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Cost effective management of summer grainage (May -August) of Muga silkworm (*Antheraea assamensis* Helfer) for better performance in Garo Hills, Meghalaya

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Abstract

Seed is the sheet anchor of sericulture industry. The quality of silkworm seed may be defined as to the one where the laying are entirely free from diseases, has more numbers of viable eggs, gives uniform hatching and assures a stable crop. Muga silkworm, (*Antheraea assamensis* Helfer) is multivoltine and has several crops in a year conducted in outdoor facing all the vagaries of nature. In the traditional Muga growing area of North East India, the farmers conducted commercial Muga rearing in two crop seasons, i.e., Spring (Jethua i.e April- May) & Autumn (Kotia i.e.-October- November) but their pre seed and seed crops falls under adverse climatic condition. Hence, in this climatic condition maintaining the basic stock is very challenging. During summer the temperature raises up to 35 to 38˚C with fluctuation of temperature and humidity that interfere in the Muga seed production for Kotia commercial crop, resulted emergence of crippled moths, poor coupling aptitude and egg laying capacity, unfertilized eggs, poor embryonic development, desiccation of eggs and leads to hatching failure (*Sarkar et. al, 2018*). In these circumstances, an experiment was conducted at P-4 seed station, Mendipathar, North Garo Hills, Meghalaya by maintaining the temperature and humidity with Low cost Technology during summer grainage (May to August) for enhancement of the realized fecundity, hatching percentage and to overcome the others problems during summer grainage. Experimental data revealed that the overall performance of economic characters of grainage during summer (May to August) in the treated lot were better than the control lot.

Keywords: Seed, Grainage, Temperature, Humidity, Low cost

Introduction

Seed is the backbone of silk industry. Healthy seed production is indeed the primary requisite for conducive growth of the entire silk industry. Timely supply of superior quality of silkworm seed can alone sustain sericulture as a commercial crop in competition with other cash crops. A key factor for success of Sericulture industry is not only augmentation of silkworm food plants but timely supply of superior quality of silkworm seed to the farmers should also be ensured. The quality of silkworm seed may be defined as to the one where the layings are entirely free from diseases, has maximum nos., of viable eggs, gives uniform hatching and assures a stable crop *(Saikia et.al, 2016*). The government grainages produce only 40% of total requirement. Remaining 60% seeds are produced by the farmers themselves for their own requirement without resorting to scientific procedures *(Annual Report, MSSO-2017).* This practice gives scope for spread of dreaded silkworm disease called pebrine as microscopic examination of mother moth is never resorted or recommended package and practices were not followed by the farmers. Moreover the seed production by the farmers is inconsistent and unorganized. To produce good quality seed there must be a sound seed organization with proper elite seed multiplication net work to produce large quantities of quality commercial seed. Muga Silkworm Seed Organization (MSSO) carried out this network (from P4 to SSPC) is a stipulated and scientific way.

North Eastern part of India has a unique position in the world sericulture map for production of vanya silk especially for Muga silk production. Muga silk is the first GI registered item of Assam. Though Assam is known for Muga silk, major portion of the vanya silk produced in Assam is from eri silk. A little amount of Muga silk is also produced in Meghalaya, Arunachal Pradesh, Manipur, Mizoram and Nagaland. Muga silkworm cultivation is newly introduced in West Bengal and Uttarakhand *(Saikia et.al, 2016*). During 2018-19 in North Eastern India about 2.27 lakh families are engaged in Muga sericulture activities and area under Muga silkworm food plants is 14872 ha *(Annual Report,CSB, 2019*). In spite of the glorious history, the production of Muga raw silk is not upto the mark. The production of Muga raw silk is 169 MT during 2016-17 in India and Assam shares 68.04% of the total production (*Annual Report,CSB,2017)* but during 2018-19 the production increased up to 231.8 MT where Assam shares 68.11 *(Annual report,2019)*. Slow increase of production might be due to shortage of food plants, non-availability of good seeds *(Bindroo et.al, 2008, Kakati,2002)* pest and parasites (*Chowdhury ,1981*), diseases, abnormal changes of temperature, humidity, rainfall, wind velocity in different seasons *(Kakati L.N, 2004)*, inbreeding depression *(Chowdhury, 2005)* etc. Among these shortage of healthy seed is the main problem of Muga sericulture industry. There is always a gap between demand and supply of Muga silkworm seed. Still now the sharing of quality seed from organized sector (i.e., CSB, State Government,Register Privet graneure) is about 40% and rest of 60% seeds are supply through unorganized privet sector *(Annual Report MSSO, 2017).*

The mandate of P-4 unit is to produce quality Basic seed and supply to the sister P-3 units and various states government for further multiplication. For this, P-4 seed station has bound to conduct rearing and grainage throughout the year. It is our chalange to produce quality seed at adverse climatic seasons. Muga silkworm seed production is one of the most important activities in Muga culture. Since production of healthy seed is prime requisite for success of a seed production, it is highly essential to adopt the prescribed procedure meticulously for production of quality Muga seed. Only quality eggs ensure a good harvest and healthy crop. The quality of the seed cocoon is greatly influenced by a number of factors such as nutritious leaf, disease free layings, optimum temperature, humidity and hygienic condition. On the other hand, the embryonic development stage in silkworm is very susceptible to environmental conditions, that is, temperature, and humidity etc. and also greatly influenced by quality seed cocoons *(Choudhury, 2005)*. Studies on silkworm nutrition have established that it is the quality of food plants that ultimately reflects on growth and development of silkworm and overall silk production *(Sinha et al., 1986)*. Further, the amount, rate and quality of food consumed by a larva influences the different parameters like growth rate, developmental time, larval weight, survival and reproductive potential *(Slansky and Scriber, 1984)*. Sarkar et al. (2010) has reported that, high temperature and fluctuation of humidity in summer affect the grainage characters of Muga silkworm. The grainage (silkworm seed production centre) activities conducted in the summer season in respect of maximum and minimum temperature and relative humidity were recorded during different grainage periods. An average

temperature of 24-28^{0}C and relative humidity of 75 to 85% which was near optimum range for grainage operation (Samson and Barah, 1989). According to Engelmann (1984), relative humidity ranged from 72 to 78%, which was congenial for development of different stages of Muga silkworm during grainage.

