CHAPTER - V

DISCUSSION

5.1 Seasonal Influences on Grainage Performances of Muga Silkworm :

Antheraea assama Ww. is a highly heterogeneous unique and semi-domesticated strain of Saturniidae family of Lepidopteran insect, endemic to Assam, adjacent foothills of Meghalaya, Nagaland, Arunachal Pradesh, and Mizorum; but even during favourable season 30% of the farmers fail to make full utilization of the available plantation due to shortage of seed cocoon and only quality muga silkworm seed in sufficient quantity will make possible the way for restoration of the past glory of muga culture of Assam (Samson and Barah, 1989). Findings of Sahu *et al.* (1998) also supports this view, according to them due to low yield of seed cocoons Regional Muga Research Centre cannot produce the required quantity of cocoons for production of targeted dfls for supplying to the commercial rearers. Recently Central Silk Board trying to explore muga culture in non-traditional belt like Cooch Behar and Jalpaiguri district, districts under terai region of West Bengal. Here also the principal constraint is poor supply of quality seed for full utilization of available plantation.

Seasonal variation in certain important parameters pertaining to grainage of muga silkworm in relation to temperature and relative humidity in all the six crops in Assam has been studied over five years by Sahu *et al.* (1998); profound seasonal effect of temperature and relative humidity have been observed in incubation period, hatching percentage, pupal period, coupling and oviposition.

All these reports of earlier works have stimulated to make an year-round investigation on seasonal influence on grainage performances of muga silkworm for the further evaluation in the unique agro-climatic region of the terai in Cooch Behar district with a view to bring a success in muga culture.

An analysis of the results shows that influences of environmental factors have strong reflection on fecundity and hatchability. During October – November the potential fecundity (276.60), realised fecundity (274.70) and upto 3rd days realised fecundity (217.80) are highest among the treatments which follows the performance during April – May (potential fecundity 248.20, realised fecundity 244.80 and upto 3rd days realised fecundity 200.70). During November – December and February – March the performance of egg laying in terms of potential fecundity (242.60 and 231.50

respectively), realised fecundity (238.70 and 228.00 respectively) and upto 3rd days realised fecundity (188.30 and 192.50 respectively) are better. However, October – November and November – December are the main commercial crop rearing season where silk production is the prime objective. The seed production season for the supply of seed during those main commercial crop-rearing seasons is August – September where the egg laying performance is below the above mentioned periods (potential fecundity 227.90, realised fecundity 216.30 and upto 3rd days realised fecundity 169.70 respectively). The low potential fecundity during August – September is may be due to high temperature and humidity and the less realized fecundity is due to highly significant egg retention (11.60).

Hatching percentage during October – November (97.64), November – December (96.52) and February – March (94.24) is quite satisfactory but the seed crop rearing during April – May for 2nd commercial rearing during May – June is not successful enough as the hatching percentage is very poor (42.45 %). The main seed crop-rearing season also suffers not only from low fecundity but also from low hatching percentage (60.05 %).

From the correlation studies of these observations confirm that temperature is the prime influencing extrinsic factor regarding fecundity (-0.99) and light period regarding hatchability (-0.99). Increase in temperature decrease the fecundity during August – September while increasing light period decreases the hatching percentage during August – September as well as during April – May.

As the grainage operation during April – May and August –September is the primary task for successful commercial rearing during May – June and October – November respectively, the performance during these seed crop-rearing seasons should be investigated properly. The extrinsic factors show strong negative influence on fecundity and hatchability during these two seasons and strong positive influence during October – November and February – March. Moreover, the seed multiplication seasons in summer months *i.e.* July – August and winter months *i.e.* during January – March also suffer badly due to negative influence of temperature and light period on grainage activity during these periods.

These performance should be investigated in the light of the effect of extrinsic factors on intrinsic factors for seed production taking the influence of host plants under consideration.

The intrinsic factors namely pupal period, emergence period, mating period, oviposition period and incubation period are influenced by the environmental factors. Shorter pupal period (17.65 days – 17.90 days) are observed during summer months while longer pupal period are observed during winter periods (23.80 days – 29.40 days). Pupal periods from 18.30 days – 21.40 days are observed during spring, autumn and early winter months namely February – M arch and mid October – m id Decemb er. Emergence period is higher in summer and lower in winter. Normal mating period is higher in autumn, winter and spring months while the mating period is shorter during summer months. Oviposition period is very short (3.90 - 4.40 days) during summer months and incubation period lengthens during winter months. Strong negative correlation exists between temperature and pupal period (-0.99) while light period has negative correlation with oviposition period (-0.95). However, there exists correlation between all the environmental factors and intrinsic factors as well as intrinsic factors and grainage parameters which ultimately reflects the poor performance during April – May and August – September.

Som plant shows better performance over soalu plant for both the intrinsic factors and grainage parameters during all the seasons, still fails to improve the grainage performance during April – May and August – September.

October-November has been observed the best season for seed production. But according to Assamese calendar this is the main commercial crop growing season. For stock maintenance some cocoons can be selected. Cocoons from August-September rearing are used for egg production to supply eggs during main commercial crop growing season. Though a single female can lay 216 eggs, actually 130 hatched larvae can be obtained for rearing. Another seed crop rearing season, April – May, to supply eggs during second commercial crop rearing season shows 245 eggs laid by a single female but as hatchability is very poor (42%), 104 eggs can be obtained from a single female. However, February – March (pre seed crop) shows 230 laying per female of which 216.20 eggs were hatched (94%). This difference is may be due to seasonal influence as winter months show better hatching performance as stated by Ochieng- Odero (1992) though potentiality is less due to outdoor rearing during winter as well as poor quality leaf. During June-July though potential fecundity is high (217), realized fecundity is less (177) due to egg retention inside female body might be due to high temperature, humidity and abnormal rainfall during that period (Biswas and Ray, 2005). High temperature and humidity affects the hatchability which might be the cause of obtaining poor number of hatched larva during April – May, June – July and August – September as mentioned by Thangavelu *et al.* (1988) who opines that decrease activity of sperm beyond 32^0C prevent during those period affects fertility reflecting in low hatching percentage.

So, from the over all observations it can be said that the conventional seed crop production seasons *i.e.* August – September and April – May are low productive. After critical observation it can be concluded that February – March can be utilized as a seed crop-rearing season instead of April – May that can be exploited as commercial crop rearing season instead of May – June. At the same time, October – November may be utilized as seed crop rearing season instead August – September and the main commercial crop rearing season may be shifted from October – November to November – December.

These slight modifications of rearing schedule of Assamese calendar may be suitable for terai region of West Bengal where micro climatic variation with Assam exists. Further more, to maintain the rearing schedule of Assam (if the modification is not possible), manipulation of environmental factors for seed production or utilization of cold preservation technology can be investigated.

Now, for economic success as well as synchronized rearing, selection of days up to which eggs can be collected from all the egg laying period (5-6 days) is necessary. It has been revealed from results that in all the seasons female lays highest number of eggs on first day which declines gradually. During all the seasons except June – July almost 85% eggs are laid within first three day, however, hatching percentage is above 90% within these days during October-November and February - March only. Only 43 eggs out of 278 eggs are laid during last three days of which 36 eggs are hatched during October - November. So, collection of last three days can be avoided as 232 quality eggs can be ascertained within 3 days. Likewise, during February – March only 36 eggs out of 230 eggs are laid during last 3 days of which 31 eggs are hatched. So, 193 quality eggs can be obtained within 3 days. During other seasons also, where egg layings are up to 5 days the laying of last two days ranges between 35 – 40 eggs and hatching percentage is very poor (35 – 48 %) and even nil during June – July.

