Journal of Animal and Veterinary Advances 11 (8): 1246-1254, 2012
ISSN: 1680-5593


# Effect of Individual Selection System of Parental Pure Lines on Productive Traits of Six Hybrids of Silkworm

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**Abstract:** In order to study effect of individual selection system of parental pure lines (31, 32, 103, 104, 107 and 110) on productive traits of six hybrids (31×32, 32×31, 103×104, 104×103, 107×110 and 110×107) of resulted offspring from faraway crossing during fourth generation, these six parental pure lines of Iran silkworm were recorded individually and forty males and forty females through cocoon weight in each of these six parental pure lines selected. Then, for each of these six lines along with selection group, a control group includes of average same as society as base society was considered. Lines based on conditions over reproductive line system of lines, Iran silkworm grand and mother in continues three generations as pure lines were maintained and trained and intra hybrids during each generation without any re-selection was carried out. Then, in fourth generation with breeding between parental lines, six types of larvae egg commercial hybrid, each one in two types of selective and random were produced. These twelve hybrids each one in the form of four repetitions, ere trained and their performance (selective and random hybrid) were recorded and compared. Finally, the results of individual selection system of parental pure lines on performance of theses offspring hybrids were analysed. For doing this, data was recorded by Excel software and the data mean based on completely random program by use of t-student test by SAS software were analysed and calculated. Then, performance (data mean) of obtained hybrids resulted from crossing parental pure lines by Duncan test were compared. Obtained results of mean comparison of each trait (performance) between (selective and control group) resulted hybrids of simple six parental pure lines studied showed that individual selection among each of these parental pure lines, a total (whole of these six lines) of four traits of eleven traits studied in this study have meaningful effect (statistically). For cocoon weight that resulted to 10000 larvae in 104×103 hybrid and 103×104 hybrid, a meaningful difference was observed. For traits of double cocoon number and double cocoon percentage in 103×104 hybrid, no meaningful difference was observed. For cocoon number produced in 104×103, meaningful difference was observed. Results showed that except in three hybrids 32×31, 107×110 and 110×107 in other produced and studied hybrids in this study, meaningful difference for some trait (total of four traits) were obtained.

**Key words:** Silkworm, generation individual selection, parental pure line, crossing, performance

## INTRODUCTION

Native silkworm production in the present circumstances is not economical because of low performance and its ready availability at the commercial level. Obtained hybrids resulted from breeding lines to produce the silk is used (Mirhoseini, 1998). The purpose of silkworm breeding is for genetic improvement of economic traits in order to increase profits of larvae egg production, cocoon and silk and other related sectors of the industry (Groen, 1990; Nezhad *et al*., 2010; Seidavi, 2010; Lokesh *et al*., 2012). Cocoon-producing countries carry out three breeding stages in order to produce commercial cocoons including the isolation of pure indigenous or imported lines, producing initial and improved hybrids. Due to the global hydride cocoons interactions and factors such as incubation period, economic infrastructure, human resources and technology needed, it seems using imported hybrids are more effective than advanced hybrids in the region (ESCAP, 1993). No breeding method of heterosis in the economic cocoon production is the most effective. Both by selecting and hybridization need to be decided. Breeding livestock specialist can rank them based on their breeding values and eliminate those with lower rank and select those with high rank for replacing in cattle (Shodja and Pirani, 2005). The worldwide selected systems, at present are using the methods of successive elimination of independent levels and index which is based on them.

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They choose proper, accurate and consistent parents and the result of this selection is improve quality and quantity performance varieties during the breeding process so that today the selection of parameters such as genetic variance and covariance, correlation and heritability and finally, traits economic factors can be useful (Falconer, 1989; Kalpana, 1992; Ho, 1996). Variety of factors are effective in the process of selecting such as number of genes controlling traits, the number of traits selected, the reformer, the generation gap, the correlation of traits, social diversity and community-based colony genetic structure or inheritance (Falahati and Eftekhar, 1997; Falconer, 1989). Thus, a sustainable selection needs all the above requirements. Production performance each being determined by effects of genotype, environment and the interactions between these two (Falconer and Mackay, 1996). Therefore to improve the quality and quantity of silk production while improving environmental conditions such as nutrition, health, management and breeding conditions, researchers should take basic steps in genetic and breeding. First time at the beginning of the twentieth century, Japanese scholars attempted to apply scientific principles in silkworm breeding (Jayaswal *et al*., 2000). Among the principles of eugenics and genetic techniques, the selection of the first steps was effective in successful silkworm breeding. Since, the response to selection in each generation is based on the intensity of selection on each trait, heritability and genetic correlations with other traits, genetic advances can be estimated as a criterion for determining the appropriate strategy for the planning and selection of breeding lines. Therefore, recommended that lines selected systems for breeding programs is carried out based on results of research on the heritability of traits and their genetic correlations with each other and selection of parental lines for offspring is designed based on these traits (Ghanipour *et al*., 2009). About >320 strains in the silkworm were separated and identified and 22 genetic linkages were obtained (Tazima, 1978; Nematnezhad, 1998). To overcome boundaries and obstacles to the free exchange of genetic resources in the silkworm, researchers can use hybrid varieties that are available in large quantities in the commercial world. Then, we should do following breeding steps. At first, it is isolation of pure lines (pure line is a line with unique heritability. In a pure line, the children performance is more or less than their parents and quantitative traits studied are directed to the average parent). Then, hybrids or a combination of pure breeds are the most efficient. Significant effect of cross type, variety, sex, season, generation and replications for individual traits (cocoon weight, cocoon shell weight and cocoon shell percentage) and the variety, season and for generations of family traits (best cocoon, best larvae ratio, cocoon number in larval duration) indicating compliance with the performance traits of varieties of genotypic and phenotypic differences from these varieties (Chattopadhyay *et al*., 1994; Shon and Ramires, 1999). Some current hybrids are >20 years old but most hybrids used in the cocoon production generally remains 5-10 years without a drop. Today, many attempts to increase performance combined with the use of modern methods of silkworm breeding is done (Bizhannia and Seidavi, 2008). Breeding commercial hybrids native over pure race lead to increase 288% cocoon weight and cocoon shell percentage, 360% of cocoon size, 266% cocoon production, 400% long fiber silk, 275% raw silk and decreasing 74% in larvae duration (ESCAP, 1993). Silkworm breeding goals include achieving superior performance in areas of larvae egg production, cocoon production and raw silk, production continued in various conditions, compatibility and production in new areas, cocoon quality and raw silk and other traits. According to the definition of pure lines, continuous selection within a pure line for each phenotype is valuable because of the diversity of the colony and diversity will be available only from the environment. Second point is the principle of separation of functions under which a pair of silkworms, development and testing with their children is possible (Bizhannia and Seidavi, 2008). This principle can detect a genetically superior strains of what they collect and what have been isolated that have been used. For traits with low heritability, progeny testing should be done, especially in older generations to obtain the desired results and significance of these traits. Different iterations are considered which makes it possible for error resulting from the variance between lines or varieties.

