370^{c-f}±0.019	19.833^{f-j}±0.321	290.730^{ef}±42.495
(44) CS120(N19)	4.000^{cde}±0.577	0.667^{f-j}±1.808	89.000^{b}±0.047	1.397^{b}±0.013	0.315^{fg}±0.802	1.220^{stu}±0.040	0.306^{fg}±0.019	24.900^{e-g}±2.042	1.560^{ef}±0.051	0.323^{fg}±0.019	20.733^{ef}±0.585	215.110^{n-p}±25.283
(45) Koming-2-5	13.333^{cde}±0.577	0.667^{ab}±1.322	98.000^{b}±0.037	1.487^{b}±0.017	0.312^{fg}±1.153	1.290^{rst}±0.030	0.301^{fg}±0.036	23.300^{e-g}±2.586	1.680^{k-o}±0.043	0.323^{fg}±0.005	19.233^{f-j}±0.208	252.580^{f-n}±20.248
(46) W2-13-4	32.667^{cde}±0.577	1.333^{bc}±2.386	96.333^{b}±0.400	1.517^{b}±0.011	0.306^{fg}±0.611	1.387^{o-q}±0.064	0.305^{fg}±0.015	22.000^{g-k}±0.173	1.640^{mno}±0.026	0.306^{fg}±0.012	18.667^{lm}±1.006	184.483^{pq}±17.617
(47) Y-5	21.333^{a}±1.527	5.333^{jk}±1.761	86.133^{b}±0.064	1.533^{b}±0.017	0.378^{abc}±1.868	1.377^{o-q}±0.061	0.687^{a}±0.057	25.733^{cde}±2.345	1.683^{k-o}±0.063	0.402^{bc}±0.026	23.867^{ab}±1.703	211.013^{n-p}±6.649
(48) 127-17	7.333^{cde}±2.309	1.333^{ef}±2.052	94.767^{b}±0.154	1.863^{b}±0.021	0.441^{bc}±0.721	1.627^{cde}±0.025	0.410^{bcd}±0.014	25.200^{efg}±0.529	2.097^{a}±0.275	0.471^{abc}±0.042	22.600^{ef}±1.300	296.807^{ef}±28.509
(49) Lemon Khorasan	4.667^{e}±0.000	0.000^{ef}±1.400	94.700^{b}±0.055	1.347^{b}±0.007	0.186^{fg}±0.321	1.207^{u}±0.047	0.179^{fg}±0.007	14.833^{n}±0.404	1.503^{o}±0.051	0.192^{gh}±0.007	12.767^{pq}±0.115	206.883^{n-p}±29.741
(50) Lemon Haratee	17.333^{bc}±4.163	3.333^{ef}±2.413	94.367^{b}±0.079	1.710^{b}±0.037	0.271^{fg}±1.550	1.507^{ef}±0.095	0.289^{fg}±0.066	19.033^{lm}±3.286	1.903^{ef}±0.077	0.252^{fg}±0.008	13.233^{p}±0.321	195.160^{opq}±24.832
(51) White Haratee	9.333^{cde}±1.154	1.333^{ef}±3.439	91.600^{b}±0.045	1.543^{b}±0.046	0.293^{fg}±2.829	1.370^{o-q}±0.010	0.279^{fg}±0.063	20.367^{kl}±4.793	1.717^{k-m}±0.095	0.307^{fg}±0.046	17.867^{mn}±1.892	211.487^{n-p}±10.391
(52) Yellow Haratee	22.667^{c-e}±4.618	2.667^{ef}±4.201	90.867^{b}±0.075	1.710^{b}±0.033	0.229^{fg}±1.422	1.523^{ef}±0.070	0.233^{efg}±0.053	15.233^{n}±2.829	1.890^{ef}±0.085	0.225^{gh}±0.017	11.867^{pq}±0.404	195.423^{opq}±23.124
(53) Pink Khorasan	5.333^{e}±0.000	0.000^{ef}±1.708	92.800^{b}±0.025	1.593^{b}±0.018	0.333^{fg}±1.452	1.433^{o-q}±0.049	0.313^{fg}±0.021	21.833^{g-k}±1.721	1.753^{f-m}±0.015	0.340^{fg}±0.026	19.440^{f-j}±1.636	227.347^{n-p}±26.321
(54) Baghdadi	13.333^{cde}±0.577	1.333^{ef}±7.958	89.933^{b}±0.110	1.637^{b}±0.017	0.286^{fg}±0.600	1.463^{mo}±0.085	0.275^{fg}±0.015	18.833^{m}±0.680	1.803^{ef}±0.0138	0.297^{fg}±0.020	16.467^{no}±0.611	231.917^{n-p}±44.089

Means in each column followed by the same letters are not significantly different at α = 0.01.

Table 1. Contd.

Pure line \ Trait	Middle cocoon weight of 250 larvae (g)	Middle cocoon weight (g)	Low cocoon weight of 250 larvae (g)	Low cocoon weight (g)	Double cocoon weight of 250 larvae (g)	Double cocoon weight (g)	Total cocoon weight of 250 larvae (g)	Total cocoon weight of 10000 4th instar larvae (g)	Cocoon number per liter	Cocoon weight per liter (g)	Male pupae weight (g)	Female pupae weight (g)
(1) 6/4-6/6	96.203^{fg}±7.262	1.333^{ut}±0.047	66.660^{a}±23.143	1.377^{bc}±0.271	3.657^{pqo}±1.730	2.717^{ef}±0.155	271.693^{klm}±17.400	5869.330^{r}±729.287	102.000^{hi}±8.544	129.273^{s}±6.903	1.165^{qrs}±0.005	1.008^{j}±0.595
(2) 104	52.427^{mn}±19.792	1.503^{l-r}±0.061	11.867^{bcd}±7.292	1.572^{bc}±0.332	13.443^{no}±8.226	3.447^{bc}±0.241	342.290^{ef}±22.156	13360.300^{lm}±563.168	88.000^{pq}±2.645	147.913^{pqr}±4.767	1.320^{f-l}±0.050	1.472^{ef}±0.044
(3) 124-K	73.507^{fg}±21.912	1.470^{l-r}±0.043	5.503^{c-d}±1.424	1.487^{bc}±0.176	10.013^{no}±0.176	3.337^{bc}±0.060	356.547^{ef}±35.981	12464.700^{lm}±999.532	103.667^{hi}±7.094	173.520^{fg}±7.675	1.279^{l-q}±0.032	1.457^{ef}±0.040
(4) 120-K	88.550^{fg}±4.787	1.583^{kl}±0.041	6.150^{c-d}±3.757	1.643^{bc}±0.189	4.300^{no}±4.982	2.130^{ef}±1.845	300.627^{j-k}±24.439	11116.300^{o-q}±294.009	97.333^{pq}±11.150	160.740^{no}±12.731	1.277^{l-q}±0.046	1.406^{ef}±0.062
(5) 108-K	83.783^{fg}±17.233	1.447^{l-r}±0.066	5.040^{c-d}±8.729	0.457^{bcd}±0.790	15.113^{no}±6.697	3.247^{bc}±0.090	377.073^{ef}±30.097	12390.000^{lm}±759.046	88.000^{pq}±2.000	149.187^{o-q}±2.338	1.323^{f-l}±0.024	1.505^{ef}±0.030
(6) W2-11-19-2(110)	83.943^{fg}±7.799	1.603^{kl}±0.0171	2.120^{cde}±0.791	1.352^{bc}±0.494	78.170^{a}±36.569	3.373^{bc}±0.355	384.433^{bc}±41.386	12915.000^{lm}±780.161	1.9.667^{hi}±9.504	185.007^{fg}±3.984	1.341^{ef}±0.126	1.514^{ef}±0.133
(7) W2-11-19-3	156.537^{a}±32.101	1.750^{ef}±0.030	10.613^{c-d}±7.727	1.547^{bc}±0.304	11.713^{no}±5.803	3.350^{bc}±0.731	444.917^{a}±19.091	11169.700^{m-q}±1619.780	81.000^{rst}±6.000	150.043^{no}±9.399	1.455^{ab}±0.026	1.632^{bc}±0.065
(8) 1002-4-C-5	119.967^{bc}±43.432	1.657^{kl}±0.015	15.673^{b}±13.460	1.960^{a}±0.220	11.200^{no}±4.523	3.413^{bc}±0.177	309.65^{f-j}±47.928	9557.330^{q}±2071.730	90.333^{pq}±4.041	150.807^{no}±6.652	1.303^{f-l}±0.027	1.483^{ef}±0.059
(9) 1002-E-8-3	82.113^{fg}±21.232	1.570^{kl}±0.081	3.700^{cde}±3.282	1.070^{bc}±0.926	7.197^{no}±6.420	2.030^{ef}±1.780	378.857^{cde}±27.945	12811.000^{lm}±1387.180	84.333^{pq}±4.041	141.347^{qrs}±6.818	1.297^{f-l}±0.132	1.496^{ef}±0.194
(10) Guilan-Orange	22.100^{n}±14.377	1.450^{r-l}±0.065	6.203^{c-d}±8.515	1.127^{bc}±0.419	1.017^{pq}±1.760	1.017^{i}±1.760	212.947^{m}±112.429	12922.000^{lm}±505.767	121.000^{cde}±12.124	186.320^{df}±12.790	1.242^{l-q}±0.057	1.393^{ef}±0.032
(11) Khorasan-Orange	37.830^{lmn}±16.053	1.413^{r-s}±0.136	0.857^{e}±1.483	0.430^{bcd}±0.744	25.587^{ng}±6.682	3.067^{ef}±0.115	313.310^{ef}±29.819	13197.000^{lm}±1076.770	115.667^{def}±14.294	177.523^{fg}±10.861	1.209^{l-q}±0.095	1.373^{ef}±0.093
(12) Shown	48.540^{mn}±17.476	1.817^{bc}±0.066	6.237^{c-d}±5.523	1.387^{bc}±0.500	7.870^{no}±6.917	1.790^{ef}±1.649	392.147^{bc}±32.580	15412.700^{abc}±416.785	86.333^{pq}±7.371	158.320^{no}±15.436	1.390^{ef}±0.106	1.521^{ef}±0.159
(13) T1-P	65.130^{fg}±9.460	1.673^{kl}±0.133	4.507^{cde}±1.132	1.933^{a}±0.085	0.000^{q}±0.000	0.000^{i}±0.000	385.747^{bc}±20.907	13596.300^{ef}±1153.590	84.000^{pq}±4.000	142.073^{qrs}±4.124	1.247^{l-q}±0.033	1.404^{ef}±0.076
(14) T5-P	69.07^{fg}±33.798	1.843^{ab}±0.047	3.830^{cde}±3.334	1.587^{bc}±0.189	8.257^{no}±1.856	3.553^{ab}±0.073	394.827^{bc}±18.477	14583.700^{ef}±1661.280	96.667^{pq}±5.773	182.143^{fg}±8.769	1.365^{ef}±0.062	1.528^{ef}±0.066
(15) CS120(7409)	68.450^{fg}±9.355	1.403^{r-s}±0.133	4.057^{cde}±3.747	0.807^{bc}±0.698	6.290^{no}±7.126	1.743^{fh}±1.522	315.630^{ef}±21.652	10302.300^{pq}±692.024	149.000^{a}±10.816	209.687^{a}±13.878	1.137^{sr}±0.078	1.248^{gi}±0.066
(16) BH-4	60.687^{fg}±6.410	1.700^{kl}±0.030	5.903^{c-d}±4.449	1.770^{ab}±0.020	21.423^{no}±6.557	3.840^{a}±0.258	431.09^{ab}±20.136	15226.700^{bc}±331.204	105.667^{h-i}±4.163	19.222^{bcd}±0.965	1.409^{ef}±0.034	1.589^{c-e}±0.040
(17) BH-3	99.023^{b-d}±9.171	1.553^{kl}±0.091	5.383^{c-d}±8.902	1.238^{bc}±0.837	2.160^{pq}±2.239	2.160^{ghi}±2.397	332.707^{ef}±21.750	10365.000^{pq}±879.640	113.000^{h-i}±12.020	175.857^{fg}±18.172	1.199^{pq}±0.008	1.350^{ef}±0.021
(18) 104×110	100.043^{df}±23.875	1.773^{ef}±0.040	1.350^{de}±1.169	1.350^{bc}±1.169	23.667^{no}±8.832	3.443^{bc}±0.021	408.227^{ab}±23.429	13815.000^{ef}±1332.81	91.333^{pq}±4.041	172.327^{fg}±6.433	1.451^{abc}±0.010	1.651^{ab}±0.050
(19) 110×104(152)	56.990^{g-m}±5.585	1.530^{kl}±0.026	1.077^{de}±0.948	1.077^{bc}±0.948	77.503^{a}±12.122	3.360^{bc}±0.160	361.710^{ef}±22.446	13929.700^{ef}±1488.47	103.000^{h-i}±2.645	158.000^{no}±2.980	1.219^{l-q}±0.039	1.368^{ef}±0.033
(20) 32×110	129.240^{ab}±27.881	1.663^{kl}±0.058	0.237^{e}±0.409	0.237^{d}±0.409	31.100^{fg}±9.806	3.300^{bc}±0.220	359.000^{ef}±34.635	10651.000^{opq}±873.666	93.667^{pq}±4.725	162.893^{no}±4.415	1.326^{f-l}±0.041	1.484^{ef}±0.029
(21) 110×32	128.247^{ab}±38.150	1.680^{kl}±0.173	0.657^{e}±1.137	0.657^{bc}±1.137	14.450^{no}±5.430	3.317^{bc}±0.080	409.077^{ab}±24.217	11639.300^{l-m}±2425.64	97.667^{pq}±5.773	167.600^{n-g}±2.505	1.335^{ef}±0.050	1.539^{ef}±0.066
(22) 18-1	63.583^{fg}±16.229	1.683^{kl}±0.025	2.237^{cde}±2.515	1.133^{bc}±0.982	13.633^{no}±5.685	3.517^{ab}±0.340	372.963^{ef}±7.858	14360.000^{ef}±1066.83	83.000^{q-t}±4.000	148.923^{o-q}±2.262	1.394^{ef}±0.026	1.579^{ef}±0.029
(23) 1538-8-2(114)	59.437^{g-m}±5.698	1.427^{rs}±0.055	2.053^{cde}±2.288	1.050^{bc}±0.911	38.323^{fg}±14.734	3.120^{ef}±0.104	352.537^{ef}±31.650	12417.000^{l-m}±552.153	111.333^{e-h}±1.527	176.037^{fg}±2.262	1.201^{l-q}±0.052	1.386^{ef}±0.064
(24) 1538-14-9(112)	69.583^{fg}±7.508	1.533^{kl}±0.075	8.317^{c-d}±2.977	1.327^{bc}±0.119	4.727^{no}±1.175	2.927^{ef}±0.383	282.690^{jkl}±23.856	11240.300^{l-m}±354.234	105.000^{h-i}±2.645	167.547^{g-n}±5.809	1.243^{l-q}±0.032	1.360^{ef}±0.046
(25) 4-4	61.250^{fg}±15.952	1.643^{kl}±0.030	1.513^{cde}±1.032	1.440^{bc}±0.242	16.703^{no}±15.176	3.280^{bc}±0.140	365.933^{ef}±47.157	13459.000^{f-l}±974.291	116.333^{def}±4.932	187.017^{b-d}±7.907	1.344^{ef}±0.024	1.541^{ef}±0.040
(26) 32	94.790^{fg}±7.143	1.833^{abc}±0.075	4.803^{cde}±4.499	1.210^{bc}±0.512	44.520^{bcd}±9.949	3.363^{bc}±0.311	358.320^{ef}±21.309	12580.000^{l-m}±653.045	100.000^{pq}±5.567	174.190^{fg}±17.186	1.343^{ef}±0.064	1.529^{ef}±0.074
(27) Tokaee-202	107.800^{bcd}±9.212	1.697^{kl}±0.055	3.487^{cde}±2.105	1.207^{bc}±0.100	29.890^{fg}±8.974	3.123^{ef}±0.219	386.383^{bc}±21.244	12222.000^{ef}±897.933	90.333^{pq}±7.505	160.253^{no}±11.932	1.369^{ef}±0.030	1.537^{ef}±0.035
(28) 106	57.940^{g-m}±10.898	1.780^{ef}±0.137	4.347^{cde}±4.496	1.277^{bc}±1.111	49.260^{bc}±4.621	3.550^{ab}±0.396	377.879^{ef}±26.701	14503.700^{abc}±659.224	95.667^{pq}±6.027	169.317^{fg}±8.501	1.333^{ef}±0.052	1.510^{ef}±0.039
(29) 17	60.580^{fg}±19.395	1.893^{a}±0.141	3.550^{cde}±3.742	1.587^{bc}±0.491	44.227^{bcd}±25.908	3.630^{a}±0.153	361.713^{ef}±51.289	15264.3^{abc}±1390.270	77.667^{t}±6.429	148.520^{o-q}±6.908	1.322^{f-l}±0.044	1.487^{ef}±0.099
(30) Shaki A×D	70.307^{fg}±10.185	1.727^{f-k}±0.020	7.550^{c-d}±2.413	1.603^{bc}±0.203	12.920^{no}±8.983	3.693^{a}±0.655	398.903^{bc}±15.045	14318.700^{ef}±425.648	110.000^{h-i}±5.000	199.717^{ab}±6.628	1.444^{bc}±0.040	1.635^{abc}±0.043
(31) 124-16-9(116)	39.407^{lmn}±9.623	1.740^{ef}±0.600	4.950^{cde}±3.820	1.597^{bc}±0.695	24.067^{no}±9.806	3.540^{ab}±0.306	385.303^{bc}±22.753	15582.300^{ab}±744.054	93.333^{pq}±5.859	165.747^{no}±5.174	1.321^{f-l}±0.048	1.480^{ef}±0.066
(32) Mose.Black-Plain(2)	31.433^{mn}±4.611	1.523^{kl}±0.120	3.520^{cde}±1.523	1.490^{bc}±0.499	21.047^{no}±4.228	3.303^{bc}±0.346	377.800^{ef}±21.918	15240.700^{c-e}±1322.790	107.000^{h-i}±14.730	178.393^{fg}±11.801	1.329^{f-l}±0.091	1.508^{ef}±0.115
(33) 726(118)	44.200^{mn}±8.530	1.590^{kl}±0.121	3.380^{cde}±3.253	1.043^{bc}±0.941	29.007^{fg}±16.456	3.183^{c-e}±0.243	409.463^{abc}±33.325	14339.700^{ef}±618.742	106.333^{h-i}±6.027	173.953^{fg}±7.769	1.313^{f-l}±0.029	1.475^{ef}±0.057
(34) 1627-14-4-3	61.517^{fg}±11.962	1.720^{f-k}±0.101	4.173^{cde}±7.228	0.597^{bc}±1.033	9.170^{no}±2.314	3.423^{bc}±0.165	431.477^{ab}±40.618	14844.000^{ef}±118.882	94.000^{pq}±5.291	166.340^{no}±6.353	1.377^{ef}±0.018	1.195^{ij}±0.629
(35) Koming-1(154)	54.283^{mn}±0.864	1.810^{cde}±0.079	1.963^{cde}±3.400	0.983^{bc}±1.703	20.097^{no}±1.800	3.827^{a}±0.489	368.720^{ef}±24.504	15507.300^{ef}±720.853	89.667^{pq}±6.110	164.700^{no}±6.113	1.423^{ef}±0.059	1.605^{c-e}±0.081