Therefore an attempt was made to make an low cost effective mode of study to observe the seed production during summer in the control temperature , normal room temperature and humidity to evaluate performance of moth emergence pattern, ovipositional potency and behaviour, egg characters and egg hatchability percentage in two different conditions.

Materials and Methods

Grainage operation of Muga silkworm was conducted in summer season (May to August) at CSB, MSSO, P-4 seed station ,North Garo Hills, Meghalaya, India [**Location (Geographical):** Lattitude-90.34^{0}E, Longitude-25.50^{0}N, Altitude-300MSL] Seed cocoons were preserved on the bamboo made mat covered by triangular bamboo frame with net. After moth emergence male and female moth get more space for natural pairing.

4 numbers of grainages from 2019 to 2020 were conducted during high temperature in unfavorable summer climate i.e data collect from Aherua & Bhodia 2019 grainage and 2020 grainage. To minimize the temperature and optimization of Relative Humidity at low cost effective way following methods were adopted.

- **Ventilation of room:** During this period of grainage activities, door and windows are kept open for free flow of heat wave. To check the insect pest and predator, the door and windows are fitted with insect proof net .

- **Use of wet Gunny cloth:** Gunny cloths were fully dipped water in a plastic container and the wet gunny cloths were surrounded the lower portion of the moth emergence cage.

- **Rising of humidity:** Filled the concrete floor of grainage room with running water to facilitate Gunny cloths to be wet for controlling the temperature and rising humidity.

- **Use of knapsack hand sprayer**: To cool the outside and inside grainage room wall, water spray is too much necessary during middle of the day.

- **Discharge of hot air:** To maintain room temperature with aeration in the grainage room the exhausted, ceiling, stand fans were used.

- **Use of sand bed inside the grainage hall-** During this period, using the wet sand bed to reduce the temperature of the grainage room and optimization of relative humidity.

- **Use of triangular bamboo cage** – Triangular bamboo cages covered by net gives the newly emerged Muga moths enough space to fly normally and also helps in managing the natural coupling. The ideal measurement of this structure is- 6 x4x3(L x B x H). This structure can reduce the labour cost also.

During the period of grainage operation the meteorological data of the control and treated rooms were also recorded. The grainage experiment was conducted with preservation of 300 nos. of seed cocoon with 60% male and 40% female cocoons in one control and treated lot. The data on different parameters such as moth emergence pattern, percentage of healthy and invalid moth emergence, potential fecundity, realized fecundity; fertilized eggs, unfertilized eggs and hatching percentage in each treatment and controlled lots were recorded. Emerged male and female moths were paired in the triangular bamboo cage (Figure 1). After completion of 6-8 hours pairing, gravid female moths were tied in "*Kharika*" for egg laying and fecundity with hatching percentage were recorded to study the suitability of different lots.

Results and Discussion

Grainage operation in summer and different economic characters of seed production was recorded for the control and treatment lot which was presented in Tables 1-4.

Table- 1 Average Temperature and Humidity during experiment period (May to August-2019) in treated grainage room.

Sl. no.	Year	Month	Temperature (Treated)		RH% (Treated)	
			Max.	Min.	Max	Min.
1	2019	**May**	31.9	22	82.4	69.5
2		**Jun**	32	24.8	88.3	70.4
3		**July**	32	25.2	90.3	73.8
4		**Aug**	30	26	82.4	72.2

Table -2 Average Temperature and Humidity during experiment period (May to August-2019) in control grainage room

Sl. no.	Year	Month	Temperature (Control)		RH% (Control)	
			Max.	Min.	Max	Min.
1	2019	**May**	36.3	29	74.4	66.5
2		**Jun**	37.2	30.3	78.3	67.4
3		**July**	36.7	29.5	79.3	63.8
4		**Aug**	35	30.2	72.4	69.2