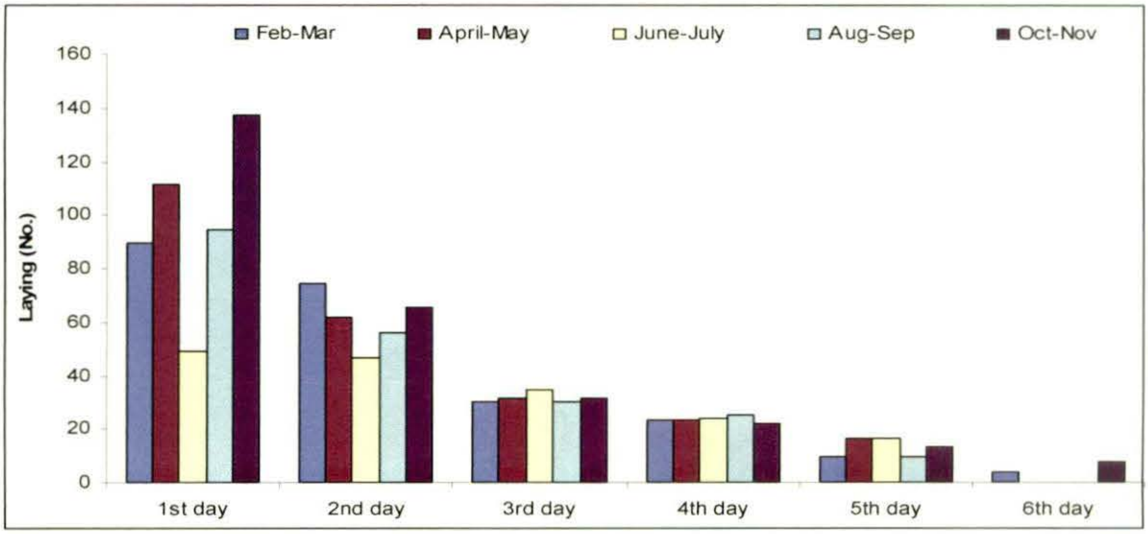

Figure 18 Effect of day and season on egg laying

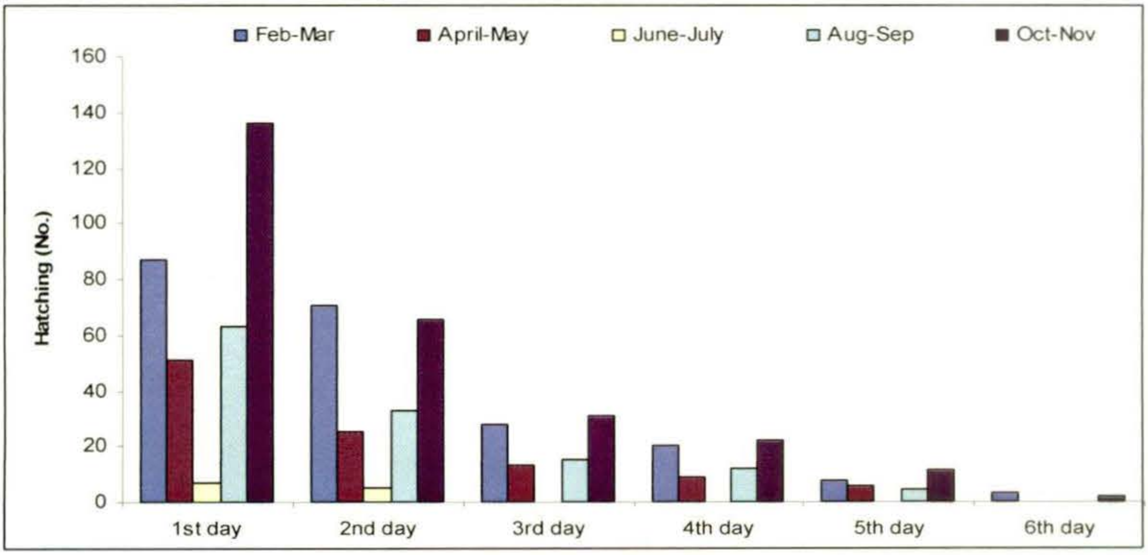

Figure 19 Effect of day and season on egg hatching

During two seed crop rearing seasons, namely April - May and August – September, 70% eggs can be collected from 3 days laying which were 205 and 181 eggs respectively of which only 89 and 111 eggs are hatched respectively. Upon collection of total laying only 104.00 and 130.00 hatched larva can be obtained during April – May and August – September respectively which are far lower than the collection of first 3 days during October – November and February – March to supply seed for commercial rearing. Moreover, this ultimately reflects in rearing hazards showing uneven rearing length and longer cocoon harvesting period as well as poor crop yield (Biswas and Ray, 2005).

So, from overall discussion it can be concluded that for supply of quality seed during commercial rearing collection of eggs from first three days (fig 18 and 19) will be effective for successful economic and synchronous rearing and it can be further suggested that February – March and October - November can be utilized as seed crop rearing period to have enough number of seeds during commercial rearing during March – April and November – December instead of May – June and October – November, which ultimately strengthens the suggestions made after observing seasonal influence on muga silkworm rearing and grainage operation.

5.2. Manipulation of abiotic factors to standardize the optimum combination responsible for seed production with higher hatchability :

Seasonal influence on muga silkworm rearing reveals that October – November is the main commercial crop rearing season which suffers badly due to poor seed supply. The seed crop rearing of October – November is August – September and after grainage operation the eggs produced as well as the hatchability of the eggs are poor. Moreover, the poor survivability rate of larvae during August – September increases the problem of low seed supply to a great extent. The second commercial crop-rearing season, May – June, though it is recommended from present study to utilize April – May as 2nd commercial season, also suffers in the similar manner. The seed produced during April – May is not sufficient enough as the survivability rate of larvae during March is poor. Furthermore, the hatchability of eggs from April – May grainage operation is very poor, even less than August – September.

This critical situation of poor seed supply during two main commercial seasons can be solved to some extent by manipulating the environmental factors namely temperature, relative humidity and photo period during egg incubation to improve hatching percentage of the laid eggs. The environmental factors cannot be manipulated during rearing as muga silkworm is in out door condition. Keeping this under consideration only a shorter but most important period of indoor grainage operation from egg incubation to hatching can be manipulated to improve the hatching percentage of the egg with an objective to increase the hatched larva for commercial rearing.

Manipulation of temperature from 15^0C to 35^0C reflects that during April – May where normal temperature is 26.65^0C manipulation of temperature to 25^0C increases the hatchability from 44.79% to 59.03% and during August – September when the normal temperature is 28.92^0C, manipulation of temperature to 25^0C increases the hatchability from 63.03% to 68.67%.

Relative humidity from 65% to above 90% manipulation shows that during April - May when normal RH is 68%, manipulation of RH to 75% increases the hatchability from 44.79% to 48.21% and during August – September when the normal RH is 77.5%, manipulation of RH to 75% can only level the normal hatching percentage while others fail.

While the temperature plays a crucial role in hatchability, where lower temperature upto 25^0C have significantly improving effect and beyond that level have adverse effect, relative humidity shows less intense effect while 85% and above 90% showed an adverse effect of humidity. This findings are in conformity with Barah *et al.* (1993) working on muga silkworm.