Table 1. Contd.

(36) 1627-14-2-8	66.007^{fg}±11.932	1.780^{ef}±0.098	5.197^{cd}±0.127	1.730^{ab}±0.043	26.153^{fg}±13.645	3.447^{bc}±0.162	389.963^{bc}±21.291	14620.000^{ef}±139.387	91.333^{pq}±2.516	165.877^{no}±7.273	1.349^{ef}±0.076	1.509^{ef}±0107
(37) Mos.Black-Black(2)	40.283^{lmn}±5.820	1.470^{r-l}±0.088	0.800^{e}±1.385	0.267^{cd}±0.461	15.313^{no}±13.415	3.140^{ef}±0.399	361.650^{ef}±14.634	13785.700^{ab}±818.785	108.667^{hi}±5.859	167.460^{g-n}±6.359	1.178^{pq}±0.058	1.344^{ef}±0.070
(38) 823	51.483^{mn}±16.746	1.613^{kl}±0.170	6.010^{cd}±2.121	1.477^{bc}±0.228	12.270^{no}±11.259	3.337^{bc}±0.762	309.480^{f-j}±66.781	13477.300^{ef}±1859.790	100.333^{i-p}±6.506	168.137^{g-n}±17.403	1.299^{f-l}±0.184	1.449^{ef}±0.242
(39) 1640	56.380^{g-m}±30.055	1.563^{kl}±0.165	4.287^{cde}±3.892	1.073^{bc}±0.973	13.483^{no}±4.968	3.423^{bc}±0.193	377.740^{ef}±57.182	14407.700^{ef}±1568.060	89.333^{pq}±9.291	153.947^{no}±15.232	1.347^{ef}±0.075	1.496^{ef}±0.088
(40) 102(Shown)	34.970^{lmn}±9.401	1.620^{kl}±0.036	1.567^{cde}±1.371	1.143^{bc}±0.081	54.420^{b}±7.546	3.397^{bc}±0.176	379.160^{c-e}±11.168	15111.000^{c-e}±722.364	94.667^{pq}±1.527	160.983^{no}±2.456	1.262^{l-q}±0.008	1.448^{ef}±0.004
(41) W2-13-9(108)	39.977^{lmn}±12.903	1.633^{kl}±0.070	0.990^{de}±1.169	0.990^{bc}±1.169	33.947^{fg}±8.497	3.487^{abc}±0.450	349.250^{ef}±10.222	15437.000^{abc}±1394.98	104.667^{hi}±5.033	180.330^{fg}±13.920	1.362^{ef}±0.051	1.508^{ef}±0.075
(42) 1001	69.260^{fg}±5.699	1.663^{kl}±0.050	5.400^{cd}±4.196	1.957^{a}±1.134	36.760^{fg}±12.134	3.513^{ab}±0.234	388.820^{bc}±26.001	14285.700^{ef}±571.434	95.333^{pq}±4.163	172.520^{fg}±7.301	1.357^{ef}±0.048	1.492^{ef}±0.023
(43) W1-2-7	52.413^{mn}±4.900	1.570^{kl}±0.075	4.097^{cde}±2.198	1.713^{ab}±0.136	10.847^{no}±5.766	2.970^{ef}±0.717	358.087^{ef}±45.624	13277.300^{ef}±368.656	95.333^{pq}±1.154	162.932^{no}±2.456	1.327^{f-l}±0.046	1.497^{ef}±0.067
(44) CS120(N19)	40.447^{lmn}±7.374	1.367^{stu}±0.030	7.887^{cd}±1.998	1.327^{bc}±0.080	7.630^{no}±8.543	1.570^{ghi}±0.513	271.073^{klm}±37.423	11362.700^{lm}±527.124	116.667^{def}±4.163	166.437^{no}±4.169	1.081^{s}±0.037	1.237^{hij}±0.032
(45) Koming-2-5	31.213^{mn}±7.261	1.400^{rs}±0.115	1.190^{de}±2.061	0.397^{bcd}±0.687	20.707^{no}±6.661	2.943^{ef}±0.136	305.690^{jk}±11.067	12626.700^{l-m}±145.710	133.397^{bc}±32.733	171.410^{f-q}±10.221	1.173^{pq}±0.034	1.357^{ef}±0.038
(46) W2-13-4	70.023^{fg}±4.090	1.610^{kl}±0.081	4.853^{cde}±3.002	1.460^{bc}±0.036	49.143^{bc}±3.129	2.900^{ef}±0.121	308.503^{jk}±21.763	11085.300^{o-q}±207.527	121.667^{cd}±5.033	174.870^{fg}±6.811	1.208^{l-q}±0.035	1.334^{ef}±0.037
(47) Y-5	44.670^{mn}±5.544	1.673^{kl}±0.081	2.353^{cde}±2.118	0.783^{bc}±0.705	42.250^{cd}±5.131	3.133^{ef}±0.066	300.287^{jk}±7.995	13003.000^{lm}±533.686	113.333^{d-e}±5.773	170.083^{fg}±1.485	1.153^{qrs}±0.071	1.282^{f-i}±0.066
(48) 127-17	55.590^{mn}±6.695	1.793^{ef}±0.005	2.690^{cde}±3.126	1.330^{bc}±1.152	15.243^{no}±16.546	3.680^{a}±0.250	370.330^{ef}±26.576	15991.300^{a}±369.369	84.000^{pq}±13.000	160.470^{no}±17.807	1.421^{ef}±0.124	1.625^{bc}±0.023
(49) Lemon Khorasan	38.583^{lmn}±12.662	1.397^{rs}±0.075	6.957^{c-d}±2.984	1.287^{bc}±0.145	5.437^{no}±1.034	2.050^{ef}±1.120	257.860^{lm}±18.972	11239.700^{lm}±721.200	139.333^{ab}±11.590	193.950^{bc}±7.546	1.170^{pq}±0.042	1.311^{ef}±0.043
(50) Lemon Haratee	116.810^{bc}±72.390	1.680^{kl}±0.111	8.610^{c-d}±3.294	1.820^{ab}±0.138	35.773^{fg}±21.401	3.540^{ab}±0.121	356.353^{ef}±36.022	11261.300^{lm}±2446.350	185.667^{pq}±8.144	148.447^{o-q}±9.525	1.434^{c-e}±0.048	1.651^{ab}±0.071
(51) White Haratee	49.497^{mn}±21.374	1.583^{kl}±0.146	7.077^{c-d}±2.545	1.433^{bc}±0.070	16.073^{no}±8.901	3.037^{ef}±0.102	284.133^{jkl}±28.878	12147.700^{lm}±1018.450	110.000^{h-i}±10.000	168.440^{fg}±13.972	1.250^{l-q}±0.051	1.409^{ef}±0.055
(52) Yellow Haratee	55.543^{mn}±16.933	1.727^{f-k}±0.055	12.473^{bc}±7.865	1.327^{bc}±0.391	43.670^{bcd}±6.213	2.870^{ef}±0.920	307.110^{jk}±26.728	1347.300^{f-l}±1569.050	78.300st±9.237	135.623^{rs}±6.208	1.478^{a}±0.047	1.665^{a}±0.068
(53) Pink Khorasan	46.850^{mn}±27.157	1.295^{u}±0.0327	3.220^{cde}±4.451	0.913^{bc}±0.791	8.460^{no}±4.878	3.157^{c-e}±0.055	285.877^{jkl}±12.989	12732.700^{lm}±1212.130	115.333^{def}±3.055	186.853^{bcd}±6.673	1.267^{l-q}±0.043	1.413^{e}±0.037
(54) Baghdadi	41.967^{lmn}±23.787	1.543^{kl}±0.171	4.813^{cde}±3.155	1.680^{abc}±0.525	22.193^{no}±6.614	3.077^{ef}±0.361	270.890^{klm}±52.065	13234.000^{lm}±1062.690	96.667^{pq}±7.571	158.600^{no}±6.720	1.348^{ef}±0.096	1.507^{ef}±0121

Means in each column followed by the same letters are not significantly different at α = 0.01.

(237.667) and T1-P (234.667) strains remained significant at the upper level than other strains, respectively (Table 1).

