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Comparative assessment of growth and performance of bivoltine silkworm races fed on mulberry (*Morus alba*) against biological and commercial parameters of *Bombyx mori* Linn.

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Abstract

Silkworm (*Bombyx mori* L.) is basically monophagous insect feeds solely on mulberry leaves (*morus* spp.). Sericulture performs a pivotal function in economic improvement of the use with the aid of producing employment, profits, in addition to foreign exchange. For performance observe 5 mulberry silkworm races/hybrids have been evaluated at silkworm rearing at sericulture laboratory, 4 are Bivoltine and one race became multivoltine. For Bivoltine race eggs had been treated with 3% HCl for acid remedy of 1:3 ratios to break the diapauses degree. The goal of the have a look at become to examine larval period, quantity of larva left after each moulting, cocoon, pupa and shell weight and shell to cocoon ratio some of the 4 mulberry silk worm Bivoltine races. whilst evaluating the imply weight of 20 cocoon some of the silk bug races the biggest become 32.5gm (natural Mysore) and the bottom was 27.5gm (NB18 Bivoltine races). And the most important suggest weight of 20 shells and 20 shell ratio determined was 15.40 gm (natural Mysore), the lowest changed into 12.80 gm (NB18 races). For each weight of 20 cocoons and 20 pupa yellow silk worms race become considerably difference a number of the relaxation silk computer virus races. For 20 shells weight of yellow silk worm race was extensively difference the various relaxation silk worm races and there is also importance difference among NB4D2, NB18, KA and NB7 silk worm races. A silkworm race of five variety silkworm eggs is the spine of silk enterprise. Wholesome egg production is certainly the primary needful for conductive growth of entire silk enterprise. Timely supply of advanced pleasant of silkworm egg races can be maintaining sericulture as an industrial crop in opposition with different coins vegetation. There is also significance of hatchability ($p < 0.05$).

Keywords: Bivoltine, pure Mysore (multivoltine races) *Bombyx mori* Linn, cocoon, mulberry leaf garden, shell, silk worms

Introduction

Silk is the maximum fashionable fabric in the world with unheard of grandeur, herbal sheen, and inherent affinity for dyes, high absorbance, mild weight, soft touch and excessive durability and is called the queen of textiles the world over. Sericulture has been a labour in depth agro based totally industry with several sports like, meals plant cultivation, silkworm rearing, silk reeling, twisting, degumming weaving, dyeing, printing and finishing and garment manufacturing enterprise in numerous states. Sericulture is a sustainable, and agro-forestry oriented trade comprising cultivation of mulberry plant types, rearing of silkworms, and production of silk. it's miles one of the most hard work-extensive sectors and has played a crucial position in rural development and monetary increase maximum of the marketable silk round the sector is being comprised of the mulberry silkworm populace of male and female moth of *Bombyx mori* L. (Begum, A.N *et al.*, 2011; Yogananda, Murthy *et al.*, 2013) [2, 31]. *B. mori* is a basically monophagous and host plant-specific insect that feeds entirely on mulberry leaves (*Morus alba*, circle of relatives: Moracea) (Krishnaswami, S *et al.* 1978; Savithri *et al.*, 2013) [12, 25]. two styles of silk proteins have been outstanding as major components of silk cocoons, the first being fibroin a fibrous protein secreted in the lumen of the posterior silk gland of *B. mori* and the second being sericin, a natural macromolecular protein that serves as an adhesive to unite fibroin for making silk cocoons of silkworm, *B. mori* (Patil, S.P *et al.* 2017 and Sabina *et al.*, 2012) [22, 24].