Combined effect of temperature and RH manipulation shows a significant improvement of hatching percentage over control as well as over individual effect of temperature and RH during both the seasons. During April – May, when 44.79% is the normal hatching percentage and 25^0C temperature individually improves it up to 59.03% as well as 75% RH improves up to 48.21%, the combined effect of temperature and RH increases it up to 73.33% where the temperature and RH are 25^0C and 75% respectively. 25^0C temperature with 85% RH also improves the hatching percentage up to 65%, surprising to note that 85% RH alone shows the adverse effect on hatching percentage. During August – September also, the combined effect of temperature and humidity improves the hatching percentage from 63.03% in normal condition or 68.67% at 25^0C temperature (75% RH maintain as per normal) to 85% where the manipulated temperature and RH are 25^0C and 75% respectively. At 25^0C, 85% RH and 65% RH also improve the hatching percentage (88% and 75% respectively). 72% hatching percentage is also obtained from manipulated the temperature at 20^0C and RH at 75%.

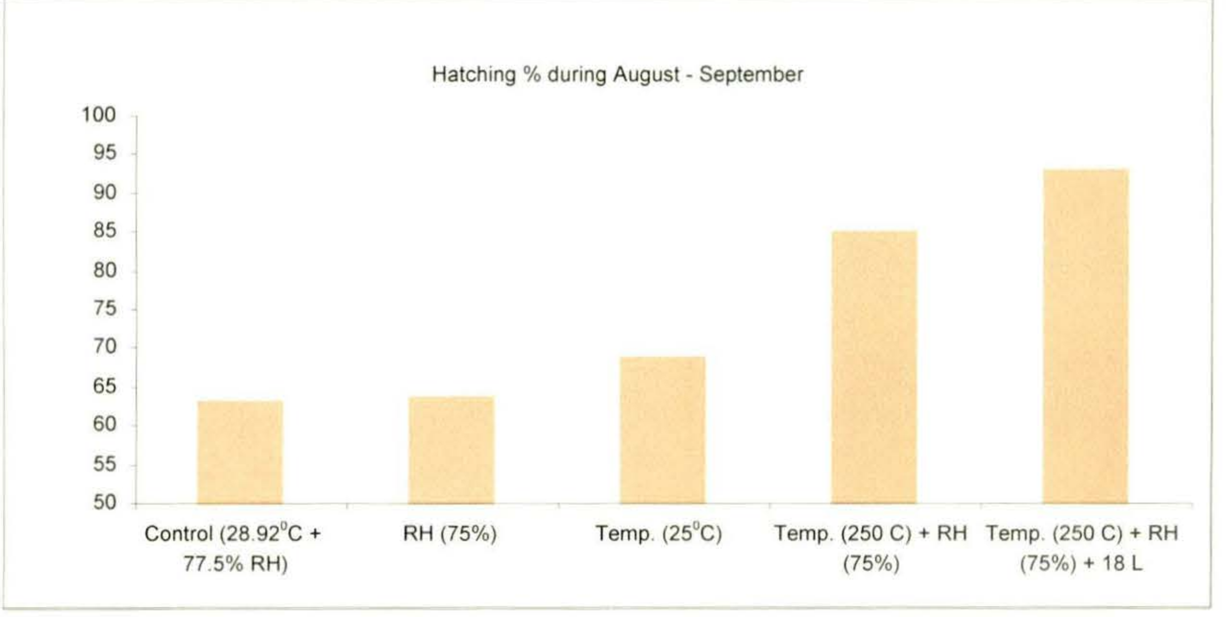

Figure 20 Effect of manipulation of temperature, relative humidity and photoperiod on hatching percentage during August – September.

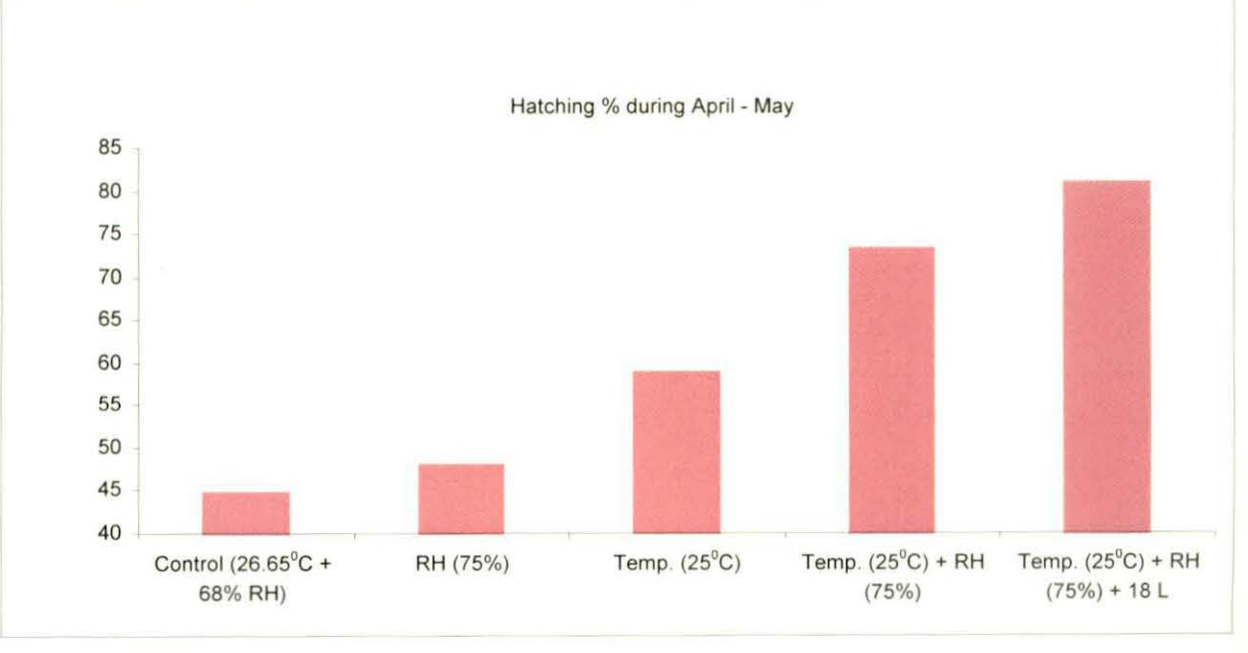

Figure 21 Effect of manipulation of temperature, relative humidity and photoperiod on hatching percentage during April - May.

Photoperiod influences the uniform and perfect hatching; eggs should be incubated under proper light regimes for better hatchability (Meenal *et al.*, 1994). The combination of temperature and RH are again manipulated with photoperiods. During April – May, where combined effect of temperature and humidity increases the hatching percentage from 44.79% to 73.33%, 12 to 18 hour light improves it with a highest of 81.07% where the manipulated temperature humidity and photoperiod are 25^0C, 75% and 18L. During August – September also, photoperiod from 12 hour to 18 hour improves the hatching percentage. The highest hatching percentage is 92.97% where the manipulated temperature, RH and photoperiods are 25^0C, 75% and 18L. 25^0C temperature along with 85% RH at 18L condition hatching percentage improves up to 91.54% also.

It can be recommended that manipulating 25^0C temperature with 75% RH and 18 hours light regimes can improve the hatching percentage to a great extent having clear conformity with the findings of Barah *et al.* (1993) according to whom 26^0C temperature with 85% RH is the incubation schedule to get 85% hatching and in the present findings adding the photoperiod at 18L condition (with 25^0C temperature and 75% RH) 93% hatching can be achieved in contrast to 63% hatching in normal condition during August – September (Figure 20) and 81.07% hatching can be achieved in contrast to 44.79% hatching in normal condition during April – May (fig. 21).