Also, based on performance, potential of strains were assessed on different parameters including number of total produced cocoons, number of good produced cocoons, number of alive good produced cocoons, number of dead good produced cocoons, number of middle produced cocoons, number of alive middle produced cocoons, number of dead middle produced cocoons, number of low produced cocoons, number of alive low produced cocoons, number of dead low produced cocoons, number of double produced cocoons, number of alive pupae in double cocoons, number of dead pupae in double cocoons, pupae vitality percentage, cocoon weight, shell cocoon weight, shell cocoon percentage, male cocoon weight, male shell cocoon weight, male shell cocoon percentage, female cocoon weight, female shell cocoon weight, female shell cocoon percentage, good cocoon weight of 250 larvae, middle cocoon weight of 250 larvae, middle cocoon weight, low cocoon weight of 250 larvae, low cocoon weight, double cocoon weight of 250 larvae, double cocoon weight, total cocoon weight of 250 larvae, total cocoon weight of 10000 4th instar larvae, cocoon number per liter, cocoon weight per liter, male pupae weight and female pupae weight. Recorded characteristics of productive characters using the evaluation index (Tables 2 and 4) and sub-ordinate function (Tables 3 and 4) methods and the details are as follows: Totally, W2-11-19-2[110] (2030.234), W2-11-19-3 (2025.089), BH-4 (1981.516), 104×110 (1963.656) and 17 (1935.046) showed higher evaluation index values (Table 4). Also, W2-11-19-3 (19.868), W2-11-19-2 [110] (2030.234), BH-4 (18.857), 104×110 (18.560) and 17 (17.917) showed higher sub-ordinate function values (Table 4).

The cluster analyses divided the 54 strains into some groups as shown in Figures 1 to 7. However, the strains of the same origin did not group together, demonstrating they can have different biological and development performance. Main groups divided into other sub-groups separately. Three sub-groups included various strains.

Table 2. Evaluation index values for cocoon traits in studied silkworm pure lines of gene bank.

Pure line \ Trait	Number of total produced cocoon	Number of good produced cocoon	Number of Alive good produced cocoon	Number of dead good produced cocoon	Number of middle produced cocoon	Number of alive middle produced cocoon (25)	Number of dead middle produced cocoon	Number of low produced cocoons	Number of alive low produced cocoon	Number of dead low produced cocoon	Number of double produced cocoon	Number of alive pupae in double cocoon
(1) 6/4-6/6	51.718	26.302	28.377	31.182	68.372	64.923	79.487	69.600	116.783	115.347	116.282	39.809
(2) 104	49.068	51.404	50.624	56.765	46.105	42.803	66.987	46.171	56.646	47.811	57.298	44.870
(3) 124-K	56.550	53.496	54.354	44.484	55.250	54.514	56.991	53.589	49.757	47.811	49.926	42.972
(4) 120-K	39.559	37.546	38.235	43.462	58.829	61.019	41.993	63.884	49.757	56.244	49.255	39.809
(5) 108-K	60.135	52.843	53.422	46.532	59.823	57.984	65.738	57.035	49.757	47.811	49.926	46.135
(6) W2-11-19-2(110)	51.094	40.945	41.832	42.440	56.841	54.731	65.738	56.992	45.999	47.811	45.905	80.291
(7) W2-11-19-3	68.240	46.698	46.761	49.602	78.710	78.368	66.987	71.651	54.767	47.811	55.287	43.604
(8) 1002-4-C-5	38.936	28.002	28.776	41.414	68.570	67.525	65.738	74.662	58.526	64.702	57.969	43.604
(9) 1002-E-8-3	59.823	55.980	56.752	45.510	56.841	57.766	48.240	54.068	47.250	47.811	47.244	41.706
(10) Guilan-Orange	20.854	38.069	37.968	49.602	34.375	34.780	39.492	36.616	51.009	47.811	51.265	37.911
(11) Khorasan-Orange	47.041	53.888	53.822	51.650	41.134	41.720	41.993	41.066	44.119	47.811	43.894	53.092
(12) Shown	54.679	60.817	59.150	64.952	41.532	42.153	41.993	40.238	50.383	47.811	50.596	42.972
(13) T1-P	63.408	65.132	65.012	53.694	48.888	49.526	45.743	45.691	47.250	47.811	47.244	37.280
(14) T5-P	54.523	56.241	54.354	65.975	47.695	48.658	43.242	46.651	53.516	47.811	53.948	41.706
(15) CS120(7409)	63.096	59.902	58.084	65.975	54.455	54.514	51.989	51.145	49.129	47.811	49.255	41.706
(16) BH-4	62.941	63.694	64.745	44.484	46.502	46.490	48.240	43.727	49.129	47.811	49.255	48.033
(17) BH-3	53.432	50.358	44.496	64.952	63.402	60.803	71.988	63.187	49.757	47.811	49.926	38.545
(18) 104×110	53.900	48.397	49.292	43.462	59.027	60.586	45.743	58.562	44.119	47.811	43.894	50.562
(19) 110×104(152)	50.938	47.090	47.027	50.624	47.695	48.442	44.490	47.392	44.119	47.811	43.894	80.923
(20) 32×110	49.847	35.846	35.304	52.672	71.752	72.947	54.490	73.439	43.492	47.811	43.222	54.989
(21) 110×32	64.811	50.097	49.292	56.765	72.149	72.947	56.991	66.678	43.492	47.811	43.222	45.502
(22) 18-1	51.873	54.934	54.754	52.672	47.894	48.225	46.991	47.392	45.371	47.811	45.233	44.870
(23) 1538-8-2(114)	54.056	51.927	53.155	41.414	50.280	49.960	51.989	49.400	45.371	47.811	45.233	60.682
(24) 1538-14-9(112)	38.157	39.376	38.368	56.765	52.467	52.129	53.241	56.773	54.767	47.811	55.287	40.443
(25) 4-4	56.862	57.549	59.417	37.322	47.695	48.442	44.490	45.909	51.636	47.811	51.937	46.767
(26) 32	43.456	37.938	39.167	39.370	56.244	56.249	53.241	59.129	49.129	47.811	49.255	62.580
(27) Tokaee-202	54.212	43.822	45.162	39.370	63.402	65.791	43.242	62.794	48.504	47.811	48.585	55.623
(28) 106	49.223	50.228	50.225	50.624	45.111	43.237	58.239	45.386	47.250	47.811	47.244	63.845
(29) 17	38.468	42.645	42.231	52.672	44.316	44.972	43.242	47.392	46.624	47.811	46.574	60.050
(30) Shaki A×D	56.705	56.634	55.953	56.765	49.684	48.658	55.739	48.047	51.636	47.811	51.937	44.238
(31) 124-16-9(116)	52.809	60.033	58.884	60.860	38.948	38.249	48.240	37.925	47.878	47.811	47.915	49.930
(32) Mose.Black-Plain(2)	56.394	63.955	65.278	42.440	37.755	37.382	45.743	36.223	47.878	47.811	47.915	49.297
(33) 726(118)	67.461	69.577	68.209	63.930	41.930	41.286	49.492	38.798	47.250	47.811	47.244	54.357

Table 2 Contd.

(34) 1627-14-4-3	67.617	68.923	69.541	48.580	46.900	45.840	54.490	43.117	47.250	47.811	47.244	42.340
(35) Koming-1(154)	45.327	52.189	52.756	46.532	43.321	42.587	50.741	43.946	44.119	47.811	43.894	47.399
(36) 1627-14-2-8	52.029	53.235	54.487	41.414	47.496	45.840	58.239	46.956	48.504	47.811	48.585	51.828
(37) Mos.Black-Black(2)	60.446	65.786	67.810	37.322	41.930	43.021	39.492	39.801	44.745	47.811	44.564	46.135
(38) 823	39.247	45.913	45.562	52.672	44.316	41.286	64.490	46.345	50.383	47.811	50.596	43.604
(39) 1640	56.082	58.987	57.818	60.860	46.304	46.056	49.492	44.120	47.878	47.811	47.915	44.870
(40) 102(Shown)	52.341	57.026	58.084	43.462	38.351	38.033	45.743	37.271	44.745	47.811	44.564	67.640
(41) W2-13-9(108)	42.833	50.620	51.157	46.532	39.941	40.635	40.741	40.543	44.119	47.811	43.894	55.623
(42) 1001	51.250	49.966	50.624	45.510	50.280	48.225	61.989	50.141	47.250	47.811	47.244	56.887
(43) W1-2-7	50.626	55.326	56.219	44.484	45.309	46.924	38.244	45.343	47.250	47.811	47.244	44.238
(44) CS120(N19)	44.079	50.358	48.359	65.975	43.123	43.671	43.242	43.946	54.141	47.811	54.617	41.706
(45) Koming-2-5	52.964	60.817	62.347	40.392	38.749	40.201	35.743	38.230	44.745	47.811	44.564	50.562
(46) W2-13-4	44.236	40.292	41.299	41.414	51.473	54.080	35.743	53.632	49.129	47.811	49.255	69.538
(47) Y-5	38.624	44.214	39.567	85.421	41.333	41.720	43.242	43.117	46.624	47.811	46.574	62.580
(48) 127-17	42.988	49.966	49.558	53.694	43.918	45.623	36.992	45.386	45.371	47.811	45.233	45.502
(49) Lemon Khorasan	40.650	48.659	49.691	42.440	41.731	43.021	38.244	43.641	52.888	47.811	52.607	41.706
(50) Lemon Haratee	45.171	33.754	35.437	35.274	65.787	67.525	48.240	68.248	51.636	73.134	49.926	56.887
(51) White Haratee	39.247	44.475	44.230	51.650	44.713	45.189	44.490	46.433	52.262	47.811	52.607	47.399
(52) Yellow Haratee	31.454	33.624	34.371	42.440	44.514	45.623	40.741	48.877	59.779	47.811	60.650	61.316
(53) Pink Khorasan	38.936	45.652	45.295	52.672	45.707	45.189	50.741	48.396	47.250	47.811	47.244	42.340
(54) Baghdadi	29.583	38.853	37.302	60.860	41.134	41.936	40.741	45.298	47.878	47.811	47.915	51.194

Table 2 Contd.

Pure line / Trait	Number of dead pupae in double cocoon	Pupae vitality percentage (%)	Cocoon weight (g)	Shell cocoon weight (g)	Shell cocoon percentage (%)	Male cocoon weight (g)	Male shell cocoon weight (g)	Male shell cocoon percentage (%)	Female cocoon weight (g)	Female shell cocoon weight (g)	Female shell cocoon percentage (%)	Good cocoon weight of 250 larvae (g)
(1) 6/4-6/6	39.511	47.192	2.660	48.427	35.844	21.601	23.601	16.642	26.876	20.541	17.943	22.720
(2) 104	43.538	56.667	33.624	48.683	52.290	57.069	56.835	58.568	53.303	55.750	57.454	51.619
(3) 124-K	42.195	51.933	52.201	48.634	49.969	49.326	53.322	58.216	49.131	49.387	51.107	52.207
(4) 120-K	39.847	44.825	55.819	48.619	48.709	50.991	49.540	50.371	44.958	48.115	51.707	39.168
(5) 108-K	45.886	49.559	48.102	48.657	49.505	50.742	50.215	51.660	53.025	50.518	50.511	53.318
(6) W2-11-19-2(110)	78.434	75.623	47.817	48.662	115.156	52.657	49.810	49.668	52.608	48.397	47.756	42.843
(7) W2-11-19-3	43.873	44.825	45.913	48.765	52.091	65.395	55.619	51.309	64.640	56.175	51.588	51.916
(8) 1002-4-C-5	41.860	59.041	37.625	48.649	50.102	50.159	51.836	54.822	52.121	51.791	52.903	31.486
(9) 1002-E-8-3	42.531	40.084	57.820	48.662	51.760	49.909	54.808	60.325	54.903	55.609	56.495	55.833

Table 2 Contd.