## MATERIALS AND METHODS

The applied research project according to the records of the colony of six pure parental lines 31, 32, 103, 104, 107 and 110 Iran silkworm was estimated and received from Iran Silkworm Research Center. For each of these six lines, a group consisting of forty male and forty female were selected and average cocoon weight was higher than the average colony and a control group composed of individuals with average of the same community as base society were studied. The data to select a single six-line system and the effect of pure parental silkworm yield (average yield) of six hybrids were (32×31, 31×32, 104×103, 103×104, 110×107 and 107×110), respectively. In this study, for each line in zero generation, the two groups were randomly selected and the conditions governing the reproduction system and grandparents and mother lines of Iran silkworm, three consecutive generations of pure lines were used to form, grow and reproduce hybrids found within the group during each generation without re-selection has taken place. Then, in the fourth generation, the intercourse between the parental lines of six integrated commercial types of larvae eggs, each in two randomly selected were produced. The twelve hybrid types in four replicates were trained and their performance (the performance of each of these two hybrids) were recorded and compared with each other (as compared to the hybrid) and the results on the performance of the hybrid of individual parental lines system were analysed.

Eleven recorded production traits in this study include cocoon number, best cocoon percentage, best cocoon number, average cocoon number, average cocoon percentage, middle cocoon number, low cocoon percentage, double cocoon number, cocoon percentage, double cocoon weight and 10000 larvae cocoon weight in the fourth generation (in the commercial hybrid intercourse of the pure parental lines in this generation) were recorded. As mentioned this data was recorded and the calculation of the performance of each of these hybrids prepared for each of these traits were analyzed.

## RESULTS AND DISCUSSION

Selected community based on individual survey resulted from cocoon weight for each line (six pure parental lines 31, 32, 103, 104, 107 and 110 Iran silkworm) were separately analysed and simply cross off the record making them the fourth generation and effect (11 traits) in any hybrid and also comparison in the performance of a hybrid group with the control group (as a hybrid) in Table 1-6 are show. It explained that production traits among 11 traits studied in this research include five traits of low cocoon number, middle cocoon number, double cocoon number, double cocoon percentage and double cocoon weight and a negative yield in larvae industry are increasing the amount of them as they did not improve the reduction rate but the improvement was significant.

**Comparing the performance of individual selection system based on performance in six parental lines for eleven traits of silkworm production**

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of produced cocoon number:** Selection in a base community based on cocoon weight reduces the amount of produced cocoon in all six studied hybrid in this study. So we can say that selected base community based on cocoon weight had no increase associated with this trait. Most reduction in the selection of this trait in the base community was in hybrid 104×103 (13.25 cocoons) and the lowest trait in hybrid 32×31 (2.50 cocoons) (Table 4 and 2). According to the results, the maximum value for this trait in control group was hybrid 110×107, 246.50 cocoons and the lowest one in the

Table 1: Comparing the performance individual selection systems (base on cocoon treat) of pure parental lines of silkworm in base community on offspring hybrid 31×32 during tree next generation for 11 traits sericulture industry*

| Hybrid 31×32 traits | Random | Selective |
|---|---|---|
| Produced cocoon number (-) (positive productive) | $204.25^a$ | $199.25^a$ |
| Best cocoon number (-) (positive productive) | $150.50^a$ | $146.00^a$ |
| Middle cocoon number (-) (positive productive) | $42.25^a$ | $44.75^a$ |
| Low cocoon number (-) (negative productive) | $7.25^a$ | $4.50^a$ |
| Double cocoon number (-) (negative productive) | $4.25^a$ | $4.00^a$ |
| Cocoon percentage (%) (positive productive) | $73.64^a$ | $73.15^a$ |
| Middle cocoon percentage (%) (positive productive) | $20.71^a$ | $22.55^a$ |
| Low cocoon percentage (%) (negative productive) | $3.54^a$ | $2.27^a$ |
| Double cocoon percentage (%) (negative productive) | $2.09^a$ | $2.01^a$ |
| Double cocoon weight (g) (negative productive) | $4.70^a$ | $5.08^a$ |
| 10000 larvae cocoon weight (g) (positive productive) | $26125.90^a$ | $26667.90^a$ |