During incubation, embryonic development is influenced by temperature. Higher the temperature shorter is the incubation period. Relative humidity also influences the incubation period in similar manner but it is a less intense effect. The present findings is in conformity with Barah *et al.* (1993) working on muga silkworm and Upadhyay and Gaur, (2002) working on *Bombyx mori.*

5.3. Synchronization of male and female moth emergence and mating behaviour studies for quantitative improvement of quality seed production :

Male moth emerges earlier than the female moth. Therefore, synchronization has been proved principal constraint for egg production because asynchronous male and female moth emergence decreases coupling efficacy (Thangavelu *et al.*, 1988).

In the present investigation after seed crop rearing commercial grainage operation during March – April and September - October has been done taking 16 possible combinations of mating for four days. The coupling efficacy of freshly emerged male and female is always better than any other combination. However, up to three days old male can be coupled fresh female showing good coupling efficacy. Fecundity and hatchability decrease after two days combination.

This observation is in conformity with the findings of Rath (1998) according to whom natural mating is not possible beyond 4 days and both mating success and fertility are considerably low when mating occurs beyond 2nd day.

To overcome the situation of poor seed production short-term preservation of male and female moths have been done at 10 ± 1^0C and utilized in 16 possible combinations. Coupling efficacy has been improved from 71.27% to 90.60% in March – April and from 46.40% to 65.54% in September - October as a whole. One day preserved female shows higher coupling efficacy, fecundity and hatchability than fresh coupling. Moreover, the coupling efficacy of 3 days preserved female are also above 80%. Fecundity also increases after preservation, however, distinctive variation in hatching percentage is not so pronounced. It has been also observed that when preserved females take more crucial role than male.

The present findings are in agreement with the earlier work made by Singha *et al.*, (1994), according to whom the fecundity in general has no significant difference after refrigeration of females up to 6th day. Similar observations were also made by Tazima (1962), Ayuzama *et al.* (1972) and Jolly (1983) show that when virgin female moths are preserved for three days at 5^0C temperature reflects no significant variation. According to Gowda (1998) fecundity is reduced significantly after three days of refrigeration of female moth.

From the overall observation it can be said that during both the seasons one day preserved female coupled with fresh male or one day preserved male improves the coupling efficacy as well as fecundity and hatchability.

The hatched larva (hatching yield), the ultimate output of grainage operation, calculated (coupling efficacy x fecundity x hatching percentage) higher (23010.39) in one day preserved female coupled with fresh male than the calculated hatched larva from natural mating of similar age male and female with out preservation (1st day male coupled with 2nd day female) showing 20485.44 hatched larva and also better than even the best performing couple (fresh male and female) in normal condition showing 22221.60 hatched larva during March – April (Fig. 22).

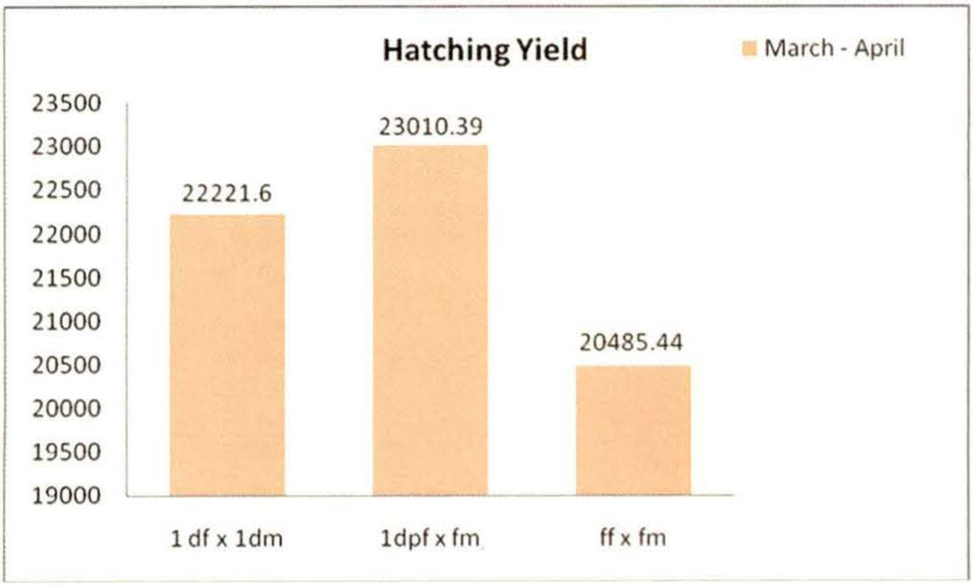

Figure 22 Comparative analysis of hatching yield in normal and preserved condition (best combination) during March – April.

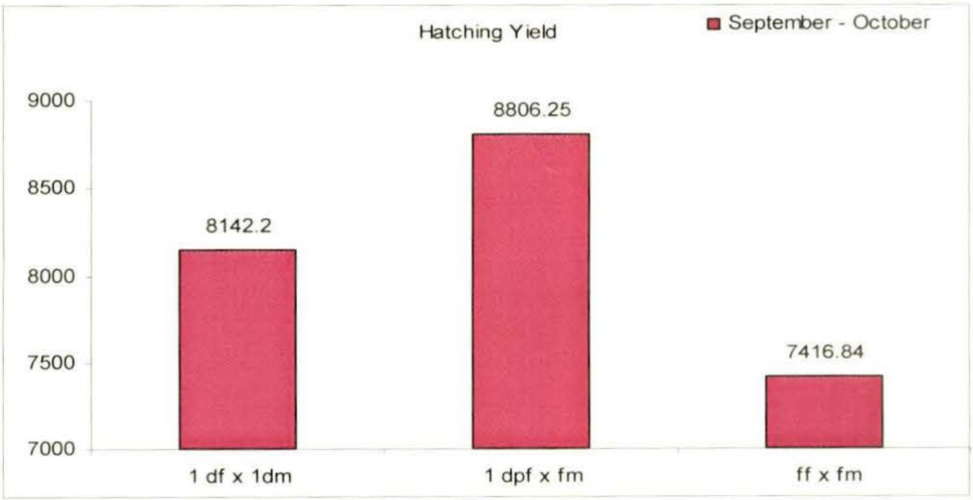

Figure 23 Comparative analysis of hatching yield in normal and preserved condition (best combination) during September - October

During September - October, the calculated hatched larva/100 coupling is also better by preservation method where the best combination (one day preserved female coupled with fresh male) shows 8806.25 number than the same age with out preservation (7416.84 in 1st day male coupled with 2nd day female) and also better than the best performing couple in normal condition (fresh male and female) showing 8142.20 hatched larva (Fig. 23).

Finally when a total of the four days coupling in normal condition and preserved condition are compared the actual reflection comes out. During March – April the calculated hatched larva/100 coupling is 20640.46 by preservation method which is more than double of the same in natural condition (9721.14) and during September - October, the difference is greater *i.e.* 7298.45 in preserved condition and 2827.62 in normal condition (Fig. 24).