(10) Guilan-Orange	38.505	40.084	44.770	48.537	42.409	39.335	38.597	38.309	36.334	79.648	33.148	35.606
(11) Khorasan-Orange	53.940	47.192	56.868	48.535	38.099	36.838	40.758	44.398	38.212	39.065	42.487	48.549
(12) Shown	43.873	40.084	48.771	48.738	53.550	63.480	54.944	51.425	60.258	62.821	62.723	64.471
(13) T1-P	37.833	40.084	55.345	48.638	52.688	50.742	56.970	63.606	49.339	57.306	62.242	62.204
(14) T5-P	42.531	40.084	45.244	48.715	52.622	57.069	52.242	50.958	60.258	61.972	61.287	60.386
(15) CS120(7409)	42.531	40.084	47.722	48.490	44.532	34.090	38.732	41.939	30.770	41.610	50.989	46.134
(16) BH-4	47.565	51.933	55.439	48.730	51.229	60.150	53.863	51.660	60.675	54.195	51.107	67.158
(17) BH-3	38.840	42.451	37.528	48.554	47.715	39.918	45.487	50.606	39.603	45.145	50.629	44.018
(18) 104×110	50.584	49.559	61.061	48.770	53.020	64.313	57.375	54.703	66.935	58.154	52.903	55.303
(19) 110×104(152)	84.474	66.149	54.487	48.577	48.179	44.081	48.864	54.000	41.481	46.418	51.466	45.338
(20) 32×110	53.604	61.408	50.103	48.651	48.643	53.489	51.161	51.541	49.339	45.994	46.319	38.534
(21) 110×32	45.215	49.559	52.675	48.676	50.765	51.574	52.917	55.525	56.781	53.347	52.066	51.854
(22) 18-1	44.880	47.192	54.104	48.719	51.229	58.235	53.322	52.012	60.258	54.761	52.185	57.349
(23) 1538-8-2(114)	61.993	44.825	58.391	48.584	49.770	40.751	50.891	60.209	45.167	51.367	56.376	49.279
(24) 1538-14-9(112)	40.182	47.192	39.243	48.596	48.378	48.743	49.134	51.074	41.202	46.983	52.544	38.858
(25) 4-4	46.558	49.559	56.677	48.689	51.495	52.906	53.322	55.757	58.380	55.892	54.699	55.890
(26) 32	61.993	59.041	52.009	48.687	51.362	54.322	53.863	55.406	56.781	54.761	53.981	40.997
(27) Tokaee-202	55.953	49.559	59.060	48.706	51.693	58.485	54.808	54.352	57.685	55.468	54.462	47.791
(28) 106	61.321	73.257	44.864	48.676	50.699	52.407	51.026	52.012	55.599	55.043	55.058	52.244
(29) 17	56.624	77.990	46.579	48.725	56.733	61.232	65.211	69.228	59.284	65.790	67.034	49.404
(30) Shaki A×D	45.215	42.451	46.771	48.721	48.112	58.485	47.918	42.993	60.467	47.266	42.487	60.235
(31) 124-16-9(116)	48.571	59.041	51.058	48.681	52.158	55.404	55.079	56.811	54.416	56.882	58.291	61.974
(32) Mose.Black-Plain(2)	50.248	42.451	59.060	48.675	50.898	52.657	52.107	53.533	55.390	54.761	55.180	62.948
(33) 726(118)	55.953	40.084	51.438	48.649	49.240	51.241	49.810	50.606	50.730	50.094	51.229	65.139
(34) 1627-14-4-3	42.866	42.451	54.962	48.698	50.102	57.902	50.485	47.676	55.807	52.922	52.307	69.836
(35) Koming-1(154)	45.886	49.559	53.058	48.776	55.274	67.060	63.185	61.965	65.544	61.831	58.291	57.125
(36) 1627-14-2-8	51.255	54.300	51.724	48.698	52.025	58.485	56.430	57.046	55.599	55.185	55.299	57.171
(37) Mos.Black-Black(2)	47.228	40.084	65.633	48.537	46.654	36.588	44.676	51.541	38.907	44.580	50.152	59.673
(38) 823	44.545	40.084	41.721	48.645	50.036	52.074	51.701	53.533	49.548	51.367	53.981	46.737
(39) 1640	44.545	49.559	47.531	48.685	50.765	57.652	53.728	53.066	53.303	52.357	52.785	59.344
(40) 102(Shown)	69.039	47.192	59.726	48.626	49.903	47.078	51.161	55.877	49.548	51.508	53.744	56.299
(41) W2-13-9(108)	56.960	42.451	59.917	122.121	48.776	56.237	48.999	46.271	52.330	48.680	48.474	53.556
(42) 1001	58.301	47.192	50.772	48.668	48.444	56.819	49.269	46.271	50.522	47.266	47.515	54.162
(43) W1-2-7	44.208	47.192	58.583	48.654	49.107	51.824	49.810	50.255	51.913	49.387	49.670	56.799
(44) CS120(N19)	41.860	44.825	41.149	48.469	45.990	28.512	43.460	55.641	30.562	42.741	52.903	41.836
(45) Koming-2-5	51.255	44.825	64.870	48.526	45.791	33.507	42.785	50.020	38.907	42.741	47.515	49.250
(46) W2-13-4	70.717	49.559	60.106	48.545	45.394	41.583	43.325	45.452	36.125	40.337	45.482	35.775
(47) Y-5	59.308	77.990	30.954	48.556	50.168	40.751	94.932	58.568	39.116	53.912	64.160	41.025
(48) 127-17	45.215	49.559	55.630	48.765	54.346	61.565	57.510	56.695	67.908	63.669	59.609	58.002
(49) Lemon Khorasan	42.531	40.084	55.439	48.437	37.436	26.597	26.303	20.271	26.598	24.217	24.290	40.208

Table 2 Contd.

(50) Lemon Haratee	55.281	63.775	54.487	48.668	43.073	51.574	41.164	35.028	54.416	32.702	25.964	37.888
(51) White Haratee	47.228	49.559	46.579	48.562	44.532	40.168	39.813	39.715	41.481	40.479	42.609	41.119
(52) Yellow Haratee	60.651	59.041	44.484	48.668	40.287	52.906	33.598	21.677	53.512	28.884	21.057	37.940
(53) Pink Khorasan	43.202	40.084	50.009	48.594	47.184	45.413	44.406	44.865	43.984	45.145	48.259	44.257
(54) Baghdadi	51.255	49.559	41.815	48.622	44.067	47.911	39.272	34.325	47.462	39.065	37.580	39.225

Table 2. Contd.

Trait / Pure line	Middle cocoon weight of 250 larvae (g)	Middle cocoon weight (g)	Low cocoon weight of 250 larvae (g)	Low cocoon weight (g)	Double cocoon weight of 250 larvae (g)	Double cocoon weight (g)	Total cocoon weight of 250 larvae (g)	Total cocoon weight of 10000 4th instar larvae (g)	Cocoon number per liter	Cocoon weight per liter (g)	Male pupae weight (gr)	Female pupae weight (g)
(1) 6/4-6/6	60.473	30.584	117.605	90.185	39.553	45.703	33.983	11.408	50.656	26.210	34.461	14.028
(2) 104	44.946	42.458	56.726	98.455	45.052	55.629	48.271	51.433	41.289	37.943	51.561	51.038
(3) 124-K	52.423	40.153	49.655	94.826	43.125	54.133	51.157	46.647	51.771	54.061	47.038	49.842
(4) 120-K	57.759	48.046	50.374	101.408	39.915	37.721	39.839	39.443	47.533	46.017	46.817	45.774
(5) 108-K	56.068	38.547	49.140	51.366	45.990	52.909	55.311	46.248	41.289	38.745	51.892	53.671
(6) W2-11-19-2(110)	56.125	49.443	45.896	89.130	81.419	54.623	56.801	49.054	55.785	61.292	53.878	54.388
(7) W2-11-19-3	81.873	59.710	55.332	97.358	44.080	54.310	69.043	39.728	36.606	39.284	66.454	63.801
(8) 1002-4-C-5	68.902	53.214	60.954	114.784	43.792	55.167	41.665	31.113	42.850	39.765	49.685	51.916
(9) 1002-E-8-3	55.476	47.138	47.652	77.231	41.542	36.361	55.672	48.498	38.836	33.810	49.023	52.953
(10) Guilan-Orange	34.190	38.756	50.433	79.636	38.070	22.586	22.093	49.091	63.367	62.118	42.956	44.737
(11) Khorasan-Orange	39.769	36.172	44.493	50.227	51.875	50.462	42.406	50.560	59.799	56.581	39.315	43.142
(12) Shown	43.568	64.389	50.470	90.607	41.921	33.097	58.362	62.399	40.174	44.494	59.283	54.947
(13) T1-P	49.452	54.332	48.548	113.645	37.499	8.757	57.067	52.694	38.613	34.267	43.507	45.614
(14) T5-P	50.849	66.205	47.796	99.045	42.138	57.070	58.905	57.969	47.088	59.489	56.525	55.505
(15) CS120(7409)	50.630	35.473	48.048	66.134	41.033	32.458	42.875	35.094	82.100	76.827	31.372	33.171
(16) BH-4	47.876	56.218	50.099	106.767	49.535	60.973	66.244	61.405	53.109	65.832	61.380	60.371
(17) BH-3	61.474	45.950	49.521	84.320	38.712	38.128	46.332	36.871	58.015	55.533	38.212	41.307
(18) 104×110	61.835	61.316	45.041	89.045	50.796	55.575	61.617	53.862	43.519	53.311	66.013	65.316
(19) 110×104(152)	46.565	44.344	44.737	77.526	81.044	54.446	52.202	54.475	51.325	44.813	40.418	42.743
(20) 32×110	72.191	53.633	43.804	42.083	54.972	53.630	51.653	36.957	45.081	47.372	52.223	51.996
(21) 110×32	71.839	54.821	44.271	59.805	45.618	53.861	61.789	42.238	47.757	50.335	53.216	56.383
(22) 18-1	48.903	55.030	46.026	79.889	45.159	56.581	54.480	56.774	37.944	38.579	59.725	59.573
(23) 1538-8-2(114)	47.433	37.150	45.822	76.387	59.031	51.183	50.345	46.393	56.900	55.646	38.432	44.179
(24) 1538-14-9(112)	51.031	44.553	52.781	88.075	40.155	48.558	36.208	40.106	52.663	50.302	43.066	42.105
(25) 4-4	48.076	52.236	45.222	92.843	46.883	53.358	53.057	51.960	60.245	62.557	54.209	56.781
(26) 32	59.972	65.507	48.877	83.138	62.512	54.487	51.516	47.264	49.318	54.483	54.098	55.585
(27) Tokaee-202	64.587	56.008	47.415	83.012	54.293	51.223	57.196	45.351	42.850	45.711	56.967	56.223
(28) 106	46.902	61.805	48.370	85.965	65.176	57.030	55.478	57.542	46.419	51.416	52.995	54.069

Table 2. Contd.

(29) 17	47.838	69.698	47.485	99.045	62.348	58.117	52.203	61.606	34.376	38.325	51.782	52.235
(30) Shaki A×D	51.288	58.103	51.929	99.720	44.758	58.974	59.730	56.554	56.008	70.551	65.241	64.040
(31) 124-16-9(116)	40.328	59.011	49.040	99.467	51.021	56.894	56.977	63.305	44.857	49.169	51.671	51.677
(32) Mose.Black-Plain(2)	37.500	43.855	47.452	94.953	49.324	53.671	55.459	61.341	54.001	57.129	52.554	53.910
(33) 726(118)	42.028	48.535	47.296	76.092	53.796	52.039	61.867	56.666	53.555	54.334	50.789	51.278
(34) 1627-14-4-3	48.170	57.614	48.177	57.273	42.655	55.303	66.323	59.360	45.304	49.542	57.849	28.944
(35) Koming-1(154)	45.605	63.901	45.722	73.560	48.790	60.796	53.621	62.905	42.405	48.516	62.924	61.647
(36) 1627-14-2-8	49.763	61.805	49.315	105.079	52.193	55.629	57.920	58.164	43.519	49.251	54.760	53.990
(37) Mos.Black-Black(2)	40.639	40.153	44.429	43.349	46.102	51.454	52.190	53.706	55.116	50.247	35.895	40.829
(38) 823	44.611	50.141	50.218	94.404	44.393	54.133	41.631	52.058	49.541	50.673	49.244	49.204
(39) 1640	46.348	46.649	48.304	77.358	45.074	55.303	55.446	57.029	42.181	41.741	54.540	52.953
(40) 102(Shown)	38.754	50.630	45.282	80.311	68.075	54.949	55.734	60.787	45.750	46.170	45.934	49.124
(41) W2-13-9(108)	40.530	51.538	44.641	73.856	56.572	56.173	49.680	62.529	52.440	58.348	56.194	53.910
(42) 1001	50.917	53.633	49.540	114.657	58.153	56.527	57.689	56.377	46.195	53.432	55.643	52.634
(43) W1-2-7	44.941	47.138	48.093	104.362	43.593	49.143	51.469	56.333	46.195	47.391	52.333	53.033
(44) CS120(N19)	40.697	32.959	52.304	88.075	41.786	30.106	33.857	40.759	60.469	49.603	25.194	32.294
(45) Koming-2-5	37.422	35.264	44.863	48.834	49.133	48.776	40.864	47.513	71.661	52.733	35.343	41.866
(46) W2-13-4	51.187	49.931	48.933	93.687	65.110	48.191	41.433	39.278	63.814	54.911	39.205	40.031
(47) Y-5	42.195	54.332	46.155	65.121	61.237	51.359	39.770	49.524	58.238	51.898	33.137	35.883
(48) 127-17	46.068	62.713	46.529	88.202	46.063	58.797	53.947	65.491	38.613	45.847	62.703	63.242
(49) Lemon Khorasan	40.036	35.054	51.270	86.387	40.554	36.633	31.183	40.102	75.633	66.921	35.012	38.196
(50) Lemon Haratee	67.782	54.821	53.107	108.877	57.598	56.894	51.118	40.218	39.729	38.279	64.138	65.316
(51) White Haratee	43.907	48.046	51.404	92.547	46.529	50.054	36.500	44.954	56.008	50.864	43.838	46.013
(52) Yellow Haratee	46.052	58.103	57.399	88.075	62.035	47.783	41.151	52.026	34.822	30.207	68.992	66.433
(53) Pink Khorasan	42.968	27.930	47.118	70.607	42.252	51.686	36.853	48.079	59.576	62.454	45.714	46.332
(54) Baghdadi	41.236	45.252	48.888	84.656	49.968	50.598	33.820	50.758	47.088	44.670	54.650	53.830

Several strains were grouped together and far from other silkworm strains, indicating they might be suitable for future crossings, maintenance of parental strains and hybridizations with peanut cocoon strains so as to maximize heterosis and to avoid depression inbreeding.

DISCUSSION

As Kumaresan et al. (2007) presented, there is an optimum level of genetic divergence between parents to obtain heterosis in F1 generation and it may not be logical to advocate the use of extreme diverge parents to obtain heterotic combination (Arunachalam et al., 1984; Kumaresan et al., 2007). As Mirhosseini et al. (2004) stated, the cocoon characteristics are important economical characteristics of silkworm and due to their high heredity, their efficiency of direct selection is very high. Efficiency of heterosis in the improvement of the mean of cocoon characteristics in the hybrids will be manifold than the inter-strain selections.

As indicated earlier, our final analysis and conclusion has been done on the basis of the average linkage between groups or UPGMA, since other researchers have shown (Peters and Martinelli, 1989; Chatterjee and Data, 1992) that UPGMA yields more accurate results for classification purposes than other hierarchical methods. After evaluation by both the statistical methods (evaluation index method and sub-ordinate function method), some oval type strains that

Table 3. Sub-ordinate function values for cocoon traits in studied silkworm pure lines of gene bank.