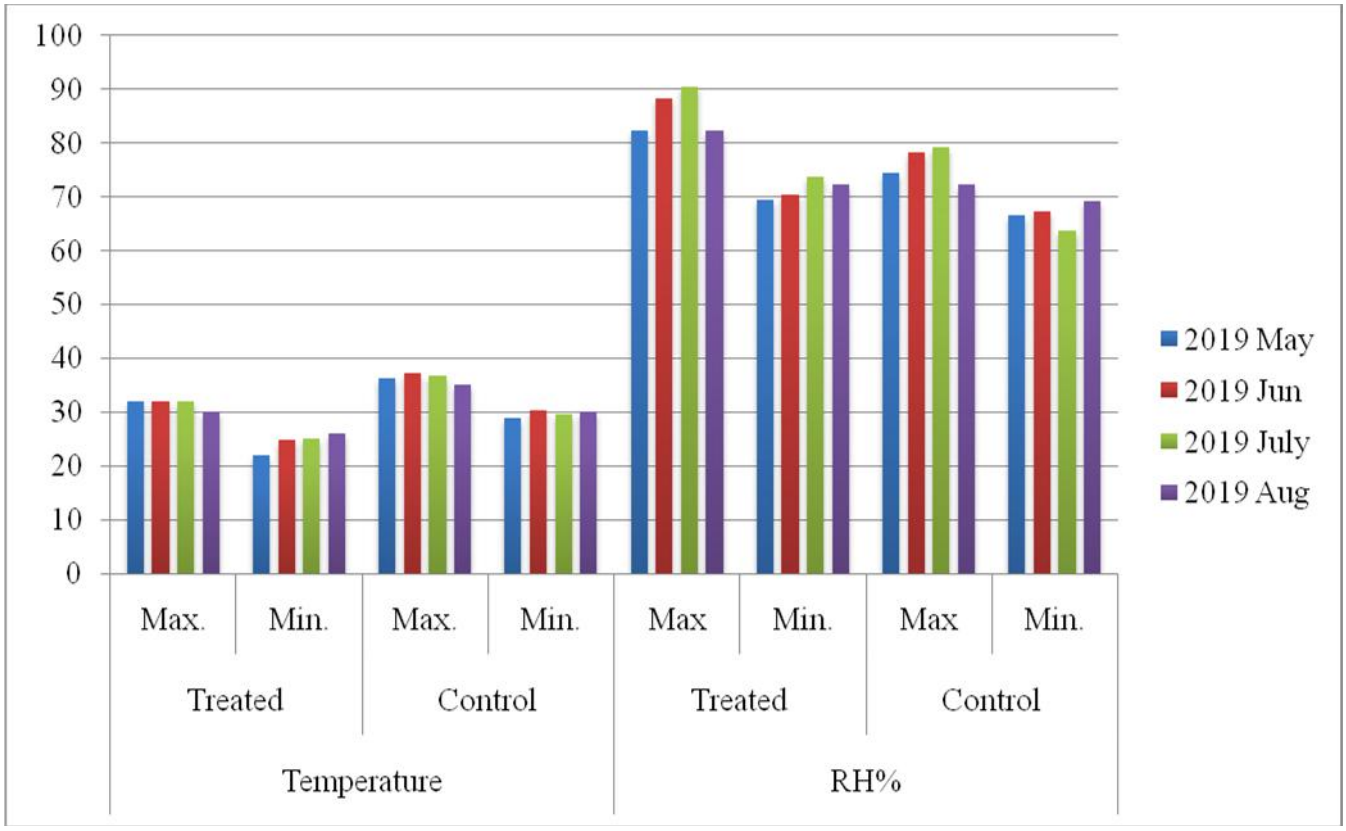

Fig 1- Difference between Temperature and Humidity in Treated and Control grainage room in the year 2019

Table- 3 Average Temperature and Humidity during experiment period (May to August-2020) in treated grainage room

Sl. no.	Year	Month	Temperature (Treated)		RH% (Treated)	
			Max.	Min.	Max	Min.
1	2020	**May**	29.8	23	86.4	73.7
2		**Jun**	30.5	25.4	91	79.7
3		**July**	29.6	25.7	92.5	84.7
4		**Aug**	31.8	27.3	90	78.5

Table - 4 Average Temperature and Humidity during experiment period (May to August-2020) in control grainage room

Sl. no.	Year	Month	Temperature (Control)		RH% (Control)	
			Max.	Min.	Max	Min.
1	2020	**May**	34.3	21	75.4	69.4
2		**Jun**	35.2	29	79.3	65.7
3		**July**	35.5	27.5	78.6	68.5
4		**Aug**	36.3	30.2	74.4	67.6