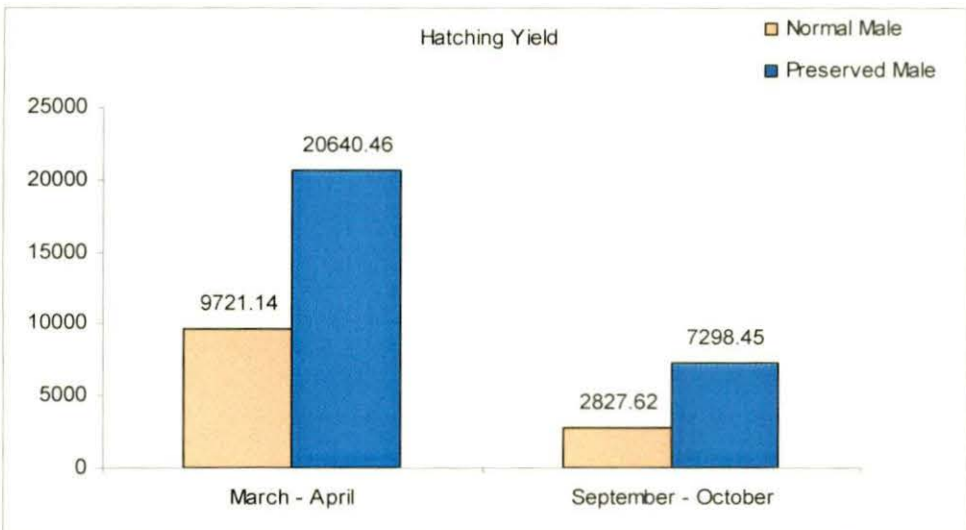

Figure 24 Comparative analysis between normal condition and preserved condition (in total of four days)

So, it can be concluded that preservation of male and female moths for 3 days and synchronization in different combinations can improve the quality seed yield to a greater extent.

Another way to overcome the constraint of asynchronous moth emergence reflecting less number of seed production is the repeated mating by exploiting the same male. For this, the optimum hours of mating should be recorded. So, in the first experiment, effect of different mating hours on egg laying and hatching have been recorded (Table – 34). Non-significant results obtained from mating hours reflects that upto 12 hours mating any duration from second hour is sufficient for successful fertilization and egg laying which confirms the observations of Samson and Barah (1989), according to whom 3-5 hours mating is sufficient. From this observation it can be suggested that minimum mating hours can be exploited and the decoupled male can be utilized for repeated mating. However, in practice mechanical injury may damage both the male and fertilized female during decoupling within 5 hours. Moreover, mating duration of 7 hours shows highest fecundity and hatchability, though the differences with others are not significant. So, mating duration can be suggested 7 hours optimum for successful mating, egg laying and hatching.

In the next experiment, repeated mating has been conducted exploiting the males for a maximum of four (4) times during March-April (Table 37) and of six (6) time during September - October (Table 38) because it has been reported that female fertility in silkworm depends upon their male mates (Sidhu *et al.,* 1967). During both the seasons though potential fecundity of the female are nearly same, repeated mating changes the egg laying and hatching. From repeated mating exploiting males upto 4 times during March-April shows that utilization of male upto 3 times have no harmful effect on fecundity as well as hatchability. During September-October also, no significant variation has been observed between the egg laying of females mated with males utilized for the 2nd, 3rd and 4th time and after that decreases significantly and hatching also decreases from single mating to 5th time mating, however, no egg hatched from 6th time utilization. Therefore, utilization of male upto 4th time during this season is effective in terms of egg laying and hatching.

Both the results have clear conformity with Benchamin *et al.* (1990), according to them in *Bombyx mori* the fecundity is comparable in the first 4 mating but reduces in 5th and 6th mating and with Ojha *et al.* (1996) trying the repeated mating in *Antheraea mylitta* where they have been found that females lay eggs even when mated with 4 x males. Repeated mating lead to inadequate discharge of spermatic fluid and result in reduced fecundity (Sidhu *et al.,* 1967). This is also reflected in terms of reduced laying and fertility percentage in the present study. Earlier studies also indicate that viability of eggs is not affected significantly upto four mating of male moths (Subramanyam, 1982).

So, in mugaculture, as synchronization of male and female is one of the principal constraints of egg production, the problem can be overcome through repeated exploitation of male moth upto four times prior to main commercial crop rearing season and upto three times before second commercial rearing by artificial coupling for seven hours which will ultimately supply higher number of quality eggs to the farmers.

5.4. Characterization of seed Cocoon

Preliminary screening of seed cocoon, based on cocoon characters namely weight, length and width, shows that when cocoon weight is selected, weight ranged between 6.50 to 8.50 g. (T_3 and T_4) gives better performance. Cocoon length between 4.50 cm. 5.50 cm (T_3 and T_4) performs better and cocoon width between 6.30 cm to 7.10 cm. shows better performance in terms of realized fecundity, laying upto three days, egg vigour and hatchability.

To perform the seed cocoon screening, one of the estimators should be selected, if possible for the farmer's point of view. With regard to that the seed cocoons are grouped under four groups namely light where weight, length and width considered as 4.50 g to 5.50 g, 3.50 cm to 4.00 cm and 5.50 cm to 5.90 cm respectively, average where weight, length and width are 5.50 to 6.50 gm, 4.00 cm - 4.50 cm and 5.90 cm to 6.30 cm respectively, moderate where weight, length and width are 6.50gm 7.50gm, 4.50 cm to 5.00 cm and 6.30 cm to 6.70 respectively cm and Heavy where weight, length and width are considered as 7.50g – 8.50g, 5.00 cm – 5.50 cm and 6.70 cm. to 6.90 cm. Results show that heavy cocoons perform best followed by moderate, average and light cocoons for all the grainage parameters.

Correlation studies showing the correlation coefficient (r) between various cocoon measurements and various grainage parameters indicate that for fecundity all the estimators have significant correlations, for hatchability weight and width have significant correlation and for egg vigour, the significant correlation has been with width only. Based on the regression equations obtained estimated value of fecundity, hatchability and egg vigour have been worked out and deviation from the mean observed fecundity, hatchability and egg vigour shows that all the estimated grainage parameters based on the weight of the cocoon is the nearest estimated values to the observed value by the least deviation. Hence, weight of the cocoon has been considered as the best estimate even though the other parameters also gives the near estimates of the observed fecundity, hatchability and egg vigour. Miller *et al.* (1982) while establishing the relation between pupal size and egg production in the case of *Antheraea polyphemus* (Gramer), indicate the pupal weight as the best estimator of the number of matured eggs. Kotikal *et al.* (1989) on *Samia Cynthia ricini* and Badhera (1992) on *Antheraea mylitta* (Drury) also have suggestion to consider pupal weight as the best estimator of fecundity. The present findings on *Antheraea assama* Westwood are in agreement with the previous study made in the other saturniids.

The distribution pattern of different weight range in male and female cocoon is reflective of normal distribution and indicates predominance of medium weight range in both male and female followed by low, lower, extreme low, high, higher and extreme high in male and low, high, lower, higher, extreme high and extreme low in female. Nagalakshmamma (1987) in *Samia Cynthia ricini* and Dubey *et al.* (2005) in *Antheraea myllita* also have similar observation.