Table 2: Comparing the performance individual selection systems (base on cocoon treat) of pure parental lines of silkworm in base community on offspring hybrid 32×31, during tree next generation for 11 traits sericulture industry*

| Hybrid 32×31 traits | Random | Selective |
|---|---|---|
| Produced cocoon number (-) (positive productive) | $201.50^a$ | $199.00^a$ |
| Best cocoon number (-) (positive productive) | $153.75^a$ | $155.25^a$ |
| Middle cocoon number (-) (positive productive) | $36.25^a$ | $31.50^a$ |
| Low cocoon number (-) (negative productive) | $6.25^a$ | $4.25^a$ |
| Double cocoon number (-) (negative productive) | $5.25^a$ | $8.00^a$ |
| Cocoon percentage (%) (positive productive) | $76.26^a$ | $77.95^a$ |
| Middle cocoon percentage (%) (positive productive) | $17.99^a$ | $15.78^a$ |
| Low cocoon percentage (%) (negative productive) | $3.11^a$ | $2.16^a$ |
| Double cocoon percentage (%) (negative productive) | $2.62^a$ | $4.09^a$ |
| Double cocoon weight (g) (negative productive) | $4.84^a$ | $4.85^a$ |
| 10000 larvae cocoon weight (g) (positive productive) | $26329.60^a$ | $26779.80^a$ |

Table 3: Comparing the performance individual selection systems (base on cocoon treat) of pure parental lines of silkworm in base community on offspring hybrid 103×104 during tree next generation for 11 traits sericulture industry*

| Hybrid 103×104 traits | Random | Selective |
|---|---|---|
| Produced cocoon number (-) (positive productive) | $213.00^a$ | $206.75^a$ |
| Best cocoon number (-) (positive productive) | $161.75^a$ | $135.50^a$ |
| Middle cocoon number (-) (positive productive) | $44.50^a$ | $40.25^a$ |
| Low cocoon number (-) (negative productive) | $2.25^a$ | $5.25^a$ |
| Double cocoon number (-) (negative productive) | $4.50^b$ | $7.75^a$ |
| Cocoon percentage (%) (positive productive) | $76.07^a$ | $74.21^a$ |
| Middle cocoon percentage (%) (positive productive) | $20.77^a$ | $19.52^a$ |
| Low cocoon percentage (%) (negative productive) | $1.05^a$ | $2.51^a$ |
| Double cocoon percentage (%) (negative productive) | $2.10^b$ | $3.74^a$ |
| Double cocoon weight (g) (negative productive) | $5.40^a$ | $4.72^a$ |
| 10000 larvae cocoon weight (g) (positive productive) | $24450.70^b$ | $26183.70^a$ |

*There is significant difference between the numbers that are shown with the different letter (s) in each row ($p<0.05$). Each row of data without any letter has not significant differences ($p>0.05$)

Table 4: Comparing the performance individual selection systems (base on cocoon treat) of pure parental lines of silkworm in base community on offspring hybrid 104×103 during tree next generation for 11 traits sericulture industry*

| Hybrid 104×103 traits | Random | Selective |
|---|---|---|
| Produced cocoon number (-) (positive productive) | 217.75[a] | 204.50[b] |
| Best cocoon number (-) (positive productive) | 177.00[a] | 159.00[a] |
| Middle cocoon number (-) (positive productive) | 30.25[a] | 39.50[a] |
| Low cocoon number (-) (negative productive) | 5.50[a] | 2.25[a] |
| Double cocoon number (-) (negative productive) | 5.00[a] | 3.75[a] |
| Cocoon percentage (%) (positive productive) | 81.26[a] | 77.75[a] |
| Middle cocoon percentage (%) (positive productive) | 13.91[a] | 19.32[a] |
| Low cocoon percentage (%) (negative productive) | 2.51[a] | 1.09[a] |
| Double cocoon percentage (%) (negative productive) | 2.29[a] | 1.83[a] |
| Double cocoon weight (g) (negative productive) | 4.64[a] | 4.99[a] |
| 10000 larvae cocoon weight (g) (positive productive) | 24026.30[b] | 25298.70[a] |

Table 5: Comparing the performance individual selection systems (base on cocoon treat) of pure parental lines of silkworm in base community on offspring hybrid 107×110 during tree next generation for 11 traits sericulture industry*

| Hybrid 107×110 traits | Random | Selective |
|---|---|---|
| Produced cocoon number (-) (positive productive) | 243.75[a] | 240.25[a] |
| Best cocoon number (-) (positive productive) | 183.25[a] | 160.75[a] |
| Middle cocoon number (-) (positive productive) | 42.75[a] | 61.75[a] |
| Low cocoon number (-) (negative productive) | 5.00[a] | 5.00[a] |
| Double cocoon number (-) (negative productive) | 12.75[a] | 12.75[a] |
| Cocoon percentage (%) (positive productive) | 75.24[a] | 66.86[a] |
| Middle cocoon percentage (%) (positive productive) | 17.45[a] | 25.74[a] |
| Low cocoon percentage (%) (negative productive) | 2.04[a] | 2.08[a] |
| Double cocoon percentage (%) (negative productive) | 5.25[a] | 8.98[a] |
| Double cocoon weight (g) (negative productive) | 3.98[a] | 3.98[a] |
| 10000 larvae cocoon weight (g) (positive productive) | 21740.60[a] | 21913.00[a] |