Pure line \ Trait	Number of total produced cocoon	Number of good produced cocoon	Number of alive good produced cocoon	Number of dead good produced cocoon	Number of middle produced cocoon	Number of alive middle produced cocoon (25)	Number of dead middle produced cocoon	Number of low produced cocoon	Number of alive low produced cocoon	Number of dead low produced cocoon	Number of double produced cocoon	Number of alive pupae in double cocoon
(1) 6/4-6/6	0.651	0.000	0.000	0.000	0.767	0.692	1.000	0.868	1.000	1.000	1.000	0.058
(2) 104	0.595	0.580	0.540	0.472	0.265	0.184	0.714	0.259	0.179	0.000	0.193	0.174
(3) 124-K	0.753	0.628	0.631	0.245	0.471	0.453	0.486	0.452	0.085	0.000	0.092	0.130
(4) 120-K	0.395	0.260	0.239	0.226	0.552	0.602	0.143	0.720	0.085	0.125	0.083	0.058
(5) 108-K	0.829	0.613	0.608	0.283	0.574	0.532	0.686	0.541	0.085	0.000	0.092	0.203
(6) W2-11-19-2(110)	0.638	0.338	0.327	0.208	0.507	0.458	0.686	0.540	0.034	0.000	0.037	0.986
(7) W2-11-19-3	1.000	0.471	0.447	0.340	1.000	1.000	0.714	0.922	0.154	0.000	0.165	0.145
(8) 1002-4-C-5	0.382	0.039	0.010	0.189	0.771	0.751	0.686	1.000	0.205	0.250	0.202	0.145
(9) 1002-E-8-3	0.822	0.686	0.689	0.264	0.507	0.527	0.286	0.464	0.051	0.000	0.055	0.101
(10) Guilan-Orange	0.000	0.272	0.233	0.340	0.000	0.000	0.086	0.010	0.103	0.000	0.110	0.014
(11) Khorasan-Orange	0.553	0.637	0.618	0.377	0.152	0.159	0.143	0.126	0.009	0.000	0.009	0.362
(12) Shown	0.714	0.798	0.748	0.623	0.161	0.169	0.143	0.104	0.094	0.000	0.101	0.130
(13) T1-P	0.898	0.897	0.890	0.415	0.327	0.338	0.229	0.246	0.051	0.000	0.055	0.000
(14) T5-P	0.711	0.692	0.631	0.641	0.300	0.318	0.171	0.271	0.137	0.000	0.147	0.101
(15) CS120(7409)	0.891	0.776	0.722	0.641	0.453	0.453	0.371	0.388	0.077	0.000	0.083	0.101
(16) BH-4	0.888	0.864	0.883	0.245	0.274	0.269	0.286	0.195	0.077	0.000	0.083	0.246
(17) BH-3	0.687	0.556	0.392	0.623	0.655	0.597	0.829	0.701	0.085	0.000	0.092	0.029
(18) 104×110	0.697	0.511	0.508	0.226	0.556	0.592	0.229	0.581	0.009	0.000	0.009	0.304
(19) 110×104(152)	0.635	0.480	0.453	0.358	0.300	0.313	0.200	0.291	0.009	0.000	0.009	1.000
(20) 32×110	0.612	0.221	0.168	0.396	0.843	0.876	0.429	0.968	0.000	0.000	0.000	0.406
(21) 110×32	0.928	0.550	0.508	0.472	0.852	0.876	0.486	0.792	0.000	0.000	0.000	0.188
(22) 18-1	0.655	0.662	0.641	0.396	0.305	0.308	0.257	0.291	0.026	0.000	0.028	0.174
(23) 1538-8-2(114)	0.701	0.592	0.602	0.189	0.359	0.348	0.371	0.343	0.026	0.000	0.028	0.536
(24) 1538-14-9(112)	0.365	0.302	0.243	0.472	0.408	0.398	0.400	0.535	0.154	0.000	0.165	0.072
(25) 4-4	0.760	0.722	0.754	0.113	0.300	0.313	0.200	0.252	0.111	0.000	0.119	0.217
(26) 32	0.477	0.269	0.262	0.151	0.493	0.493	0.400	0.596	0.077	0.000	0.083	0.580
(27) Tokaee-202	0.704	0.405	0.408	0.151	0.655	0.711	0.171	0.691	0.068	0.000	0.073	0.420
(28) 106	0.599	0.553	0.531	0.358	0.242	0.194	0.514	0.238	0.051	0.000	0.055	0.609
(29) 17	0.372	0.378	0.337	0.396	0.224	0.234	0.171	0.291	0.043	0.000	0.046	0.522
(30) Shaki A×D	0.757	0.701	0.670	0.472	0.345	0.318	0.457	0.308	0.111	0.000	0.119	0.159
(31) 124-16-9(116)	0.674	0.779	0.741	0.547	0.103	0.080	0.286	0.044	0.060	0.000	0.064	0.290
(32) Mose.Black-Plain(2)	0.750	0.870	0.896	0.208	0.076	0.060	0.229	0.000	0.060	0.000	0.064	0.275
(33) 726(118)	0.984	1.000	0.968	0.604	0.170	0.149	0.314	0.067	0.051	0.000	0.055	0.391
(34) 1627-14-4-3	0.987	0.985	1.000	0.321	0.283	0.254	0.429	0.179	0.051	0.000	0.055	0.116
(35) Koming-1(154)	0.516	0.598	0.592	0.283	0.202	0.179	0.343	0.201	0.009	0.000	0.009	0.232
(36) 1627-14-2-8	0.658	0.622	0.634	0.189	0.296	0.254	0.514	0.279	0.068	0.000	0.073	0.333

Table 3. Contd.

(37) Mos.Black-Black(2)	0.836	0.912	0.958	0.113	0.170	0.189	0.086	0.093	0.017	0.000	0.018	0.203
(38) 823	0.388	0.453	0.417	0.396	0.224	0.149	0.657	0.263	0.094	0.000	0.101	0.145
(39) 1640	0.743	0.755	0.715	0.547	0.269	0.259	0.314	0.205	0.060	0.000	0.064	0.174
(40) 102(Shown)	0.664	0.710	0.722	0.226	0.090	0.075	0.229	0.027	0.017	0.000	0.018	0.696
(41) W2-13-9(108)	0.464	0.562	0.553	0.283	0.126	0.134	0.114	0.112	0.009	0.000	0.009	0.420
(42) 1001	0.641	0.547	0.540	0.264	0.359	0.308	0.600	0.362	0.051	0.000	0.055	0.449
(43) W1-2-7	0.628	0.671	0.676	0.245	0.247	0.279	0.057	0.237	0.051	0.000	0.055	0.159
(44) CS120(N19)	0.490	0.556	0.485	0.641	0.197	0.204	0.171	0.201	0.145	0.000	0.156	0.101
(45) Koming-2-5	0.678	0.798	0.825	0.170	0.099	0.124	0.000	0.052	0.017	0.000	0.018	0.304
(46) W2-13-4	0.493	0.323	0.314	0.189	0.386	0.443	0.000	0.453	0.077	0.000	0.083	0.739
(47) Y-5	0.375	0.414	0.272	1.000	0.157	0.159	0.171	0.179	0.043	0.000	0.046	0.580
(48) 127-17	0.467	0.547	0.515	0.415	0.215	0.249	0.029	0.238	0.026	0.000	0.028	0.188
(49) Lemon Khorasan	0.418	0.517	0.518	0.208	0.166	0.189	0.057	0.193	0.128	0.000	0.128	0.101
(50) Lemon Haratee	0.513	0.172	0.172	0.075	0.709	0.751	0.286	0.833	0.111	0.375	0.092	0.449
(51) White Haratee	0.388	0.420	0.385	0.377	0.233	0.239	0.200	0.266	0.120	0.000	0.128	0.232
(52) Yellow Haratee	0.224	0.169	0.146	0.208	0.229	0.249	0.114	0.329	0.222	0.000	0.239	0.551
(53) Pink Khorasan	0.382	0.447	0.411	0.396	0.256	0.239	0.343	0.317	0.051	0.000	0.055	0.116
(54) Baghdadi	0.184	0.290	0.217	0.547	0.152	0.164	0.114	0.236	0.060	0.000	0.064	0.319

Table 3. Contd.

Trait / Pure line	Number of dead pupae in double cocoon	Pupae vitality percentage (%)	Cocoon weight (g)	Shell cocoon weight (g)	Shell cocoon percentage (%)	Male cocoon weight (g)	Male shell cocoon weight (g)	Male shell cocoon percentage (%)	Female cocoon weight (g)	Female shell cocoon weight (g)	Female shell cocoon percentage (%)	Good cocoon weight of 250 larvae (g)
(1) 6/4-6/6	0.036	0.188	0.000	0.000	0.000	21.601	0.000	0.000	0.007	0.000	0.000	0.000
(2) 104	0.122	0.437	0.492	0.003	0.207	57.069	0.466	0.797	0.646	0.596	0.805	0.613
(3) 124-K	0.094	0.313	0.787	0.003	0.178	49.326	0.417	0.791	0.545	0.488	0.676	0.626
(4) 120-K	0.043	0.125	0.844	0.003	0.162	50.991	0.364	0.641	0.444	0.467	0.688	0.349
(5) 108-K	0.173	0.250	0.722	0.003	0.172	50.742	0.373	0.666	0.640	0.507	0.663	0.649
(6) W2-11-19-2(110)	0.871	0.938	0.717	0.003	1.000	52.657	0.367	0.628	0.630	0.471	0.607	0.427
(7) W2-11-19-3	0.129	0.125	0.687	0.005	0.205	65.395	0.449	0.659	0.921	0.603	0.685	0.620
(8) 1002-4-C-5	0.086	0.500	0.555	0.003	0.180	50.159	0.396	0.726	0.618	0.529	0.712	0.186
(9) 1002-E-8-3	0.101	0.000	0.876	0.003	0.201	49.909	0.438	0.831	0.685	0.593	0.785	0.703
(10) Guilan-Orange	0.014	0.000	0.669	0.001	0.083	39.335	0.210	0.412	0.236	1.000	0.310	0.273
(11) Khorasan-Orange	0.345	0.188	0.861	0.001	0.028	36.838	0.241	0.528	0.281	0.313	0.500	0.548
(12) Shown	0.129	0.000	0.732	0.004	0.223	63.480	0.439	0.661	0.815	0.715	0.912	0.886
(13) T1-P	0.000	0.000	0.837	0.003	0.212	50.742	0.468	0.893	0.551	0.622	0.902	0.838
(14) T5-P	0.101	0.000	0.676	0.004	0.212	57.069	0.402	0.653	0.815	0.701	0.883	0.799

Table 3. Contd.

(15) CS120(7409)	0.101	0.000	0.716	0.001	0.110	34.090	0.212	0.481	0.101	0.356	0.673	0.497
(16) BH-4	0.209	0.313	0.838	0.004	0.194	60.150	0.424	0.666	0.825	0.569	0.676	0.943
(17) BH-3	0.022	0.062	0.554	0.002	0.150	39.918	0.307	0.646	0.315	0.416	0.666	0.452
(18) 104×110	0.273	0.250	0.927	0.005	0.217	64.313	0.473	0.724	0.976	0.636	0.712	0.692
(19) 110×104(152)	1.000	0.688	0.823	0.002	0.156	44.081	0.354	0.710	0.360	0.438	0.683	0.480
(20) 32×110	0.338	0.563	0.753	0.003	0.161	53.489	0.386	0.664	0.551	0.431	0.578	0.336
(21) 110×32	0.158	0.250	0.794	0.003	0.188	51.574	0.411	0.739	0.731	0.555	0.695	0.618
(22) 18-1	0.151	0.188	0.817	0.004	0.194	58.235	0.417	0.673	0.815	0.579	0.698	0.735
(23) 1538-8-2(114)	0.518	0.125	0.885	0.002	0.176	40.751	0.383	0.828	0.449	0.522	0.783	0.564
(24) 1538-14-9(112)	0.050	0.188	0.581	0.002	0.158	48.743	0.358	0.655	0.354	0.447	0.705	0.343
(25) 4-4	0.187	0.250	0.858	0.004	0.197	52.906	0.417	0.744	0.769	0.598	0.749	0.704
(26) 32	0.518	0.500	0.784	0.004	0.196	54.322	0.424	0.737	0.731	0.579	0.734	0.388
(27) Tokaee-202	0.388	0.250	0.896	0.004	0.200	58.485	0.438	0.717	0.753	0.591	0.744	0.532
(28) 106	0.504	0.875	0.670	0.003	0.187	52.407	0.384	0.673	0.702	0.584	0.756	0.627
(29) 17	0.403	1.000	0.697	0.004	0.263	61.232	0.583	1.000	0.791	0.766	1.000	0.566
(30) Shaki A×D	0.158	0.062	0.700	0.004	0.155	58.485	0.341	0.501	0.820	0.452	0.500	0.796
(31) 124-16-9(116)	0.230	0.500	0.769	0.003	0.206	55.404	0.441	0.764	0.673	0.615	0.822	0.833
(32) Mose.Black-Plain(2)	0.266	0.062	0.896	0.003	0.190	52.657	0.400	0.702	0.697	0.579	0.759	0.854
(33) 726(118)	0.388	0.000	0.775	0.003	0.169	51.241	0.367	0.646	0.584	0.500	0.678	0.900
(34) 1627-14-4-3	0.108	0.062	0.831	0.004	0.180	57.902	0.377	0.590	0.707	0.548	0.700	1.000
(35) Koming-1(154)	0.173	0.250	0.800	0.005	0.245	67.060	0.555	0.862	0.943	0.699	0.822	0.730
(36) 1627-14-2-8	0.288	0.375	0.779	0.004	0.204	58.485	0.460	0.768	0.702	0.586	0.761	0.731
(37) Mos.Black-Black(2)	0.201	0.000	1.000	0.001	0.136	36.588	0.295	0.664	0.298	0.407	0.656	0.784
(38) 823	0.144	0.000	0.620	0.003	0.179	52.074	0.394	0.702	0.556	0.522	0.734	0.510
(39) 1640	0.144	0.250	0.713	0.004	0.188	57.652	0.422	0.693	0.646	0.538	0.710	0.777
(40) 102(Shown)	0.669	0.188	0.906	0.003	0.177	47.078	0.386	0.746	0.556	0.524	0.729	0.713
(41) W2-13-9(108)	0.410	0.062	0.909	1.000	0.163	56.237	0.356	0.563	0.623	0.476	0.622	0.654
(42) 1001	0.439	0.188	0.764	0.003	0.159	56.819	0.360	0.563	0.579	0.452	0.602	0.667
(43) W1-2-7	0.137	0.188	0.888	0.003	0.167	51.824	0.367	0.639	0.613	0.488	0.646	0.723
(44) CS120(N19)	0.086	0.125	0.611	0.001	0.128	28.512	0.278	0.742	0.096	0.376	0.712	0.406
(45) Koming-2-5	0.288	0.125	0.988	0.001	0.125	33.507	0.269	0.635	0.298	0.376	0.602	0.563
(46) W2-13-4	0.705	0.250	0.912	0.002	0.120	41.583	0.277	0.548	0.231	0.335	0.561	0.277
(47) Y-5	0.460	1.000	0.449	0.002	0.181	40.751	1.000	0.797	0.303	0.565	0.941	0.389
(48) 127-17	0.158	0.250	0.841	0.005	0.233	61.565	0.475	0.762	1.000	0.730	0.849	0.749
(49) Lemon Khorasan	0.101	0.000	0.838	0.000	0.020	26.597	0.038	0.069	0.000	0.062	0.129	0.371
(50) Lemon Haratee	0.374	0.625	0.823	0.003	0.091	51.574	0.246	0.350	0.673	0.206	0.163	0.322
(51) White Haratee	0.201	0.250	0.697	0.002	0.110	40.168	0.227	0.439	0.360	0.337	0.502	0.391
(52) Yellow Haratee	0.489	0.500	0.664	0.003	0.056	52.906	0.140	0.096	0.652	0.141	0.063	0.323
(53) Pink Khorasan	0.115	0.000	0.752	0.002	0.143	45.413	0.292	0.537	0.421	0.416	0.618	0.457
(54) Baghdadi	0.288	0.250	0.622	0.003	0.104	47.911	0.220	0.336	0.505	0.313	0.400	0.350

Table 3. Contd.