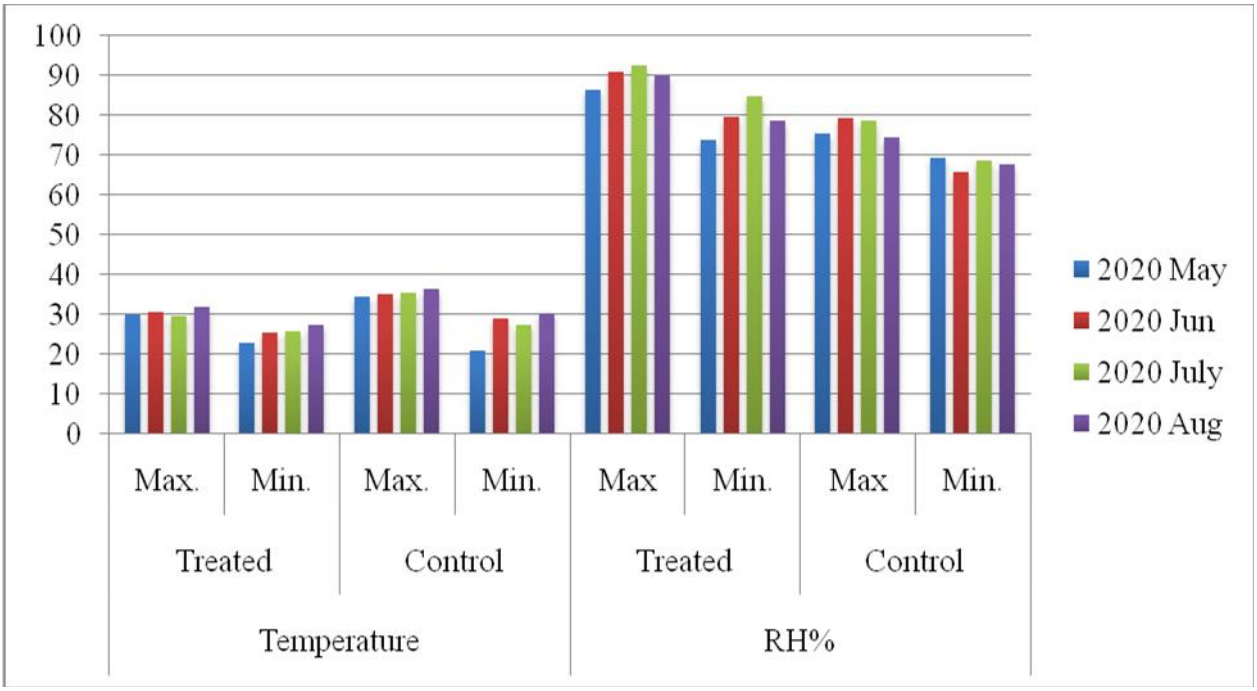

Fig 2- Difference between Temperature and Humidity in Treated and Control grainage room in the year 2020

Emergence of moth

Healthy moth

Emergence of male and female moths were found higher in treated lot than control lot in both Aherua and Bhodia grainage, where Aherua grainage , 82 % moth emergence was recorded in treated lot and it is only 69% in control lot. The percentage of healthy male moth emergence was 45% in treated lot and 37% was recorded in control lot (Table 5, Fig-5). The percentage of healthy female moth emergence was 37% in treated lot and 32% was found in control lot.

Data also recorded in Bhodia grainage i.e. 78 % moth emergence was recorded in treated lot and it is only 68% in control lot. The percentage of healthy male moth emergence was 43% in treated lot and 34% was recorded in control lot (Table 5, Fig-5). The percentage of healthy female moth emergence was 35% in treated lot and 32% was found in control lot. Cocoons remain more unmerged in control lot in both the grainage. The emergence of healthy moth was found maximum in treated lot than normal one in both Aherua and Bhodia grainage condition.

Invalid moth

During Aherua grainage the percentage of invalid male and female moth emergence was found 7% and 4% respectively in treated lot and in control lot it was 13% and 7% respectively. The data also recorded in Bhodia crops where the percentage of invalid male and female moth emergence was found 9% and 7% respectively in treated lot and in control lot it was 17% and 9% respectively. The high temperature and humidity in control lot influences normal metamorphosis of Muga pupa resulted invalid moth emergence. (Table 5, Fig-5).

Un-emerged cocoon

The percentage of un-emerged cocoons varies with the treated and control lot. The total un-emerged cocoon was found in case of treated lot is 7%, followed by 11% in control lot, this data was recorded in Aherua grainage. In Bhodia grainage it was 6% and 8% in treated and control lot respectively. Therefore it was noted that in treated conditions the required temperature and humidity by artificial method, the moth emergence increased significantly. (Table 5, Fig-5).

Table-5 Moth emergence pattern of Muga moth in treated and control environment-
(Pooled data **Aherua** (May-June) Grainage)

Parameter	Healthy male moth (%)	Healthy female moth (%)	Invalid male moth (%)	Invalid female moth (%)	Un emerged cocoon (%)
Treated	45	37	7	4	7
Control	37	32	13	7	11

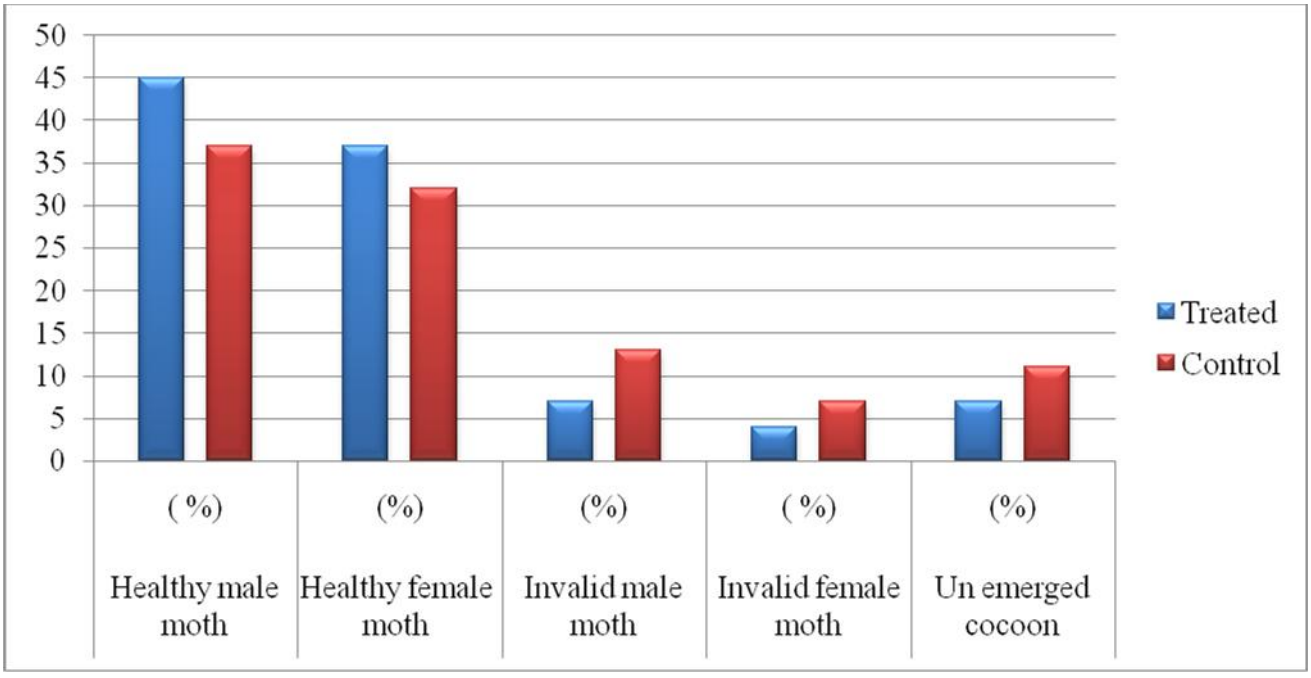

Fig 3:- Moth emergence pattern of Muga moth in treated and control environment.
(Pooled data **Aherua** Grainage)