Table 6: Comparing the performance individual selection systems (base on cocoon treat) of pure parental lines of silkworm in base community on offspring hybrid 110×107 during tree next generation for 11 traits sericulture industry*

| Hybrid 110×107 traits | Random | Selective |
|---|---|---|
| Produced cocoon number (-) (positive productive) | 246.50[a] | 243.75[a] |
| Best cocoon number (-) (positive productive) | 174.50[a] | 181.50[a] |
| Middle cocoon number (-) (positive productive) | 59.00[a] | 45.50[a] |
| Low cocoon number (-) (negative productive) | 3.75[a] | 2.50[a] |
| Double cocoon number (-) (negative productive) | 9.25[a] | 14.25[a] |
| Cocoon percentage (%) (positive productive) | 70.76[a] | 74.48[a] |
| Middle cocoon percentage (%) (positive productive) | 23.94[a] | 18.65[a] |
| Low cocoon percentage (%) (negative productive) | 1.53[a] | 1.02[a] |
| Double cocoon percentage (%) (negative productive) | 3.76[a] | 5.84[a] |
| Double cocoon weight (g) (negative productive) | 3.90[a] | 4.07[a] |
| 10000 larvae cocoon weight (g) (positive productive) | 20932.30[a] | 21092.80[a] |

*There is significant difference between the numbers that are shown with the different letter (s) in each row ($p<0.05$). Each row of data without any letter has not significant differences ($p>0.05$)

selected hybrid was 32×31, 199 cocoons (Table 6 and 2). Comparison of performance of the selected groups with control groups of each hybrid, only in the hybrid 103×104 (Table 4), showed significant difference ($p<0.05$) and the other hybrids, significant differences were observed ($p>0.05$). The averages of this trait in selected hybrid 104×103 and in control group were 204.50 and 217.75, respectively.

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of best cocoon number:** According to the results of this test, selection in base community based on cocoon weight increase best cocoon number in the hybrids 110×107 (7 cocoons) and 32×31 (1.50 cocoons) (Table 6 and 2) and in other hybrids reduce this treat. According to the results, the maximum amount for this trait in control group was hybrid 107×1110 with 183.25 cocoons and the lowest in the select of hybrid 31×32 was 146 cocoons (Table 1 and 5). Comparing the performance of the selected groups with control groups in each hybrid showed no significant difference among any of the six hybrids studied in this research ($p>0.05$).

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of middle cocoon number:** The results suggested that the selection of base community based on the cocoon weight increase the average Cocoon number in the hybrids 107×110 (19 cocoons), 104×103 (9.25 cocoons) and 31×32 (2.50 cocoons), respectively (Table 1, 4 and 5) and in other hybrids, reduction in this trait was observed. According to the results, most of these traits was in the hybrid 107×110 (61.75 cocoons) and the lowest in the control group was in hybrid 104×103 (30.25 cocoons) (Table 4 and 5). Comparing the performance of the selected groups with control groups for each hybrid showed no significant difference among any of the six hybrids studied in this research ($p>0.05$).

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of low cocoon number:** The study indicates that selection in base community based on cocoon weight increase low cocoon number only in hybrid 103×104 (3 cocoons) but had no effect in hybrid 107×110 (Table 3 and 5) however, in other hybrids this reduction was observed. Performance rate (average) in selected group for this trait was in hybrid 103×104 (5.25 cocoons) and in control group of hybrid 104×103 was 2.25 cocoon. According to the results, the maximum amount for this trait in control group for each hybrid 31×32 (7.25 cocoons) and the lowest in the control group in hybrid 103×104 (2.25) and in hybrid 104×103 (2.25 cocoons) (Table 1, 3 and 4). Comparison in the performance of the selected groups with control groups in each hybrid showed no significant difference among any of the six hybrids studied in this research ($p>0.05$).

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of double cocoon number:** According to the results of this test, selection in base community based on cocoon weight increase double cocoon number in the hybrids 110×107 (5 cocoons), 103×104 (3.25 cocoons) and 32×31 (2.75 cocoons), respectively (Table 2, 3 and 6) and the hybrid 107×110, no effect was observed (Table 5) but in other hybrids, reduction of this trait was observed. According to the results, most of these traits was in the selected group of hybrid 110×107 (14.25 cocoons) and the lowest in the selected group of hybrid 104×103 (3.75 cocoons). Comparing the performance of the selected groups with control groups of each hybrid, only in hybrid 103×104 showed statistically significant difference ($p<0.05$) and in the other hybrids, significant differences were observed ($p>0.05$). The averages of this trait in selected hybrid 103×104 and in control group were 7.75 and 4.50, respectively.

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of best cocoon percentage:** The study indicates that selection in base community based on cocoon weight increase best cocoon percentage in hybrid 110×107 (3.72 %) and 32×31(1.69%) but in other hybrids this reduction was observed (Table 2 and 6). According to the results, most of these traits in the control group in hybrid 104×103 were (81.26%) and the lowest in the selected group of hybrid 107×110 was (66.84%) (Table 4 and 5). Comparing the performance of the selected groups with the control groups in each hybrid showed no significant difference among any of the six hybrids studied in this research ($p>0.05$).