Pure line \ Trait	Middle cocoon weight of 250 Larvae (g)	Middle cocoon weight (g)	Low cocoon weight of 250 larvae (g)	Low cocoon weight (g)	Double cocoon weight of 250 larvae (g)	Double cocoon weight (g)	Total cocoon weight of 250 larvae (g)	Total cocoon weight of 10000 4th instar larvae (g)	Cocoon number per liter	Cocoon weight per liter (g)	Male pupae weight (g)	Female pupae weight (g)
(1) 6/4-6/6	0.551	0.064	1.000	0.662	0.047	0.708	0.253	0.000	0.341	0.000	0.212	0.000
(2) 104	0.226	0.348	0.175	0.775	0.172	0.898	0.558	0.740	0.145	0.232	0.602	0.706
(3) 124-K	0.382	0.293	0.079	0.725	0.128	0.869	0.619	0.652	0.364	0.550	0.499	0.683
(4) 120-K	0.494	0.482	0.089	0.816	0.055	0.555	0.378	0.518	0.276	0.391	0.494	0.606
(5) 108-K	0.459	0.254	0.072	0.128	0.193	0.846	0.708	0.644	0.145	0.248	0.610	0.756
(6) W2-11-19-2(110)	0.460	0.515	0.028	0.647	1.000	0.878	0.739	0.696	0.449	0.693	0.655	0.770
(7) W2-11-19-3	1.000	0.761	0.156	0.760	0.150	0.872	1.000	0.524	0.047	0.258	0.942	0.950
(8) 1002-4-C-5	0.728	0.605	0.232	1.000	0.143	0.889	0.417	0.364	0.178	0.268	0.559	0.723
(9) 1002-E-8-3	0.446	0.460	0.052	0.483	0.092	0.529	0.715	0.686	0.093	0.150	0.544	0.743
(10) Guilan-Orange	0.000	0.259	0.090	0.517	0.013	0.265	0.000	0.697	0.607	0.709	0.406	0.586
(11) Khorasan-Orange	0.117	0.197	0.009	0.112	0.327	0.799	0.433	0.724	0.533	0.600	0.322	0.556
(12) Shown	0.197	0.873	0.090	0.667	0.101	0.466	0.773	0.943	0.121	0.361	0.778	0.781
(13) T1-P	0.320	0.632	0.064	0.984	0.000	0.000	0.745	0.763	0.089	0.159	0.418	0.603
(14) T5-P	0.349	0.916	0.054	0.784	0.106	0.925	0.784	0.861	0.266	0.657	0.715	0.791
(15) CS120(7409)	0.345	0.181	0.058	0.331	0.080	0.454	0.443	0.438	1.000	1.000	0.141	0.365
(16) BH-4	0.287	0.677	0.085	0.890	0.274	1.000	0.940	0.924	0.393	0.783	0.826	0.884
(17) BH-3	0.572	0.431	0.077	0.581	0.028	0.563	0.516	0.471	0.495	0.579	0.297	0.521
(18) 104×110	0.580	0.799	0.017	0.646	0.303	0.897	0.842	0.785	0.192	0.535	0.932	0.979
(19) 110×104(152)	0.260	0.393	0.013	0.488	0.991	0.875	0.641	0.796	0.355	0.368	0.348	0.548
(20) 32×110	0.797	0.615	0.000	0.000	0.398	0.859	0.630	0.472	0.224	0.418	0.617	0.725
(21) 110×32	0.790	0.644	0.006	0.244	0.185	0.864	0.845	0.570	0.280	0.477	0.640	0.808
(22) 18-1	0.309	0.649	0.030	0.520	0.174	0.916	0.690	0.839	0.075	0.244	0.788	0.869
(23) 1538-8-2(114)	0.278	0.221	0.027	0.472	0.490	0.813	0.602	0.647	0.472	0.582	0.302	0.575
(24) 1538-14-9(112)	0.353	0.398	0.122	0.633	0.060	0.762	0.301	0.531	0.383	0.476	0.408	0.536
(25) 4-4	0.291	0.582	0.019	0.698	0.214	0.854	0.660	0.750	0.542	0.718	0.662	0.816
(26) 32	0.541	0.900	0.069	0.565	0.570	0.876	0.627	0.663	0.313	0.559	0.660	0.793
(27) Tokaee-202	0.637	0.672	0.049	0.563	0.382	0.813	0.748	0.628	0.178	0.385	0.725	0.805
(28) 106	0.267	0.811	0.062	0.604	0.630	0.924	0.711	0.853	0.252	0.498	0.635	0.764
(29) 17	0.286	1.000	0.050	0.784	0.566	0.945	0.641	0.928	0.000	0.239	0.607	0.729
(30) Shaki A×D	0.359	0.722	0.110	0.793	0.165	0.962	0.802	0.835	0.453	0.876	0.914	0.954
(31) 124-16-9(116)	0.129	0.744	0.071	0.789	0.308	0.922	0.743	0.960	0.220	0.454	0.605	0.718
(32) Mose.Black-Plain(2)	0.069	0.381	0.049	0.727	0.269	0.860	0.711	0.923	0.411	0.611	0.625	0.761
(33) 726(118)	0.164	0.493	0.047	0.468	0.371	0.829	0.847	0.837	0.402	0.556	0.584	0.711
(34) 1627-14-4-3	0.293	0.711	0.059	0.209	0.117	0.891	0.942	0.887	0.229	0.461	0.746	0.285
(35) Koming-1(154)	0.239	0.861	0.026	0.433	0.257	0.997	0.672	0.952	0.168	0.441	0.861	0.909
(36) 1627-14-2-8	0.327	0.811	0.075	0.867	0.335	0.898	0.763	0.865	0.192	0.455	0.675	0.763

Table 3. Contd.

(37) Mos.Black-Black(2)	0.135	0.293	0.008	0.017	0.196	0.818	0.641	0.782	0.435	0.475	0.244	0.511
(38) 823	0.219	0.532	0.087	0.720	0.157	0.869	0.416	0.752	0.318	0.483	0.549	0.671
(39) 1640	0.255	0.448	0.061	0.485	0.172	0.891	0.710	0.844	0.164	0.307	0.670	0.743
(40) 102(Shown)	0.096	0.543	0.020	0.526	0.696	0.885	0.717	0.913	0.238	0.394	0.474	0.670
(41) W2-13-9(108)	0.133	0.565	0.011	0.437	0.434	0.908	0.588	0.945	0.379	0.635	0.708	0.761
(42) 1001	0.351	0.615	0.078	0.998	0.470	0.915	0.758	0.831	0.248	0.538	0.695	0.737
(43) W1-2-7	0.225	0.460	0.058	0.857	0.139	0.773	0.626	0.831	0.248	0.418	0.620	0.744
(44) CS120(N19)	0.136	0.120	0.115	0.633	0.098	0.409	0.251	0.543	0.547	0.462	0.000	0.349
(45) Koming-2-5	0.068	0.176	0.014	0.093	0.265	0.766	0.400	0.668	0.781	0.524	0.232	0.531
(46) W2-13-4	0.356	0.527	0.069	0.710	0.629	0.755	0.412	0.515	0.617	0.567	0.320	0.496
(47) Y-5	0.168	0.632	0.032	0.317	0.540	0.816	0.377	0.705	0.500	0.507	0.181	0.417
(48) 127-17	0.249	0.833	0.037	0.634	0.195	0.958	0.678	1.000	0.089	0.388	0.856	0.939
(49) Lemon Khorasan	0.123	0.171	0.101	0.609	0.070	0.534	0.194	0.531	0.864	0.804	0.224	0.461
(50) Lemon Haratee	0.704	0.644	0.126	0.919	0.458	0.922	0.618	0.533	0.112	0.238	0.889	0.979
(51) White Haratee	0.204	0.482	0.103	0.694	0.206	0.791	0.307	0.620	0.453	0.487	0.426	0.610
(52) Yellow Haratee	0.249	0.722	0.184	0.633	0.559	0.747	0.406	0.751	0.009	0.079	1.000	1.000
(53) Pink Khorasan	0.184	0.000	0.045	0.392	0.108	0.822	0.314	0.678	0.528	0.716	0.469	0.616
(54) Baghdadi	0.148	0.415	0.069	0.586	0.284	0.801	0.250	0.728	0.266	0.365	0.673	0.760

Table 4. Ranking of studied silkworm germplasm based on average of evaluation index method and sub-ordinate function method for cocoon traits.

Method / Pure line	Evaluation index method		Sub-ordinate function method	
	Value	**Rank**	**Value**	**Rank**
(1) 6/4-6/6	1670.593	48	11.415	51
(2) 104	1847.450	24	15.903	31
(3) 124-K	1842.482	30	16.000	29
(4) 120-K	1735.219	41	13.701	42
(5) 108-K	1828.328	33	15.724	32
(6) W2-11-19-2(110)	2030.234	1	19.782	2
(7) W2-11-19-3	2025.089	2	19.868	1
(8) 1002-4-C-5	1845.624	25	16.031	26
(9) 1002-E-8-3	1817.557	34	15.437	35
(10) Guilan-Orange	1533.043	53	9.194	54
(11) Khorasan-Orange	1662.978	49	12.335	48
(12) Shown	1881.323	19	16.549	20
(13) T1-P	1812.250	36	15.358	36
(14) T5-P	1925.036	7	17.502	10

Table 4. Contd.

(15) CS120(7409)	1731.168	42	13.757	41
(16) BH-4	1981.516	3	18.857	3
(17) BH-3	1771.949	38	14.689	38
(18) 104×110	1963.656	4	18.560	4
(19) 110×104(152)	1860.196	22	16.619	19
(20) 32×110	1844.737	27	16.327	22
(21) 110×32	1924.977	8	17.916	6
(22) 18-1	1845.433	26	16.002	28
(23) 1538-8-2(114)	1816.543	35	15.495	33
(24) 1538-14-9(112)	1716.881	43	13.245	43
(25) 4-4	1891.266	16	16.941	16
(26) 32	1907.309	12	17.457	12
(27) Tokaee-202	1912.296	11	17.500	11
(28) 106	1917.253	10	17.751	7
(29) 17	1935.046	5	17.917	5
(30) Shaki A×D	1926.310	6	17.688	8
(31) 124-16-9(116)	1900.828	14	17.124	14
(32) Mose.Black-Plain(2)	1856.616	23	16.131	24
(33) 726(118)	1889.323	17	16.921	17
(34) 1627-14-4-3	1870.076	21	16.545	21
(35) Koming-1(154)	1905.823	13	17.124	15
(36) 1627-14-2-8	1917.566	9	17.578	9
(37) Mos.Black-Black(2)	1712.561	44	13.242	44
(38) 823	1769.099	39	14.317	40
(39) 1640	1844.264	28	15.920	30
(40) 102(Shown)	1842.974	29	16.013	27
(41) W2-13-9(108)	1877.072	20	16.068	25
(42) 1001	1892.440	15	17.160	13
(43) W1-2-7	1796.726	37	15.000	37
(44) CS120(N19)	1615.088	52	11.146	52
(45) Koming-2-5	1640.473	51	11.903	49
(46) W2-13-4	1762.834	40	14.482	39
(47) Y-5	1828.771	32	15.494	34
(48) 127-17	1887.499	18	16.732	18
(49) Lemon Khorasan	1521.460	54	9.409	53
(50) Lemon Haratee	1841.317	31	16.213	23
(51) White Haratee	1676.566	47	12.556	46
(52) Yellow Haratee	1686.571	45	12.834	45
(53) Pink Khorasan	1678.361	46	12.426	47
(54) Baghdadi	1641.641	50	11.827	50

stood within high ranks were identified as potential parents for further breeding programme. Constant efforts are being made to develop productive polyvoltine silkworm hybrids suitable for sericulture, since more than ninety percent of the raw silk is still coming from polyvoltine silkworm hybrids only (Rao et al., 2006). Therefore, maintenance of polyvoltine resource material and their effective utilization has become very important (Rao et al., 2006).

Researchers emphasized that the high genetic variation might not always give a high genetic diversity in the inbreeding population of same species (Kumaresan et al., 2007). This further confirmed the earlier report that the genetic diversity is not always related with geographical diversity (Ramamohana and Nakada, 1998). It is obvious that the silkworm germplasm contributes the potential raw materials for breeding having wide genetic variation in their genotypic expression besides additive effect due to inbreeding (Kumaresan et al., 2007).