Table - 6 Ovipositional behaviour and egg characters of Muga silkworm grainage conducted in treated and normal environment (Pooled data **Aherua** Grainage)

Parameter	Natural Coupling (%)	Mechanical coupling (%)	Realized fecundity (No)	Potential fecundity (No)	Eggs retained in ovary (No)	Nos. Of egg per gm (No)	Fertile egg (%)	Unfertile egg (%)	Hatching (%)	Desiccated and unhatched eggs (%)
Treated	85	15	195	269	74	138	82	18	74	8
Control	69	31	163	256	93	153	73	27	62	17

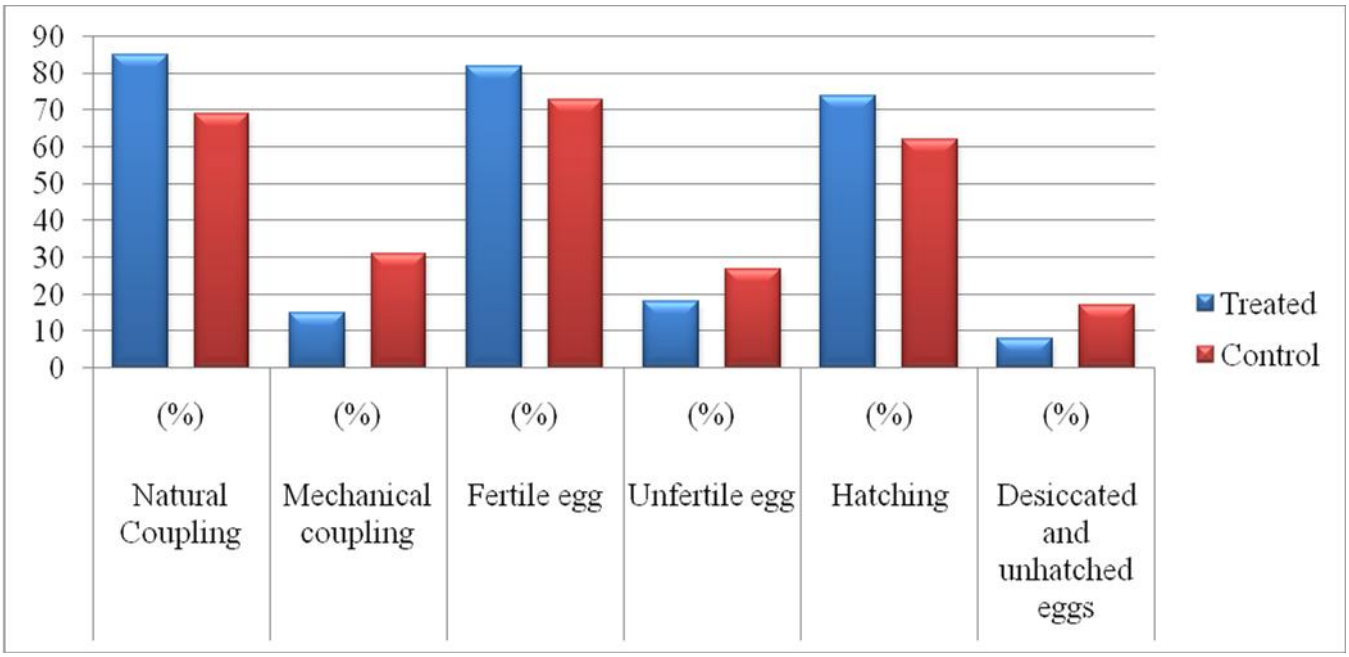

Fig 4:- Ovipositional behaviour and egg characters of Muga silkworm grainage conducted in treated and normal environment. (Pooled data **Aherua** Grainage)