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of middle cocoon percentage:** Selection in a base community based on cocoon weight increase middle Cocoon percentage in the hybrids 107×1110 (8.29%) and in 104×103 (5.41%) and 31×32 was (1.84%) (Table 1, 4 and 5) and in other hybrids this reduction was observed. According to the results, most of these traits, the selected group in hybrid 107×110 (25.74%) and the lowest in the control group of hybrid 104×103 was (13.91%) (Table 4 and 5). Comparing the performance of the selected groups with control groups in each of the hybrid showed no significant difference among any of the six hybrids studied in this research ($p>0.05$).

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of low cocoon percentage:** The results of this study indicate that the selection of base community based on cocoon weight increase the low cocoon percentage in the hybrids 103×104 (1.46%) and in 107×110 was (0.04%) (Table 3 and 5) and in other hybrids this reduction was observed. According to the results, the maximum amount for this trait, control group of hybrid 31×32 (3.54%) and the lowest in the selected group of hybrid 110×107 (1.02%) (Table 1). Comparing the performance of the selected groups with the control groups in each hybrid showed no significant difference among any of the six hybrids studied in this research ($p>0.05$).

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×103 with its own control groups for traits of double cocoon percentage:** According to the results of this test, selection in base community based on cocoon weight increase double Cocoon number in hybrids 107×110 (3.72%) in 110×107 (2.08%), 103×104 (1/64%) and 32×31 was (1.47%) (Table 2, 3, 5 and 6) and two hybrid 31×32 and 104×103 had reduction of this trait (Table 1 and 4). According to the results, most of these traits, the selected group of hybrid 107×110 (8.98 %) and the lowest in the selected group of hybrid 104×103 was (1.83%). Compare the performance of the selected groups with control groups of each hybrid, the only hybrid 103×104 (Table 3), showed no significant difference ($p<0.05$) and the other hybrids showed no significant differences ($p>0.05$). The averages of this trait in selected hybrid 103×104 and in control group were 3.74 and 2.10, respectively.

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of double cocoon weight:** The results of this test, selection in base community based on cocoon weight increase double Cocoon weight in hybrids of 31×32 (0.38 g) in 104×103 (0.35 g) and 110×107 (0.17 g) and 32×31 was (0.01 g) (Table 1, 2, 4 and 6) and hybrid 107×110 (Table 5) had no effect but in other hybrids, reduction of this trait was observed. According to the results, the maximum amount for this trait in the control group for hybrid 103×104 (5.40 g) and the lowest in control group in hybrid 110×107 was (3.90 g) (Table 3 and 6). Comparing the performance of selected groups with control groups in each hybrids showed no significant difference among any of the six hybrids studied in this research (p>0.05).

**Comparison of the efficiency of the individual selection system based on the performance of hybrids in 31×32, 32×31, 103×104, 104×103, 107×110 and 110×107 with its own control groups for traits of 10000 larvae cocoon weight:** The test results showed that selection in a base community based on cocoon weight increase, cocoon 10000 larvae cocoon weight in six hybrids studied. According to the results, most of these traits, the selected group of hybrid 32×31 (26779.8 g) and the lowest in the control group of hybrid 110×107 (20932.3 g) (Table 2 and 5). Comparing the performance of the selected groups with control groups of each hybrid, only two hybrid 103×104 and 104×103 (Table 3 and 4) showed no significant difference (p<0.05) and the other hybrids, significant differences were observed (p>0.05). The averages of this trait in selected hybrid 103×104 and in control group were 26183.7 g and 24450.7 g, respectively and in selected hybrid 104×103 and in control group were 25268.7 and 24026.3 g, respectively.

**Hybrid 31×32:** The results are shown in Table 1, it is noted that the offspring hybrid performance of 31×32 on any of the 11 traits studied showed no statistically significant differences and individual pure parental lines selection in a base society based on cocoon weight had no significant effect on the performance of hybrid progeny in a hybrid 31×32. Generally, the effect of the individual parental lines in base community based on cocoon weight on performance of offspring hybrid 31×32 increase 4 traits of 11 traits is studied that three traits are positive traits (improving of these traits) and just one of them is negative trait.

**Hybrid 32×31:** The results are shown in Table 2, it is noted that the offspring hybrid performance of 32×31 on any of the 11 traits studied showed no statistically significant differences and individual pure parental lines selection in a base society based on cocoon weight had no significant effect on the performance of hybrid progeny in a hybrid 32×31.

Generally, the effect of the individual parental lines in base community based on cocoon weight on performance of offspring hybrid 32×31 increase 6 traits of 11 traits is studied that three traits are positive traits (improving of these traits) and three of them are negative trait.

**Hybrid 103×104:** The results are shown in Table 3, it is noted that the offspring hybrid of 103×104 for the three traits of the 11 traits studied has shown no significant difference. For these three traits, hybrid 103×104 increase 10000 larvae cocoon weight (1733 g; positive productive traits), double cocoon number (3/25 cocoons, positive productive traits) and double cocoon percentage (1/64%, positive productive traits). Another important point is that this selected groups of hybrid showed no significant difference (increase or decrease regardless of the traits), for any of these traits, showed no significant difference in comparison to each other. Totally, the effect of individual selection pure parental lines in the base community based on cocoon weight on performance of offspring hybrid 103×104 increase five traits of eleven traits that from these five traits, one of them is positive and the other four are negative. From these eleven traits, two traits showed no change in comparison selected group with control group. And from seven traits which their amount reduced, all of them are positive. Selected groups of this hybrid about five traits which showed significant different (regardless increase or decrease amount of trait), for none of these traits, there was no significant difference.