As Mohammadis and Prasanna (2003) stated, cluster

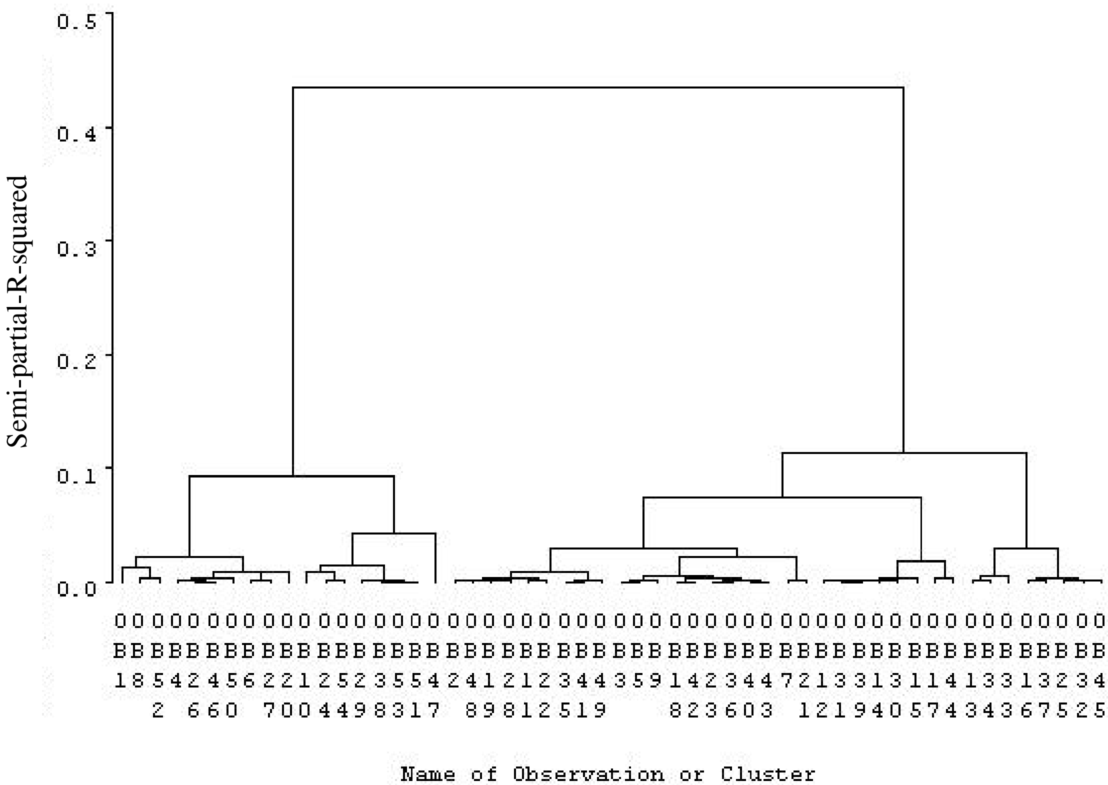

Figure 1. Cluster analysis based on all 37 studied productive traits for 51 silkworm strains according to the grouping from WARD method using SAS.

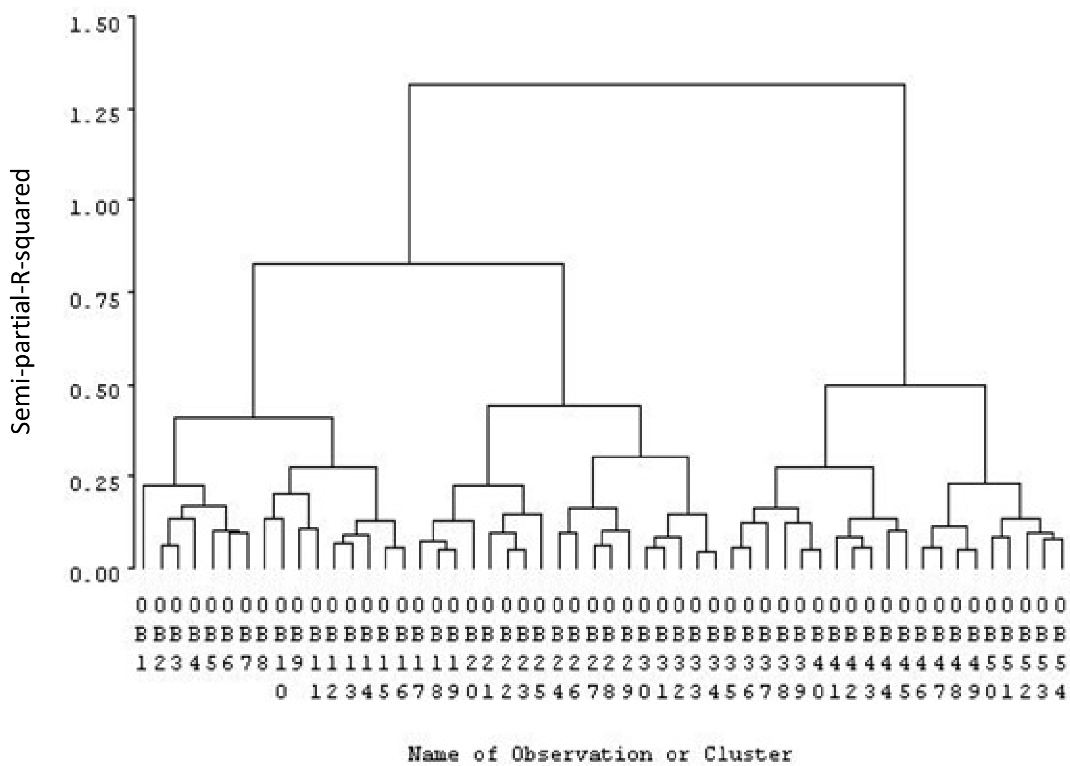

Figure 2. Cluster analysis based on all 37 studied productive traits for 51 silkworm strains according to the grouping from average method using SAS.

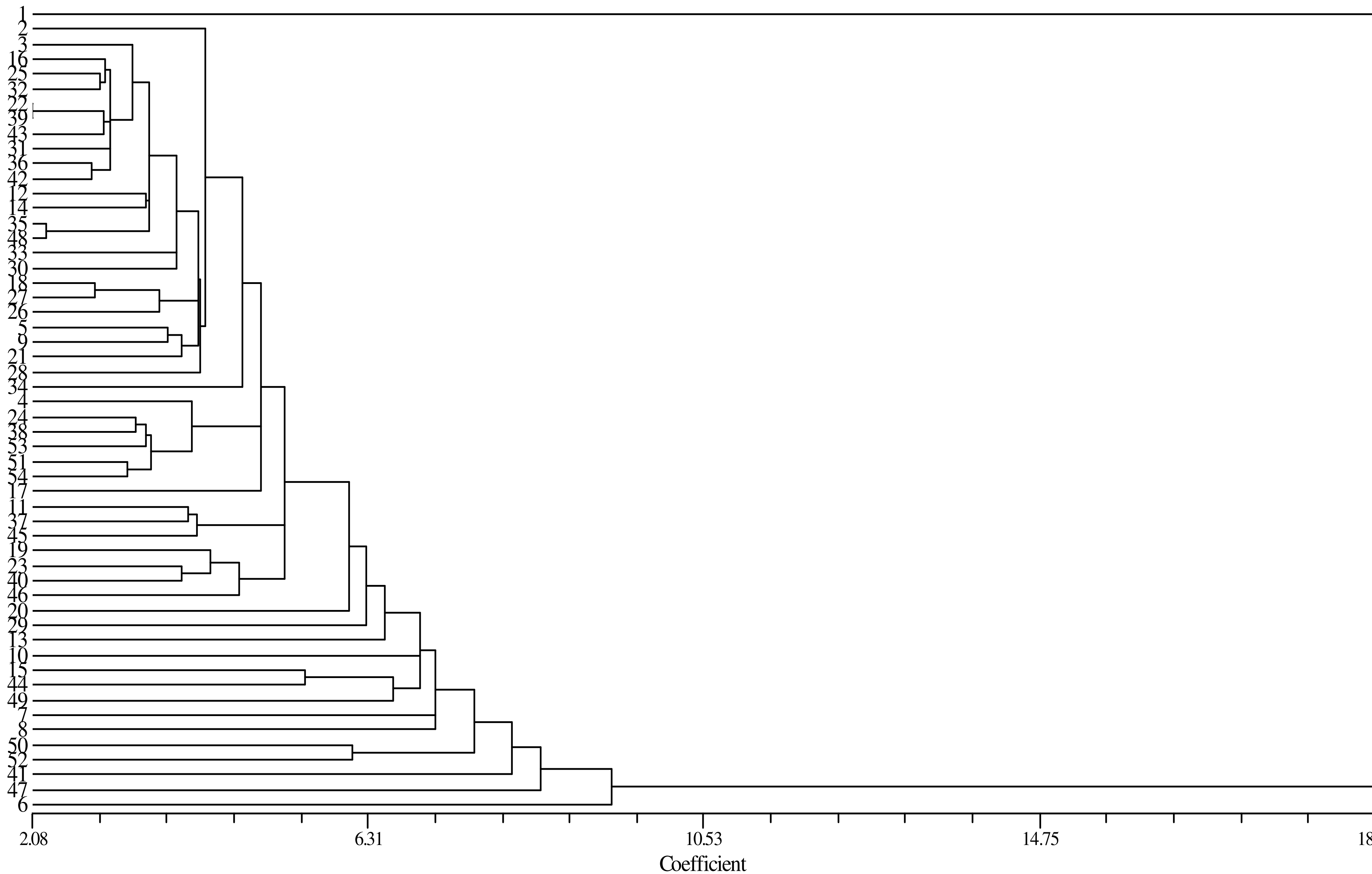

Figure 3. Cluster analysis based on all 37 studied productive traits for 51 silkworm strains according to the grouping from complete method using NTSYS.

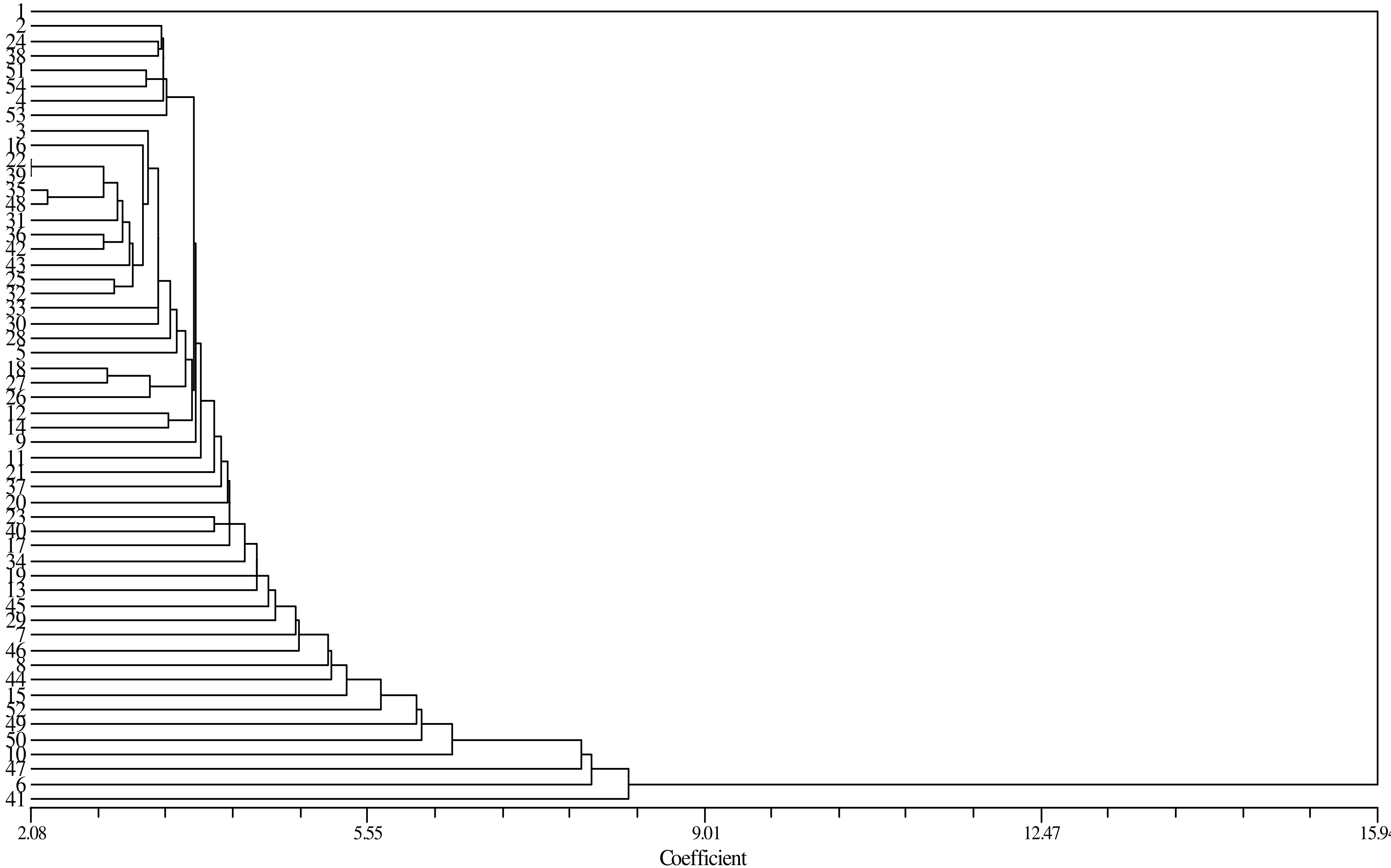

Figure 4. Cluster analysis based on all 37 studied productive traits for 51 silkworm strains according to the grouping from single method using NTSYS.