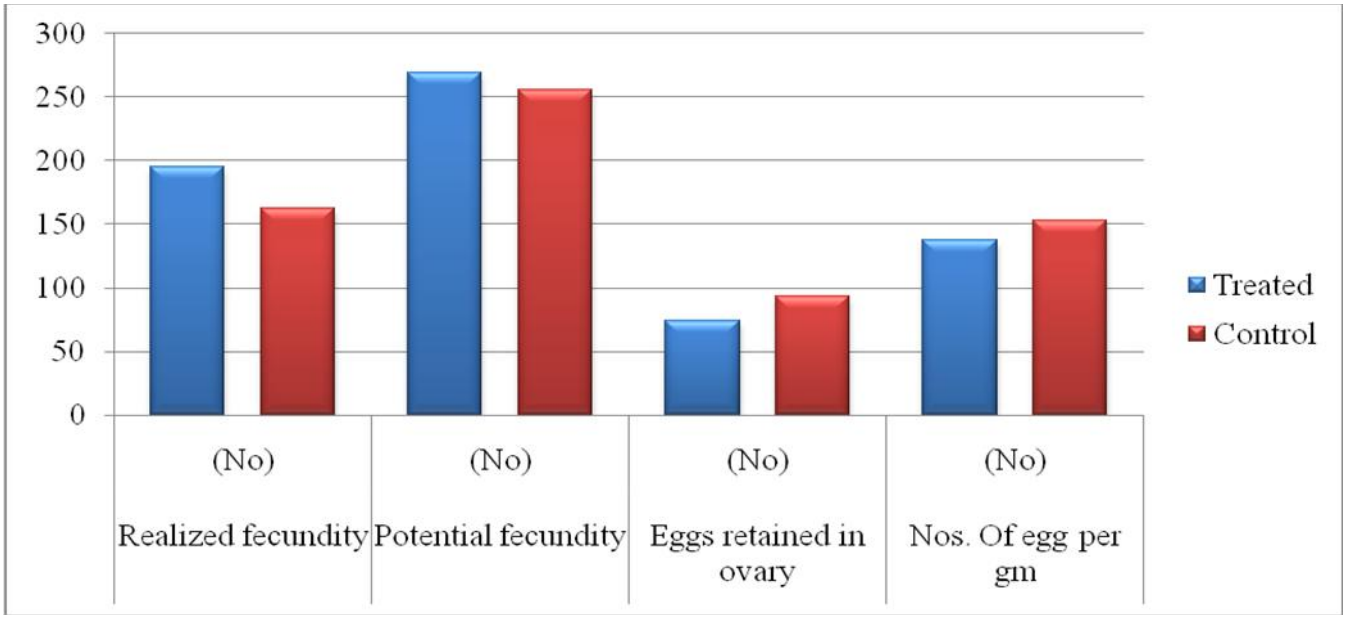

Fig 5:- Ovipositional behaviour and egg characters of Muga silkworm grainage conducted in treated and normal environment. (Pooled data **Aherua** Grainage)

Table-7 Moth emergence pattern of Muga moth in treated and control environment - (Pooled data **Bhodia** (July-August) Grainage)

Parameter	Healthy male moth (%)	Healthy female moth (%)	Invalid male moth (%)	Invalid female moth (%)	Un emerged cocoon (%)
Treated	43	35	9	7	6
Control	34	32	17	9	8

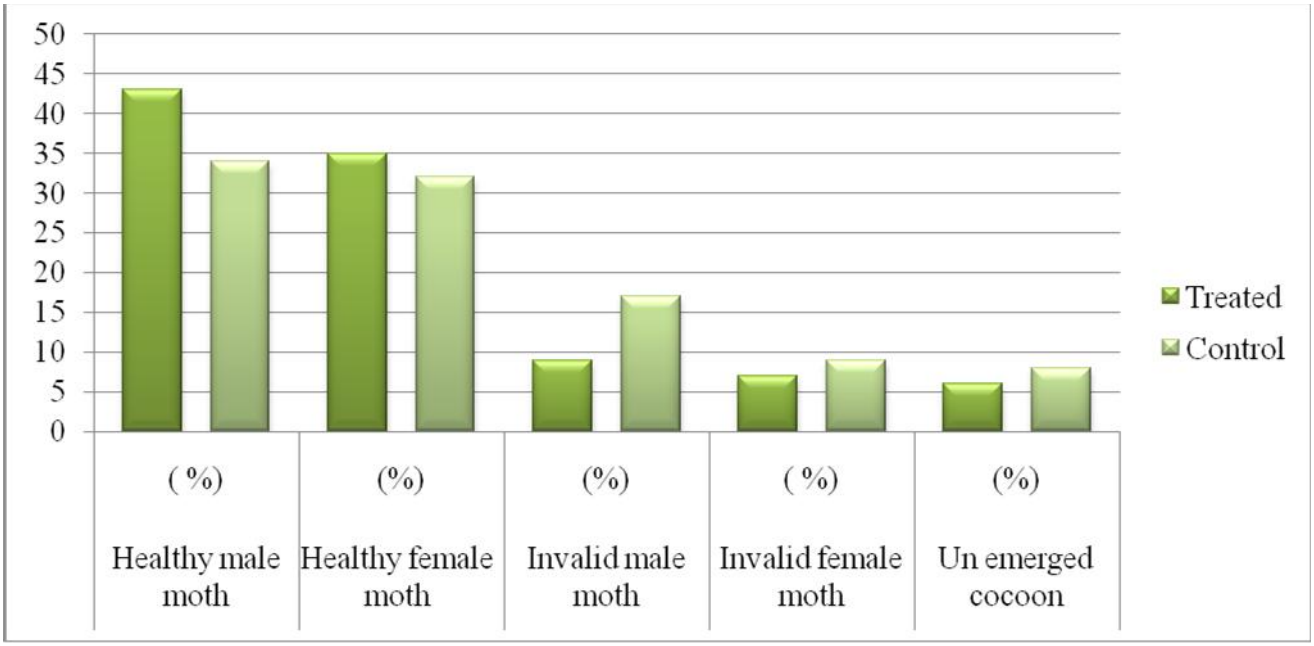

Fig 6:- Moth emergence pattern of Muga moth in treated and control environment. (Pooled data **Bhodia** Grainage)

Table - 8 Ovipositional behaviour and egg characters of Muga silkworm grainage conducted in treated and normal environment (Pooled data **Bhodia** Grainage)

Parameter	Natural Coupling (%)	Mechanical coupling (%)	Realized fecundity (No)	Potential fecundity (No)	Eggs retained in ovary (No)	Nos. Of egg per gm (No)	Fertile egg (%)	Unfertile egg (%)	Hatching (%)	Desiccated and unhatched eggs (%)
Treated	82	18	198	263	65	135	86	14	78	6
Control	67	33	171	258	87	149	74	26	67	13