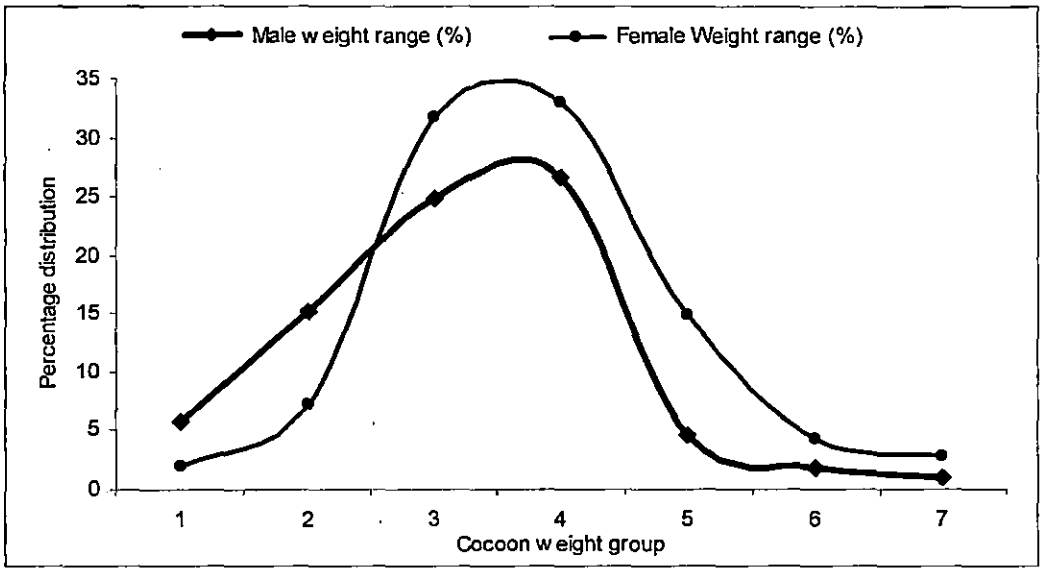

Figure 25 Sex-wise distribution pattern of seed cocoon weight group

The male and female cocoon weight classified in different groups indicate that 26.72 percent population of male cocoon weight falls in medium group which varies between 4.00-4.49 g whereas 33 percent population of female cocoon weight varies in the range of 6.00-6.49 g. The confidence interval at 95 percent reveals that the average male cocoon ranges maximum between 4.26 - 4.36 g and average female between 6.29 - 6.43 g in normally distributed population. It is evident from the normal distribution graph (figure 25) that 20.11 percent population of male and female seed cocoons both overlap each other between low, medium and high groups.

Hence, it is inferred that proper care should be taken while segregating this 20.11 percent population of male and female seed cocoons, in other groups the chances of error is negligible. Dubey *et al.* (2005) have the similar findings on tasar silkworm with 38% critical male and female population.

Cocoon weight instead of pupal weight should be selected for seed cocoon selection for farmers view taking under consideration. For that relationship between cocoon and pupal weight has been studied and correlation studies indicates highly significant and positive correlation between pupal and cocoon weight in both the sexes.

From the regression equations, it is possible to predict and estimate the pupal weight from cocoon weight. It indicates that in case of male cocoon an increase of 0.91 g in pupal weight raises the cocoon weight 1.0 g with 98% variation, whereas in case of female cocoon an increase of 0.98 g in pupal weight increases the cocoon weight by 1.0 g with 99% variation. The pupal weight is in fact the determiner / estimator of fecundity as mentioned by Kotikal *et al.*, 1989; Badhera *et al.*, 1992 and Dubey *et al.*, 2005. As there exists a highly significant positive correlation between pupal weight and cocoon weight, it may be wise to select cocoon weight as estimator of seed cocoon selection for the farmers.

Realised fecundity, hatchability and egg vigour increases with the increased cocoon weight. Extreme high female (F_7) x extreme high male (M_7), extreme high female (F_7) x higher male (M_6), higher male (M_6) and female (F_6), high female (F_6) x medium male (M_5) show better performance which reflects female cocoon weight is more determining factor than male and the combinations of high weight groups (male and female) perform better having clear conformity with Dubey *et al.* (2005) working on *Antheraea mylitta.*

From the above discussion, it can be said that cocoon weight is the best estimator of seed cocoon selection for seed (egg) production. Moreover, female cocoon is the ultimate estimator as male cocoons have non-significant positive relationship with quality egg production.

Keeping this view under consideration seven groups of female seed cocoons have been selected on the weight basis namely extreme low (T_1 : 4.50 - 4.99 g), lower (T_2 : 5.00 - 5.49 g), low (T_3 : 5.50 - 5.99 g), moderate (T_4 : 6.00 - 6.49 g), high (T_5 : 6.50 - 6.99 g), higher (T_6 : 7.00 -7.49 g) and extreme high (T_7 : 7.50 - 7.99 g). Non-significantly best performing groups are extreme high, higher and high, which means that female cocoons weighting above 6.50 g can be selected for seed production. Non-availability of these cocoons moderate and low cocoon groups *i.e.* female cocoons weighing in between 5.50 g and 6.49 g can be selected for quality seed production.

These results support the earlier investigations of Shamachary *et al.* (1980), Gowda *et al.* (1988) and Shaheen *et al.* (1992) on *Bombyx mori* ; Nagalakshmamma (1987) and kotikal *et al.* (1989) on *Samia cynthia ricini* (eri silkworm); Miller *et al.* (1982) on *Antheraea polyphemus* and Badhera (1992) and Dubey *et al.* (2005) on *Antheraea mylitta.*

5.5. Short-term cold preservation of cocoon, moth and egg of muga silkworm:

For the success of sericulture industry, proper supply of silkworm egg (seed) is essential. The hatching period of eggs must coincide with the availability of suitable leaves (Upadhyay and Pandey, 2000). Muga culture in particular needs sufficient supply of seed during commercial rearing which is far below the target (Sahu *et al.,* 1998 a, b). Main commercial rearing seasons (October – November) suffer badly due to poor supply of quality seed. Because the seed crop rearing fails (August – September) due to poor seed supply from pre seed crop rearing (June – July). From the observation during June – September rearing and grainage operations it has been found that the hatching percentage of eggs coming from June – July rearing as well as July – August rearing is very poor which is almost below 10 percent. Though during August – September the hatching percentage is high (63%) but this rearing lacks acute shortage of hatched larva from June – July.

This situation calls an investigation whether there is any possibility to skip the rearing during June – August. Therefore, the hatching of larvae has to be controlled, accelerated or postponded by artificial treatment under the refrigerated condition (Upadhyay and Pandey, 2000).

Short-term cold preservation of cocoon at 5^0C, 7^0C and 10^0C shows lengthening of the pupal period in all the temperatures which gradually decreases with the increase of temperature. Significantly moth emergence as well as coupling efficacy is better at 10^0C though fecundity and hatchability are higher from the females emerged as well as coupled after refrigerating at 5^0C and 7^0C.

From the standpoint of more number of hatched larvae, 10^0C temperature is optimum for short-term preservation of cocoon as the emergence percentage and coupling efficacies are high (figure 26) which is of clear conformity with the findings of Anderwartha *et al.* (1974) who suggest to follow 10^0C as preservation temperature globally. Thangavelu *et al.* (1985) also have better results of cocoon preservation at 10^0C at high altitude (2590 mt.).