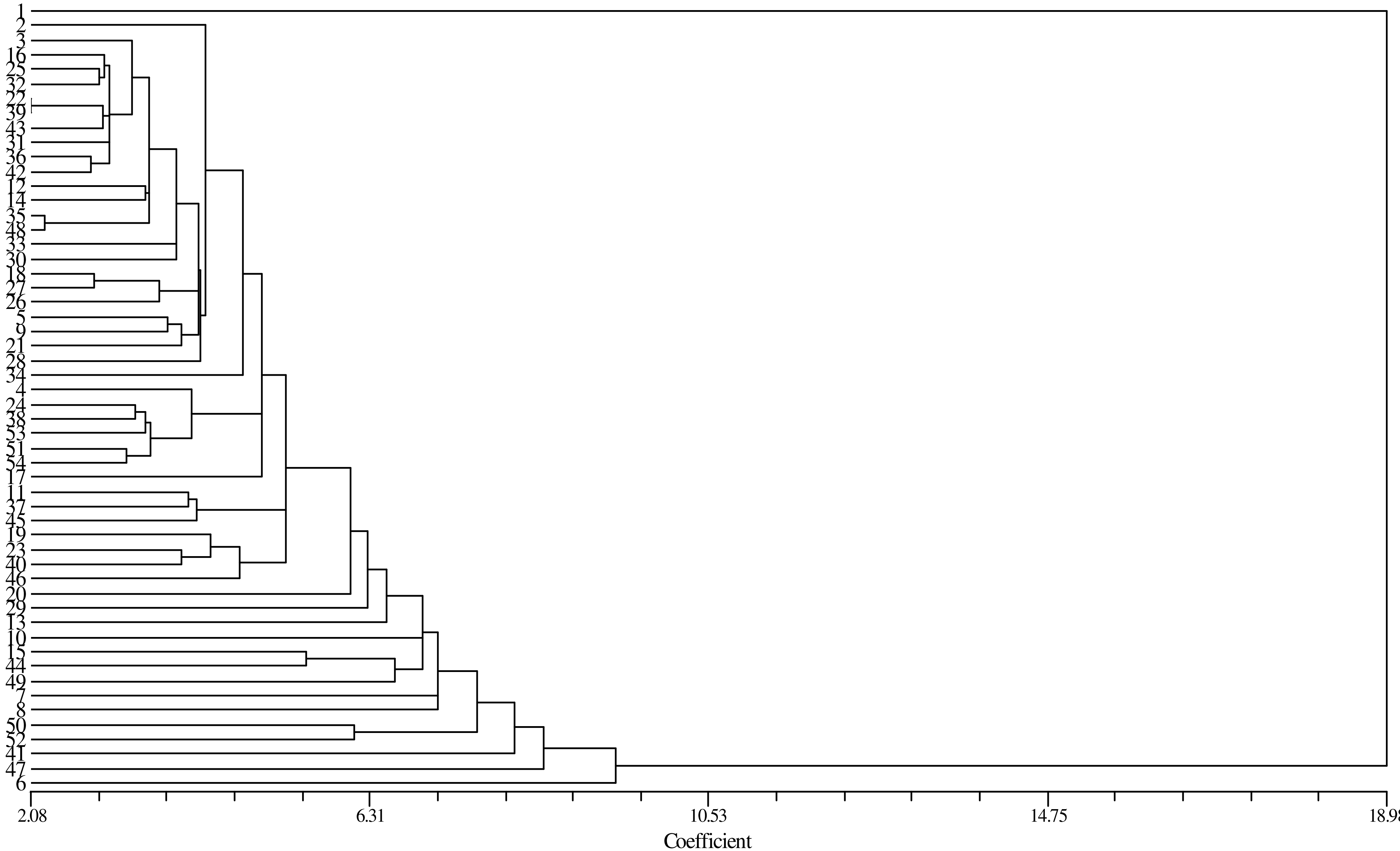

Figure 5. Cluster analysis based on all 37 studied productive traits for 51 silkworm strains according to the grouping from UPGMC method using NTSYS.

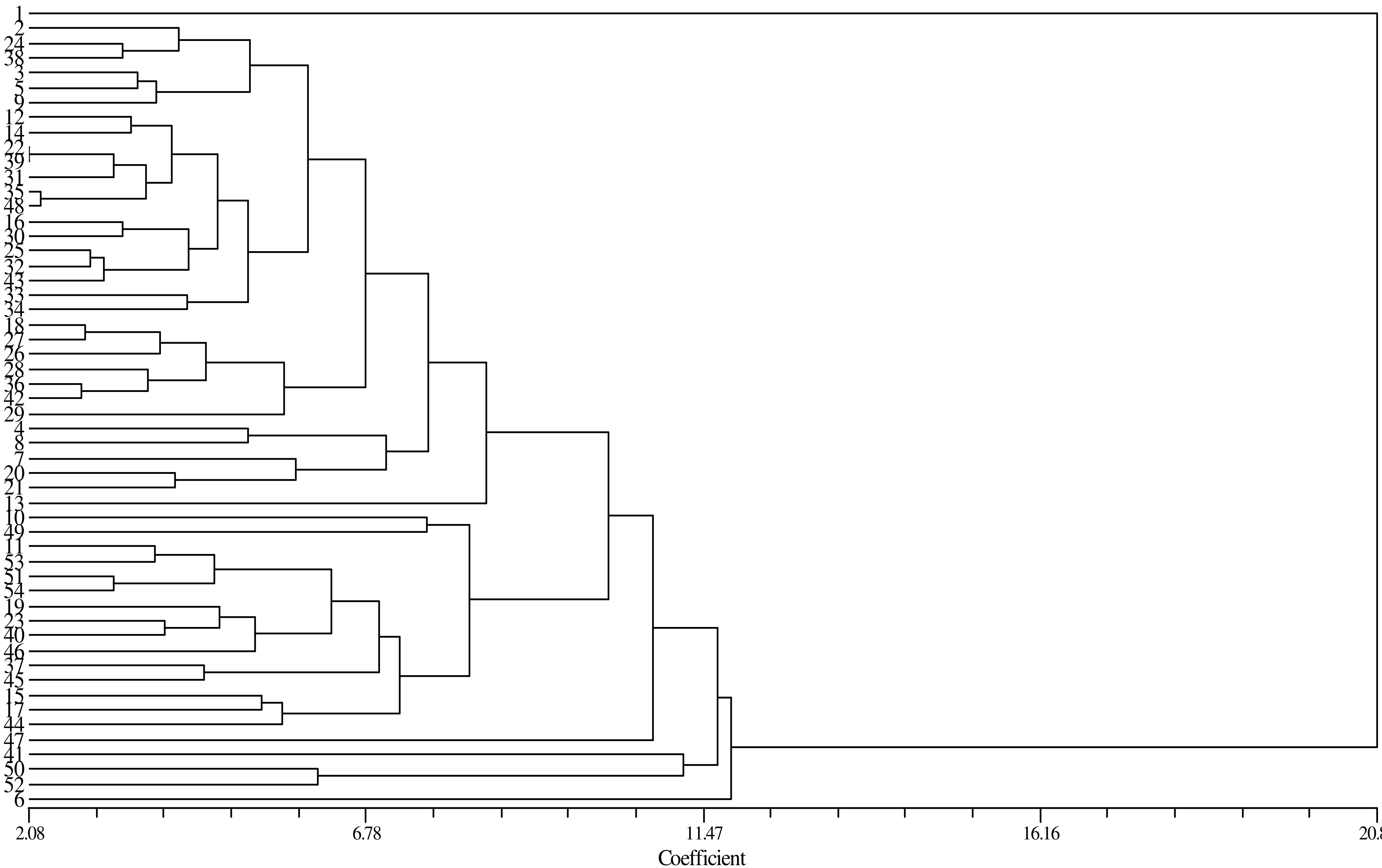

Figure 6. Cluster analysis based on all 37 studied productive traits for 51 silkworm strains according to the grouping from FLEXI method using NTSYS.

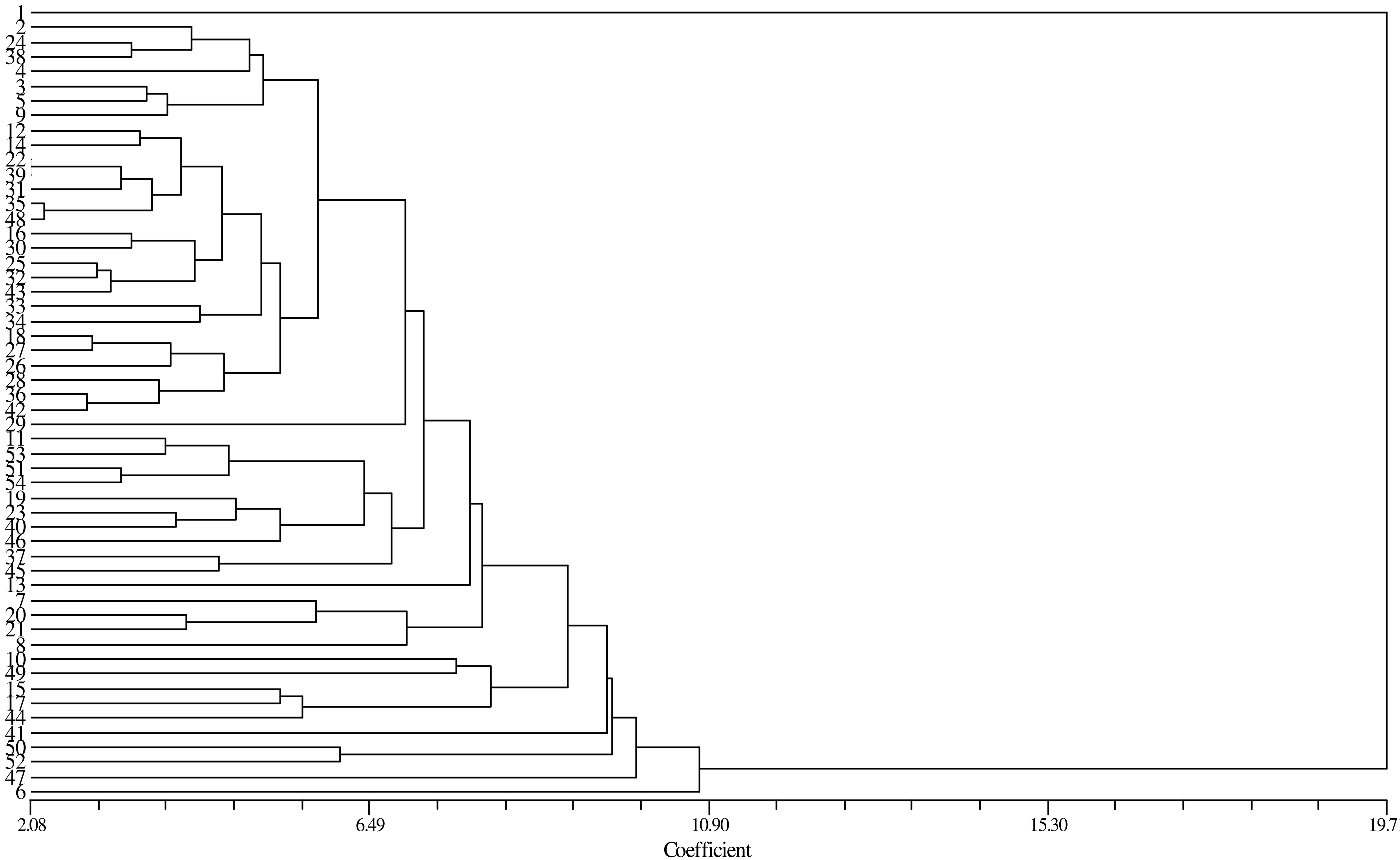

Figure 7. Cluster analysis based on all 37 studied productive traits for 51 silkworm strains according to the grouping from UPGMA (Unweighted Pair Group Method Average) method using NTSYS.

analysis refers to a group of multivariate techniques whose primary purpose is to group individuals or objects based on the characteristics they possess, so that individuals with similar descriptions are mathematically gathered into the same cluster (Hair et al., 1995). The resulted clusters of individuals should exhibit high internal (within cluster) homogeneity and high external (between clusters) heterogeneity. Thus, if the classification is successful, individuals within a cluster shall be closer when plotted geometrically and different clusters shall be farther apart (Hair et al., 1995).

Chatterjee and Data (1992) presented that domestication has played a major role in genetic diversification of silkworm (Gamo, 1983; Chatterjee and Data, 1992). As sericultural regions of the world have different climatic conditions, physiological diversification has also been influenced by agro-climatic factors. Thus, given geographic isolation and limited cultural exchange, some strains may have acquired similar genotypes due to similar selection pressures. On the other hand, it remains possible that there were exchanges of genetic material between the two countries at a still earlier time (Chatterjee and Data, 1992). Comparable examples are also available in this analysis.

Garson (2009) stated that hierarchical clustering is appropriate for smaller samples (typically <250). When n is large, the algorithm will be very slow to reach a solution and, indeed, may "hang" one's computer. To accomplish hierarchical clustering, the researcher must specify how similarity or distance is defined and how clusters are aggregated (or divided). Hierarchical clustering generates all possible clusters of sizes 1...K, but is used only for relatively small samples. In hierarchical clustering, the clusters are nested rather than being mutually exclusive, as is the usual case. In hierarchical clustering, larger clusters created at later stages may contain smaller clusters created at earlier stages of agglomeration. In forward clustering, also called agglomerative clustering, small clusters are formed by using a high similarity index cut-off (ex., .9). Then, this cut-off is relaxed to establish broader clusters in stages until all cases are in a single cluster at some low similarity index cut-off. The merging of clusters is visualized using a tree format (Garson, 2009).

Constant efforts are being made to develop productive polyvoltine silkworm hybrids suitable for sericulture, since more than ninety percent of the raw silk is still coming from polyvoltine silkworm hybrids only. Therefore, maintenance of polyvoltine resource material and their effective utilization has become very important (Rao et al., 2006).

The obtained data showed that there are highly significant differences among the genotypes for all the studied characters. Varietal differences for studied traits in *B. mori* have been reported by Ahsan and Rahman (2000). Similar results on varietal diversity have also been substantiated by the findings of Reza and Rahman (1996), Ahsan et al. (1999) and Ahsan and Rahman (2008).

In conclusion, our results confirmed and complemented previous papers regarding importance of evaluation and classification of Iranian silkworm strains based on economical and biological characters (Salehi et al., 2009, 2010a, b, c).

Obtained results classify our silkworm germplasm resources based on productive performances and use the highest potential varieties for future breeding programs. Also, investigating other silkworm germplasm characteristics such as larval phenotypic, reproductive and larval gain and developments are recommended for future researches.

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