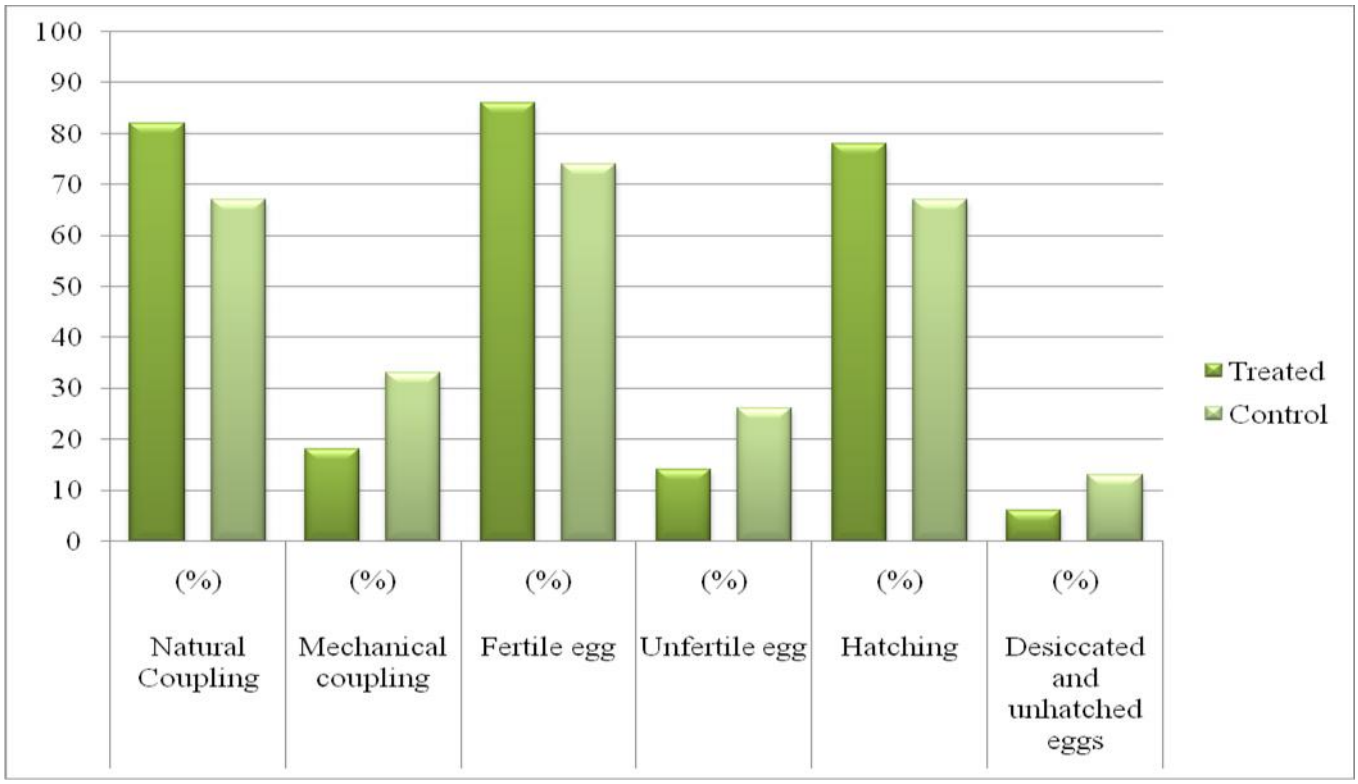

Fig 7:- Ovipositional behaviour and egg characters of Muga silkworm grainage conducted in treated and normal environment. (Pooled data **Bhodia** Grainage)