**Hybrid 104×103:** The results are shown in Table 4, it is noted that the offspring hybrid of 104×103 for the three traits of the 11 traits studied has shown no significant difference for these three traits, hybrid 104×103 increase 10000 larvae cocoon weight (1733 g; positive productive traits), double cocoon number (3/25 cocoon, positive productive traits) and double cocoon percentage (1/64%, positive productive). Three traits are positive and just one of them is negative. Among these 22 traits, one of them showed no change but among seven reduced traits, three of them are positive and the other four are negative. Another important point is that this selected groups of hybrid of 2 of 11 traits showed no significant difference (increase or decrease regardless of the traits).

**Hybrid 107×110:** The results are shown in Table 2, it is noted that the offspring hybrid of 107×110 on any of the 11 traits studied did not show statistically significant differences. Individual parental pure lines selection in a base society based on cocoon weight had no significant effect on the performance of hybrid 107×110.

It should be noted that among these 11 traits, hybrid 107×110, for the three traits of a low cocoon number, pupae cocoon number (double) and pupae cocoon weight (double) have shown no increase or decrease. This shows that the individual selection of parental pure liens in base community base on cocoon weight in mention traits show no chignons. Totally the effect of individual selection of parental pure liens on performance offspring hybrid 107×110 increase five traits of 11 treats that 3 of them or positive to of them or negative.

**Hybrid 110×107:** The summary results are shown in Table 6, it is noted that the offspring hybrid of 110×107 on any of the 11 traits studied did not show statistically significant differences. Individual parental pure lines selection in a base society based on cocoon weight had no significant effect on the performance of hybrid 110×107.

Generally, the effect of the individual parental lines in base community based on cocoon weight on performance of offspring hybrid 110×107 increase 6 traits of 11 traits is studied and all these six traits are positive traits and show improving of these traits. That 3 of them or positive on the next 3 traits or negative.

One of the purposes of crossing pure lines is producing F1 individual or superior hybrids (Bizhannia and Seidavi, 2008). Therefore, measuring private combining capability, general combining capability and dynasties parent in parental selection is very important (Mirhoseini and Gholami, 2002). Study on some economic characters of single, three-way and double cross hybrids obtained from four Iranian silkworm varieties. Combining capability of parents is completely dependent on the genetic interaction which cannot be accessed through phenotypic performance (Satenahalli *et al*., 1991). General capability includes non-additive gene effects, dominance effects and other types of gene interactions (Bandyopadhyay, 1990; Mirhoseini *et al*., 2004).

In fact, selection is used to provide hybrids to find a pair lines with appropriate combining capability to be able to have long lasting lines and provide the necessary convergence and commercial use. However, actual performance of these lines should also be estimated because each line must have a reasonable level of production to maintenance and use for crossing. For traits with low heritability, offspring testing should be done, especially in older generations to obtain the desired results and significance of these traits. Different replications which make it possible error resulting from the variance between lines or varieties to be considered. Each individual or group of breeding specialise to achieve its goals of eugenics which includes conditions requiring the establishment of a breeding facility, skilled manpower, facilities, tools, budgets and working (Bizhannia and Seidavi, 2008). Simple crossings, three-way and four-way have diversity and different genetic structure that makes it different from their own.

The influence of gender and breeding season on the desired traits has been proven. (Gholami *et al*., 2002; Petkov, 1989, 1997). Today, sericulture industry use parents with high general combining capability to improve the performance of the silkworm. The parents create a high heterosis because of additive effects and additive×additive interactions (Bandyopadhyay, 1990; Mirhoseini *et al*., 2004). To study combining capability in the silkworm, various methods such as Griffing (1956) and Kempthorne (1957) are used (Griffing, 1956; Kempthorne, 1957; Singh *et al*., 2003; Seidavi *et al*., 2004). Among traits such as cocoon, cocoon shell weight and cocoon shell percentage were the highest and lowest levels of heterosis. This represents a large share of non-additive effects in the genetic control of this trait. High percentage of heterosis for production traits can be estimated according to the additive and non-additive genetic variance of cocoon traits. Non-additive genetic effects have high proportion in the total genetic variance of cocoon traits. Non-additive genetic variance has fewer roles in phenotypic resistance traits. Cocoon traits is the most important economic traits of silkworm and due to high heritability, the efficiency direct selection on their traits is very high (Griffing, 1956; Mirhoseini *et al*., 2004).

There are many researches about silkworm genetics, nutrition and biochemistry (Seidavi *et al*., 2008, 2009; Seidavi, 2009, 2010a-c, 2011a-c). Results reported by Mirhoseini *et al*. (2004) showed that in improving the average efficiency of heterosis in hybrids, especially for traits of cocoon shell weight will be selected by breeding methods. This indispensable role of heterosis revealed in larvae egg production of silkworm. In order to increase production capacity and fertility, often hybrid methods (three-way crossing, four-way crossings and F2 hybrids) is used however, reduce cost of uniformity is inevitable. Ashoka *et al*. (1989) studied the amount of heterosis in the four-way hybrids and produced eight generations of two lines 7NB, 18NB, 122J and KA were evaluated on various traits and showed a significant relative heterosis for KA×7NB hybrid trait in larvae duration but most of four-way hybrids showed rarely significant improvement for >2 traits (Ashoka *et al*., 1989). Another study showed that four-way hybrids show rarely full heterosis for more than two traits, Singh *et al*. (2002) noted in the silkworm in general, parameters before and after cocoon, heterosis is always more in easy crosses with three and four-way crossings (Singh *et al*., 2002).