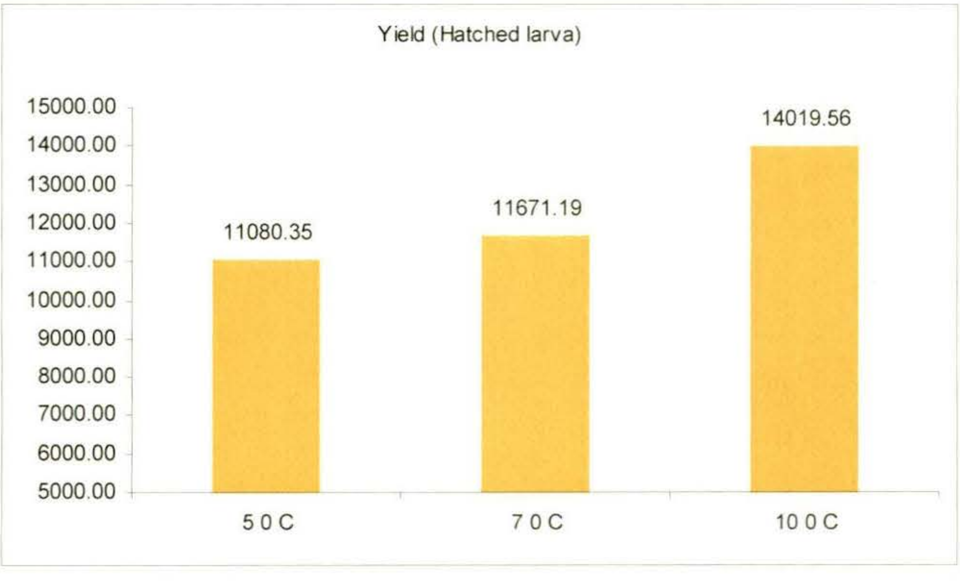

Figure 26 Effect of adult preservation on yield (hatched larva/100 coupling)

Several studies by Bora (1998) and Khanikor and Dutta (1998) also have positive observations by cold preservation from 5 – 12^{0}C.

One day cold preservation of adult at 5^{0}C, 7^{0}C and 10^{0}C shows significantly better fecundity and hatchability than control. But the coupling efficacy of the adult is significantly lower when refrigerated at 5^{0}C and 7^{0}C than refrigeration at 10^{0}C which ultimately reflects in lower number of hatched larvae (figure 27). So, from the standpoint of higher number of hatched larva, 10^{0}C temperature can be used for preservation of adult.

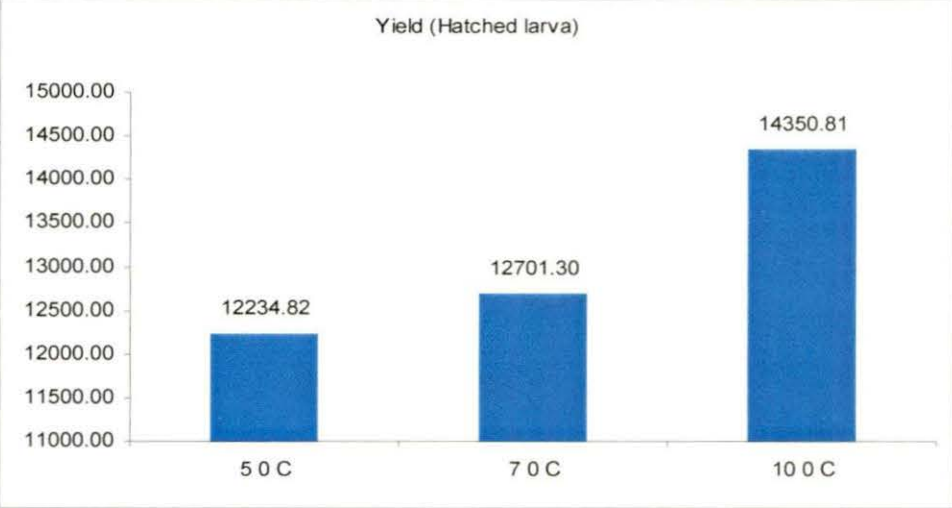

Figure 27 Effect of cocoon preservation on yield (hatched larva/100 coupling)

According to Tazima (1978) and Jolly (1983) *Bombyx mori* moths can be refrigerated at 5^{0}C for a minimum period of 7 days (for male) and 3 days (for female) for better fecundity and hatchability. In further study by Singh *et al.* (1994) refrigeration at 5^{0}C beyond 5 days should be avoided. The present study also shows the similar trend. However, at 10^{0}C temperature the muga moth can be refrigerated for 7 days with out any deleterious effect. Moreover, the coupling efficacy is also higher from the moth refrigerated at 10^{0}C which ultimately gives higher number of hatched larvae than from 5^{0}C or 7^{0}C.

The present investigation on egg preservation is based on two important aspects – age of egg and preservation temperatures as both the parameters have combined effect on hatching. Among the four age group considered (24 hours, 48 hours, 72 hours and 96 hours) eggs of 24 hours performed best in respect to delayed hatching with higher hatching percentage.

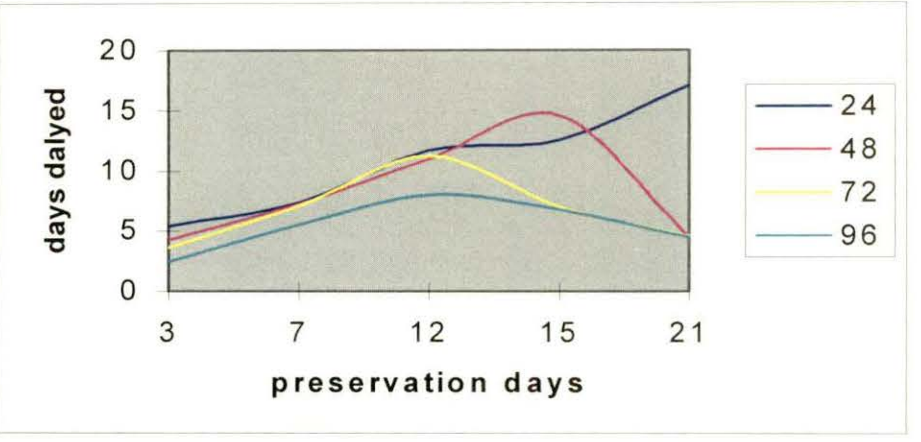

Figure 28 Effect of preservation on delayed hatching

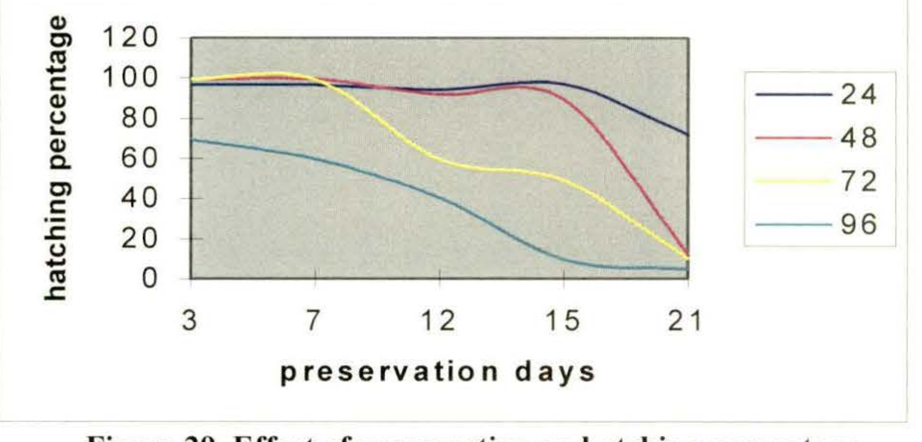

Figure 29 Effect of preservation on hatching percentage

When compared with the normal incubation period of 7 days, all the preservation period from 3 days to 21 days show longer incubation period, highest being from 21 days. Eggs of 24 hours when preserved for 21 days, hatch after 26.10 days which is 19.10 days more than normal condition and hatching percentage is also better (99.10%) than in normal condition (82%). Among all the temperature stress condition (4, 6, 8 and 10^0C), 10^0C is the optimum for 24 hours egg, 8^0C for 48 hours old, 6^0C for 72 hours old and 4^0C for 96hours old. Therefore, from the result it can be said that higher the age of eggs, higher the temperature stress required for successful cold preservation (Figure 28 and 29).