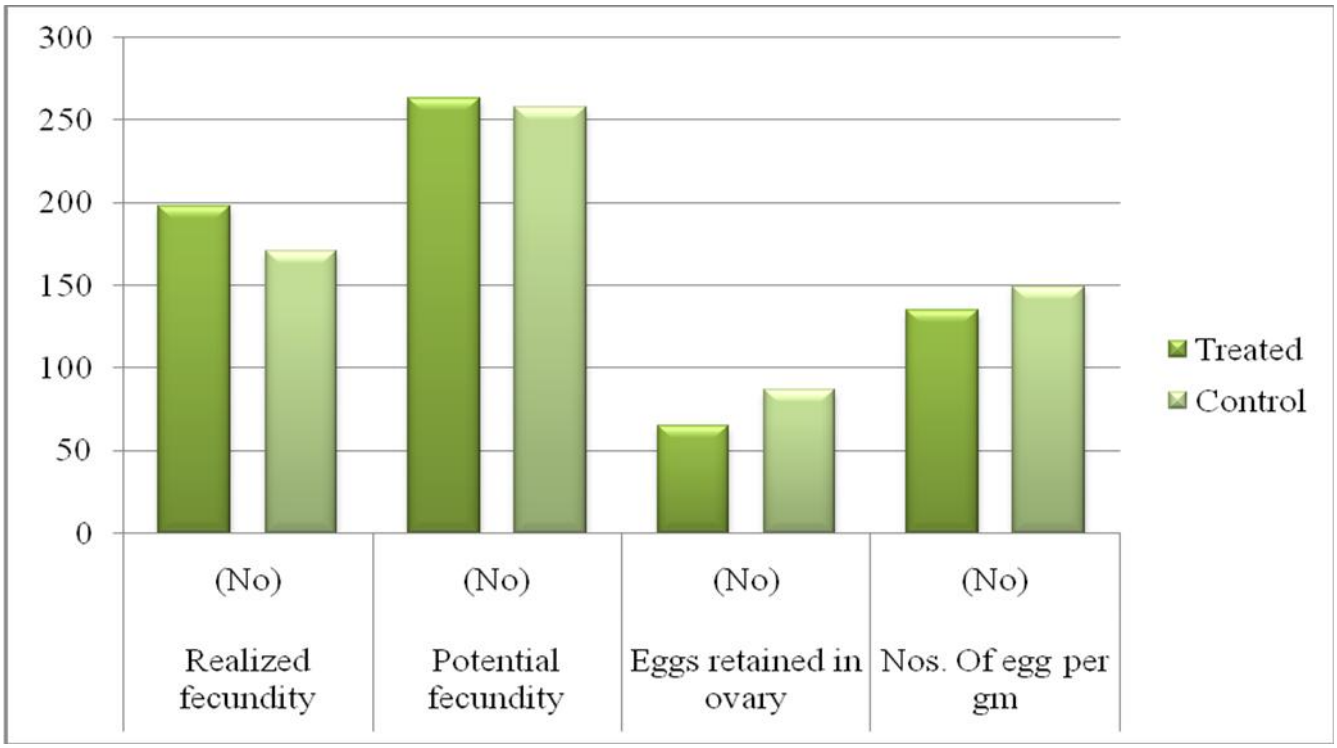

Fig 8:- Ovipositional behaviour and egg characters of Muga silkworm grainage conducted in treated and normal environment. (Pooled data **Bhodia** Grainage)

Coupling:-

Coupling behavior was different in treated and control lot of summer grainage of Muga silk moths. During Aherua grainage the natural coupling percentage was highest 85% in treated lot and lowest 69% in control lot (Table-6, Fig-4) where in Bhodia grainage it is 82% and 18% respectively. The healthy moths of both treated and control lot were naturally paired after one hour of emergence. (Table-8, Fig-7)

Fecundity:-

The effective fecundity (eggs laid) and potential fecundity (total eggs of laid and retained in ovary) were found to be highest in treated lot than control lot in both Aherua and Bhodia grainage. In the treated lot average fecundity was recorded 195 nos. and control lot 163 nos., and the average nos. of eggs retained in the ovary in treated lot is 74 and 93 in control lot in Aherua grainage (Table- 6, Fig-5). Where in Bhodia grainage the average fecundity was recorded as 198 nos. in treated lot and 171 nos. in control lot. The average no of egg retained in the ovary in treated lot is 65 and 87 in control lot was recorded in Bhodia grainage (Table-8, Fig-8).

Egg characters:-

In Aherua grainage the total number of eggs in one gram of Muga seed in treated lot showed 138 nos. comparatively higher than control lot 153 nos (Table-6, Fig-5). where in Bhodia grainage it was 135 nos and 149 nos respectively. The result indicated that healthy eggs were laid in treated lot (Table-6, Fig-8).

Plate-1: Low cost Bamboo made triangular moth coupling structure use in Treated Grainage room.

Plate-2: Using wet gunny bags and wiping the floor with cold water inside the Treated Grainage room.

Plate-3: Water is being sprayed to cool the walls and applied cold water on the verandah to maintained the optimum temperature and humidity inside the Treated Grainage room.

Plate-4: In Treated Grainage room the moth emergence and fecundity is very good and mother moth is very strong with expanded wings.

Plate-5: Inside the Control Grainage room with normal temperature and humidity condition.

Plate-4: In Control Grainage room the moth emergence and fecundity is very poor and crippled mother moths are found.

Fertile eggs (%)

The percentage of fertile eggs varies with treatment and control lot. It was found highest 82% in treated lot, followed by 73% in control lot in Aherua grainage (Table-6, Fig-4), which is more or less same in Bhodia grainage i.e 86% and 74 % at treated and control lot respectively. It indicates that the in treated condition the Muga grainage can be conducted successfully (Table-8, Fig-7).

Hatching (%)

In this study it was reported that in Aherua grainage the temperature ranging between 35 to 37°C and relative humidity less than 70% where in Bhodia the average range of temperature was recorded i.e. 34 to 36°C and relative humidity less than 65 % or fluctuation of temperature and humidity interfere the normal grainage activities. It was observed that maximum hatching percentage is in treated lot 74% and the lowest percentage 62% was recorded in control lot in Aherua grainage (Table-6, Fig-4) and in Bhodia grainage it was 78% and 67% in treated and control lot respectively. The data reveal that in treated conditions in both Aherua and Bhodia increase the hatching percentage 11- 12% (Table-8, Fig-7).

Desiccated eggs (%)

It was observed that in treated lot desiccated eggs are 8 % in control lot it is 11%, which is 3 % more in control lot in Aherua grainage (Table-6, Fig-4) .The data also recorded in Bhodia grainage i.e.6% and 13% in treated and control lot respectively (Table-8, Fig-7).

Here too it was observed that the percentage of desiccated eggs is 7% more in control lot than treated lot. The fluctuation of temperature and humidity leads to desiccation of Muga silkworm eggs and embryonic development failed in control lot also. But, it was found the overall fecundity and hatching was better in treated lot.

Conclusion

The present study indicates that taking some readily available cost effective measures, viz, using wet gunny cloths around the lower portion of the moth emergence triangular structure, wiping the concrete floor with cold water and spraying the outside and inside wall with sprayer is very effective for controlling the temperature and humidity and using of exhausted / ceiling/stand fan to maintain cross ventilation the grainage room during the period of grainage operation showed the positive performances of Muga seed production.

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