Ashoka and Govindan (1994) also examine hybrids resulted from simple, three-way and four-way crossings of silkworm stated that the four-way hybrids (18NB×122J)×(KA×7NB) and (7NB×KA)×(18NB×122J) was significantly superior to the five traits (amount of production cocoon by 10,000 silkworms, cocoon weight and cocoon shell, cocoon shell percentage, fiber length of

Denier cocoon) and can significantly increase their level of agricultural production (Ashoka and Govindan, 1994). Narayanaswamy *et al*. (1991) studied the performance of hybrids resulted from simple and four-way crossings of silkworm for cocoon traits and recommended to use some of them to improve production levels of sericulture industry (Narayanaswamy *et al*., 1991).

## CONCLUSION

The result of this study showed that individual selection of parental pure lines of silkworm on performance of offspring hybrid has meaningful effect. So in production of commercial larvae egg individual selection system among parental pure lines can have more profit.

## ACKNOWLEDGEMENTS

This manuscript is obtained from M.Sc. thesis of Hossein Hojatpour at Islamic Azad University, Karaj Branch, Karaj, Iran. Researchers are grateful to the Iran Silkworm Research Centre (ISRC) for providing silkworm data and Islamic Azad University, Karaj Branch, Iran for support.

## REFERENCES

Ashoka, J. and R. Govindan, 1994. Performance of some bivoltine silkworm breeds and their single and double cross hybrids for yield and cocoon traits. Karnataka J. Agric. Sci., 7: 28-31.

Ashoka, J., R. Govindan, B. Narasimharaju and S.G. Rayar, 1989. Heterosis for larval quantitative traits in bivoltine single and double-crosses hybrids of mulberry silkworm. Environ. Ecol., 7: 437-440.

Bandyopadhyay, A., 1990. Utility of diallel mating designs in breeding. Proceedings of Workshop on Biochemical Genetics, October, 7-9, 1990 Mysore, pp: 22-27.

Bizhannia. A. and A. Seidavi, 2008. Principles and Techniques of Silkworm Breeding. 1st Edn., Haghshenass publishing, U.K., pp: 150.

Chattopadhyay, S., B. Ghosh and A.K. Das, 1994. Performance of some hybrids of bivoltine silkworm, *Bombyx mori* L. in tropical condition of West Bengal. Bangladesh J. Zool., 22: 209-215.

ESCAP, 1993. Principles and Techniques of Silkworm Breeding. United Nations, Economic and Social Commission for Asia and Pacific, New York, Pages: 114.

Falahati, R.M. and S.F. Eftekhar, 1997. Resystems Heritability Mechanism. 1st Edn., Jihad University of Mashhad University Publications, Iran.

Falconer, D.S. and T.F.C. Mackay, 1996. Introduction to Quantitative Genetics. 4th Edn., Benjamin Cummings, England, ISBN-13: 9780582243026, Pages: 464.

Falconer, D.S., 1989. Introduction to Quantitative Genetics. 3rd Edn., Longman Scientific and Technical, New York, Pages: 438.

Ghanipour, M., S.Z. Mirhoseini, A.R. Seidavi, E.R. Shadparvar and E.R. Bizhannia, 2009. Estimation of genetic parameters for economic traits of silkworm six commercial lines. Pazhouheshname Agric. Sci., 2: 31-38.

Gholami, M.R., S. Vishkaee, A.R. Seidavi and S.Z Mirhosseini, 2002. Evaluation of seven new lines of silkworm *Bombyx mori* and their crosses. Proceedings of the 15th Iranian Plant Protection, September 7-11, 2002, Razi University of Kermanshah, Iran, pp: 274-275.

Griffing, B., 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci., 9: 463-493.

Groen, A.F., 1990. Influences of production circumstances on the economic revenue of cattle breeding programmes. Anim. Prod., 51: 469-480.

Ho, Z.L., 1996. Basic principles and practical techniques of silkworm breeding. Korea, Pages: 119.

Jayaswal, K.P., S. Masilamani, V. Lakshmanan, S.S. Sindagi and R.K. Datta, 2000. Genetic variation, correlation and path analysis in mulberry, *Bombyx mori*. Sericologia, 40: 211-223.

Kalpana, G.V., 1992. Breeding of superior races of silkworm *Bombyx mori* L. for tropical climates. Ph.D Thesis, University of Mysore, Mysore.

Kempthorne, O., 1957. An Introduction to Genetic Statistics. 1st Edn., John Wiley and Sons, New York.

Lokesh, G., P.P. Pao, K.N. Madhusudhan, P.K. Kar and A.K. Srivastava *et al*., 2012. Study of phenotypic variability in silk gland characters in three ecoraces of tropical tasar silkworm antheraea mylitta drury. Asian J. Anim. Vet. Adv., 7: 80-84.

Mirhoseini, S.Z. and M.R. Gholami, 2002. Study on some economic characters of single, three-way and double cross hybrids obtained from four Iranian silkworm varieties. Proceedings of 19th Congress International Sericul. Commission, (CISC'02), Thailand, pp: 190-194.