Within the boom and productiveness of cocoons became tremendous in particular because of creation of high yielding silkworm breeds (Vishakanta, 2017) [28]. India has rich assets of mulberry types that are traditionally cultivated, and some exclusive sorts have been added sometimes. except the influence of environmental factors, the silk productivity is related to the amount and best of mulberry leaves (Sharad Bhatnagar *et al.*, 2008 and Nagaraju, 2002) [26, 19] dietary body structure has a crucial role in influencing the performances of different ranges of silkworm. To higher understand the chemical ecology of the insect plant relationship, analyzing the quantitative issue of nutrients within the insect is vital and except it's far very an awful lot important to modify the water supply to the crop carefully whilst the leaves are harvested in the course of silkworm (Waldbauer, 1968) [30] development of silkworm is substantially inspired by the nutrient composition of the mulberry host leaves, which is also the figuring out aspect of the excellent and races of silk (Jyothi *et al.*, 2014) [11]. The overall performance of silkworm is clear via the digestion and assimilation of the dietary substances found in mulberry leaves consequently the ordinary irrigation is the maximum crucial for efficient production of various races of mulberry silkworm (Lalfelpuii *et al.*, 2014a,b) [16-17]. The existence cycle routine of the silkworm from equal genetic stock varies notably based on nutritional fine of mulberry leaves (Rahmathulla, 2011) [21]. As such, the amount of meals ate up and the amount digested by way of the silkworms has an instantaneous effect on its physiological overall performance and silk production. Pioneering studies has proved that deficiency of sure vitamins or imbalance of nutrient at the diet impacts the digestibility and metabolic pastime of larvae (Waldbauer, 1964) [29]. Sericulture is an agro-based totally rural industry having terrific employment potential and forex profits (Bothikar *et al.*, 2014) [7] it's far the rearing of silkworm for the production of raw silk originated in China among 2600 and 2700 BC (Rahmathulla, 2012) [21]. Silk is referred to as the queen of textiles because of its glittering luster, softness, elegance and sturdiness. it is a very pricey fiber, produced via silk worms (Borisade, 2012) [6]. Silkworm is one of the maximum crucial domesticated insects where the growth and development is substantially stimulated with the aid of environmental conditions fulfillment of silkworm breeds/hybrids largely relies upon on their adaptability to the environment wherein it's miles destined to be reared. The organic as well as cocoon-associated characters are prompted through ambient temperature, rearing seasons, high-quality mulberry leaf, and genetic charter of silkworm strains. it's far a nicely mounted truth that underneath tropical situations, not like multivoltine, bivoltine are greater vulnerable to numerous stress like hot climatic situations of tropics, terrible leaf fine, and fallacious control of silkworm crop during summer season that isn't always conducive for bivoltine rearing for technologically and economically poor farmers of India (Suresh *et al.*, 2001; Lakshmi, 2007 and Begum *et al.*, 2008) [27, 15, 1]. Silkworm (*Bombyx mori* L.) is essentially monophagous insect feeds totally on mulberry leaves (*Morus species*). Its growth and development as well as cocoon and silk production totally relies upon upon the amount and exceptional of mulberry leaves (Nagaraju, 2002) [19]. The fulfillment of sericulture enterprise relies upon upon numerous factors of which the impact of the environmental elements which includes biotic

and abiotic elements is of essential importance. some of the abiotic elements, temperature performs a major function on growth and productivity of silkworm, as it is a poikilothermic (cold blooded) insect (Benchamin and Jolly, 1986) [5]. Silk performed an critical position inside the social and spiritual existence of Ethiopia from the earliest days of the kingdom of Axum. The silk turned into imported in large quantities from India, Arabia and China and saved in sizable caverns within the primary highlands of Ethiopia (Metaferia *et al.*, 2007) [18]. As a end result, failure of well timed introduction of good enough technology, a negative capacity constructing, lack of incorporated and effective extension services, and lack of discern inventory of silkworm eggs contributed lots for the much less effect around stakeholders consequently, feed flora cultivation and silkworm rearing is practiced by using a completely small number of users and reeling is done in regionally prepared handloom to reel coarse silk yarn that isn't always appropriate for the manufacturing of satisfactory fabrics. also in case no parent stock of silkworm eggs are regionally produced and as some distance as it is predicated on external deliver assets, now not simplest a high great silkworm egg is hard to be ensured however also it's far difficult to meet customer's requirement in terms of well timed shipping. The objectives of the take a look at where to assess the growth and improvement of silk worms (*Bombyx mori*) feed on mulberry leaves. To pick out adaptable, excessive yielding and pest resistant mulberry silkworm races with suited silk parameters to evaluate six distinct bivoltine and one multivoltine mulberry feeding silkworm breeds beneath perfect rearing situations. And to compare larval duration, quantity of larva left after each molting, cocoon, pupa and shell weight and shell to cocoon ratio among the seven mulberry silkworm races.

Materials and Methods

Study Site: Mulberry plants grown in garden and silkworm rearing experiments were conducted in ideal rearing in laboratory. Silkworm rearing laboratory for performance study five mulberry silkworm races/hybrids were evaluated, four of them are bivoltine and one race was multivoltine. Mulberry plant was raised simultaneously to serve as feed for the silkworms. For bivoltine race eggs were treated with 37% HCl of 1:3 ratios to break the diapauses stage. Twenty four hours prior to hatching, eggs were covered with paper to stimulate uniform embryonic growth. Eggs were exposed to light for 30 minutes on the day of hatching. Upon hatching young age instars (1st & 3rd) were fed with young shoots chopped to the size appropriate for growing larvae. Whereas late age instars (4th & 5th) were fed with medium to mature leaves. Young age larvae were fed with tender, succulent and nutritious leaves which are known to favour the growth and development of silkworms, while mature and coarse leaves were fed to larvae when they grow till ripening. Normal daily feedings of four times per day (at 8:00 AM, 11:00 AM, 2:00 PM and 5:00 PM) were given for each silkworm race. Rearing beds were cleaned every day before 1st feeding. The room temperature and relative humidity (RH) were maintained based on recommendations. Mountages were arranged timely for matured worms. Cocoon yield were harvested after seventh day from mounting. Completely Randomized Design /CRD/ with three replications were employed for this experiment. Necessary data were collected during the study period which

includes number of larvae left after each molting stage under observation (at 1st & 4th instar), total number of larvae reach full maturity, weight of ten matured larvae (gm) at 5th instars at 6 days of age, developmental period (egg, larvae, pupae & adult longevity), date of mounting, date of harvesting, fresh weight of twenty five cocoons (gm), fresh weight of shells (gm), silk shell to cocoon ratio (%), no. of eggs three female adult moth (fecundity), first date of hatching, last date of hatching.