Moreover, as the age of the eggs progress preservation period become shorter. For example a minimum of 15 days for 48 hours egg and a maximum of 12 days for 96 hours eggs (Figure 30 and 31).

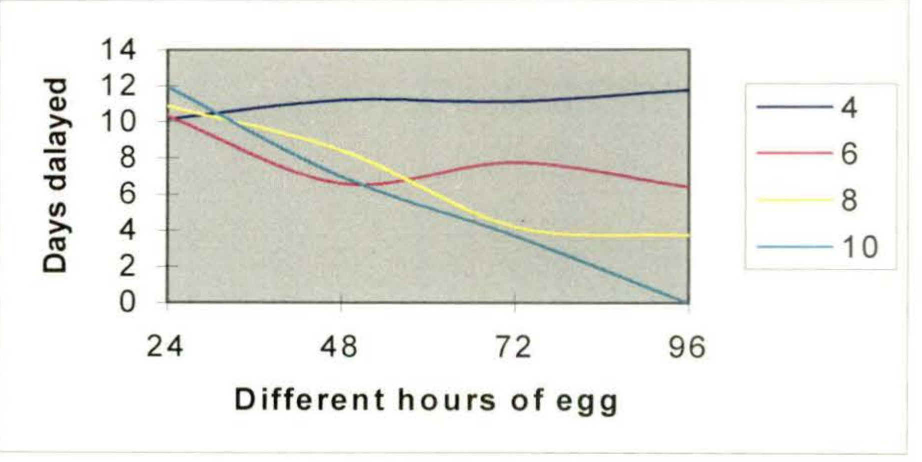

Figure 30 Effect of different hours of egg on delayed hatching

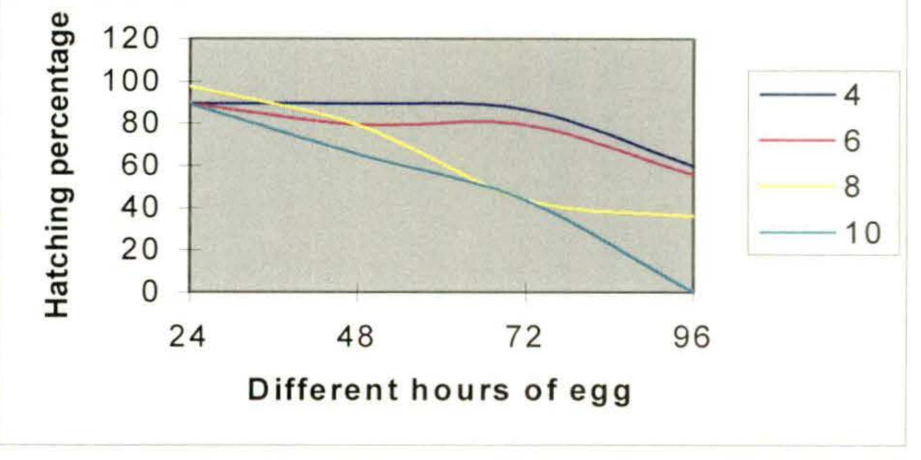

Figure 31 Effect of different hours of egg on hatching percentage

Result reflects that if 48 hours old eggs are necessary for preservation, 15 days preservation at 8^0C shows 18 days delayed hatching with higher hatching percentage. A delayed hatching with high hatching percentage of two weeks can be done by 72 hours eggs when preserved for 15 days at 6^0C. Delayed hatching (9-13 days) with satisfactory hatching percentage can be obtained from 96 hours eggs at 4^0C when preserved for a maximum of 12 days. The results have in clear conformity with the extensive studies by Dutta *et al.* (1972) on *Bombyx mori* where they observed that eggs incubated for shorter periods (up to 36 hours) are able to withstand preservation for longer period in comparison to eggs incubated for a longer period and then subjected to low temperature preservation.

So far as muga silkworm egg preservation is concern, low temperature stress on eggs can be exploited to control hatching period as and when needed. 24 hours old egg at 10^0C preserved for 21 days can delay hatching of 19 days having no deleterious effect on hatching percentage. Moreover, for older eggs longer preservation period have adverse effect on hatching and also needs higher temperature stress to get positive performance, Singha *et al.* (1998), on muga silkworm also have the similar findings where according to them cold preservation of 36 hours eggs can delay the hatching up to 36 days.

Keeping the results obtained from present experiment i.e. refrigeration of cocoon, moth and egg can delay the hatching under consideration, the attempt has been made to avoid rearing during June to August reflecting poor supply of seed during main commercial season (October – November) by refrigerating the cocoon from previous commercial crop (May – June), the subsequent adult and the eggs laid by them at 10^0C.

From the result it can be said that 15 days cocoon preservation from preceding commercial crop rearing can delay the moth emergence for 10 days, subsequent adult moth preservation for 5 days show almost no deleterious effect on fecundity and hatchability. The eggs thus obtained if preserved after 24 hours for 21 days can delay the hatching for 24 days. These results have conformity with the earlier findings of Khanikar and Dutta, (1998); Biswas and Ray, (2003), Singh *et al.* (1998) though exploration of only one stage for preservation at much lower than this experiment (10 ± 1^0C) has been made. The eggs thus brushed will be reared for supply of seed for commercial rearing. The grainage performance was also observed satisfactory.

So, by maintaining the schedule and preservation package collecting the cocoons from commercial crop of May – June the adverse seasons can be avoided as well as only 35 paisa/dfl. additional expenditure is required to supply adequate amount of healthy seed to the farmers for main commercial crop rearing during October – November. Additional electrical expenditure calculated for 20,000 dfl seed for commercial rearing which can be affordable (Table 60).

Table 60 Additional expenditure : (as electricity charge)

Input			
Cocoon Preservation (2500 cocoon)	15 days	180.00/day x 15	2700.00
Adult Preservation (90% Emergence) (@ 2200)	5 days	540.00/day x 5	2700.00
Egg Preservation (70% coupling & 210 fec.) @ 1000 dfl. Total electricity charges (Rs. 3.00 per unit)	21 days 6345.00	45.00/day x 21	945.00
Output			
Seed crop rearing dfl (having 70% hatching, 30% ERR and 230 realised fecundity)		20,000 dfl. Seed	
Additional expenditure (6345.00, 20,000) or 32 paise @ 35 paise/dfl.			

Finally, by short-term cold preservation at 10±1^{0}C a package of practice regarding the schedule of muga silkworm rearing can be formulated to overcome the environmental stress investigating all the loop and holes including the economic investigations in the following manner.

Table 61 Schedule of preservation for successful seed production

Cocoon Collection	**Commercial Crop Rearing**	:	**May-June**
	Spinning	:	9th June
Preservation	Cocoon Preservation at 10±1^{0}C	:	14th June
	Moth Emergence	:	6th July
	Moth Preservation at 10±1^{0}C	:	6th July to 11th July
	Coupling and egg laying	:	12th July to 15th July
	Egg preservation at 10±1^{0}C	:	13th July to 16th July
	Egg hatching	:	14th August to 17th August
Seed Crop Rearing	Seed crop rearing	:	14th August to 10th September
	Moth Emergence	:	29th September
	Coupling and egg laying	:	30th September to 3rd October
	Brushing for commercial rearing	:	8th October to 11th October
Main commercial rearing		:	**From 9th October**

The success of this experiment can able to provide a schedule of rearing for better supply of seed during the main commercial crop rearing during October – November (Table 61).