Mirhoseini, S.Z., 1998. Study of Iran silkworm genetic diversity using protein and DNA markers. Ph.D. Thesis, College of Agriculture Tarbiatmodares University, Iran, Tehran.

Mirhoseini, S.Z., A.R. Seidavi, M. Ghanipoor and K. Etebari, 2004. Estimation of general and specific combining ability and heterosis in new varieties of silkworm, *Bombyx mori* L. J. Biological Sci., 4: 725-730.

Narayanaswamy, K.C., T.K. Narayanaswamy, B.LV. Gowda, R. Govindan and M.C., Devaiah, 1991. Comparative performance of bivoltine single and double cross hybrids of silkworm *Bombyx mori* L. for cocoon characters. Mysore J. Agric. Sci., 25: 488-493.

Nematnezhad, B., 1998. Sericulture and Important Issues that Laboratory. 1st Edn., University Press of Imam Reza (A.S.), Mashed, Iran, Pages: 200.

Nezhad, M.S., S.Z. Mirhosseini, S. Gharahveysi, M. Mavvajpour and A.R. Seidavi, 2010. Comparative study on the larval development duration of 51 different peanut cocoon strains of Iran silkworm *Bombyx mori* (Lepidoptera: Bombycidae) gene bank. Asian J. Anim. Vet. Adv., 5: 234-245.

Petkov, N., 1989. Improving the initial breeds of the regionally distributed hybrid Hessa 1 X Hessa 2 intended for spring industrial silkworm feedings. II. Correlations between quantitative breeding characters. Genetika Selektsiya, 22: 536-540.

Petkov, N., 1997. Study on heterosis, depression and degrees of domination in interline hybrids of silkworm moth, *Bombyx mori* L.I. technological traits of cocoons. Zhivotnov dni-Nauki, 34: 76-80.

Satenahalli, S.B., R. Govindan and J.V. Goud, 1991. Heterosis studies on cocooning, pupation, pupal weight and pupal duration in silkworm. Mysore J. Agric. Sci., 25: 338-340.

Seidavi, A., 2010a. Estimation of genetic parameters and selection effect on genetic and phenotype trends in silkworm commercial pure lines. Asian J. Anim. Vet. Adv., 5: 1-12.

Seidavi, A., 2009. Determination and comparison of nutritional indices in commercial silkworm hybrids during various instars. Asian J. Animal Vet. Adv., 4: 104-113.

Seidavi, A., 2010c. Relationship between season and efficiency of individual selection in six peanut and oval lines of silkworm. Int. J. Eng. Technol., 2: 211-214.

Seidavi, A., 2011a. Analysis of combining ability for some parameters in Iranian lines of silkworm *Bombyx mori* L. (Lepidoptera., Bombycidae). Annals Biol. Res., 2: 158-163.

Seidavi, A., 2011c. Evaluation of the genetic potential of six native strains of silkworm, *Bombyx mori* L.. Afr. J. Agric. Res., 6: 4816-4823.

Seidavi, A., Z. Mirhosseini, M. Mavvajpour, M. Ghanipoor, A. Bizhannia, A. Qotbi and M. Chamani, 2009. Additive genetic variations and selection index changes of economic traits of the silkworm commercial pure lines against parent selection pressure. Am. Eurasian J. Agric. Environ., 6: 460-665.

Seidavi, A.R., 2010b. Investigation on effect of individual selection based on cocoon weight on additive genetic value and selection index value in six commercial silkworm pure lines. World J. Zool., 5: 7-14.

Seidavi, A.R., 2011b. Analysis of biochemical divergence for classification of six native silkworm based on total cholesterol, triglycerides, high density lipoprotenins (HDL) cholesterol, low density lipoprotenins (LDL) cholesterol, total lipase and lipids. Afr. J. Microbiol. Res., 5: 2912-2919.

Seidavi, A.R., A.R. Bizhannia, M. Ghanipoor and A.A.A. Qotbi, 2008. Investigation on improvement possibility of resistance, production and reproduction traits in 3p, 2p and p generations in three japanese pure lines of silkworm *Bombyx mori* L., using individual selection in 3P generation. Asian J. Anim. Vet. Adv., 3: 443-447.

Seidavi, A.R., M.R. Gholami, A.R. Bizhannia and M. Mavvajpoor, 2004. Evaluation of heterosis, general and special combining ability for some biological characters in six silkworm lines. Proceedings of Biology in Asia International Conference, Dec. 7-10, National Institute of Education and National University of Singapore, pp: 124-125.

Shodja, J. and N. Pirani, 2005. Genetics for the Animal Sciences. 1st Edn., Tabriz University Publishing, Iran, Pages: 463.

Shon, K.W. and L. Ramires, 1999. Comparison of the variation in cocoon quality among the single, three-way and double cross hybrids in the silkworm, *Bombyx mori* L. Sericologia, 39: 15-26.

Singh, R.D., D.R. Rao, B.K. Kariappa, V. Premalatha and S.B. Dandin, 2003. Studies on analysis of combining ability in the mulberry silkworm, *Bombyx mori* L. Int. J. Indust. Entomol., 6: 107-113.

Singh, T., B. Saratchandra and G.N. Murthy, 2002. An analysis of heterosis in the silkworm, *Bombyx mori* L. Int. J. Ind. Entomol., 5: 23-32.

Tazima, Y., 1978. The Silkworm: An Important Laboratory Tool. Kodansha Ltd., Tokyo, Japan. Pages: 307.