Study Material

Silkworm rearing was conducted following the standard method under natural conditions and also at recommended temperature and humidity conditions wooden compensator made mountages was used for mounting the ripened larvae. After 48 hours of mounting, when the larvae formed hammock, the mountages were turned upside down. Cocoon harvesting was carried out on the 7th day of spinning. The cocoons were removal of soft and loose layer of silk filament and the defective ones were sorted out. Assessment was carried out on the subsequent day. The survival rate was calculated as the number of live pupae to the number of larvae treated.

Parameters Studied:

Various quantitative traits such as fecundity, cocoon weight, shell weight, silk shell to cocoon ratio, larval weight, number of larva at different stage, and larval duration were calculated. The characteristic features of the selected breeding resource materials are given below:

Silkworm breeds: The six bivoltine and one multivoltine mulberry silkworm races the races were obtained from silkworm Grainage Baharaich. The races used were bivoltine (NB4D2, NB18, KA and NB7) and multivoltine race (Yellow).

Silkworm rearing and estimation of genetic traits:

Disease free eggs from each strain were reared and cocoons were harvested and maintained until eclosion of moths. Healthy female moths emerging on the peak day of eclosion (pupal case) were allowed to mate for three to four hours and held until oviposition. The bivoltine eggs were acid treated within 20 hours after oviposition, following the method developed by Yokoyama (1962) [32] to prevent hibernation. The whole process, from silkworm egg incubation to completion of rearing activities, was carried out under hygienic conditions in a silkworm rearing laboratory thoroughly disinfected with bleaching powder and formalin solution. Two hundred worms of each race treated as one treatment and were kept in uniform size wooden tray. Silkworm rearing was conducted for each breed by feeding them the same variety of mulberry leaves from the well maintained irrigated at mulberry garden. A standard rearing procedure was adopted as recommended by (Datta, 1992) [8]. The young larvae (1st & 3rd instar) were reared at 26±1°C with 80±% RH and 12±1hrs at ideal rearing condition of late age larvae (4th and 5th instars) were maintained of fifth instar. Each group has been divided into three replicates under ideal rearing conditions. Fecundity of each race was computed by taking average number of eggs laid by single female moth of each race. Cocoons were

harvested 7–8 days later after completion of cocoon spinning. Harvested cocoons were accessed for survival to pupation. During the process of silkworm rearing, data on larvae and cocoons for the seven silk worm races (larval weight, cocoon, pupa and shell weight, and shell ratio) were collected and calculated according to the equations below:

Larval weight (gm): Mean larval weight (g) recorded for 20 randomly selected larvae at the peak of growth of fifth instar larvae from each replication. This was an indicator of the general health of the larvae.

Cocoon weight (gm): The Mean 20 cocoon weight in grams randomly chosen on the 7th or 8th day of spinning from each replication.

Shell weight (gm): The Mean 20 shell weight in grams shell randomly chosen from each replication. The shells used were the same cocoons used for the cocoon weight determination.

Pupa weight (g): The Mean 20 pupa weight in grams calculated by subtracting shell weight from cocoon weight for each replication. Pupa weight = cocoon weight –shell weight

Shell ratio (%): The total quantity of silk available from 20 cocoons was expressed as a percentage using the following equation for each replication.

Shell ratio (%) = Single cocoon shell weight (gm)/Single cocoon weight (gm) X100

Silkworm Moulting: Molting test was carried out up to 4th molt following standard rearing methods with three replications and 200 larvae replication. Tender leaves (1st & 4th larval stage) on healthy shoots were harvested and fed to young age silkworm larvae up to second molt (Benchamin and Nagaraj, 1987) [3]. Silkworm rearing was conducted under standard conditions (Krishnaswami, 1986 & 1990) [13-14]. First appearance of one larva out of molt was considered as commencement of molting (Benchamin and Anantharaman, 1990) [4].

Statistical Analysis

Data collected on various parameters were tabulated for statistical analysis. Statistical analysis was done by ANOVA. For significant ANOVA test was checked using mean separation. $p < 0.05$ and 95% Confidence interval (class interval CI) were considered significant during the analysis.

Results and Discussion

The Mean of 200 larval weights at 5th instar moulted larvae were varied in the range of 150.00 gm to 175.00 gm. The performance of different races ranges as NB4d2 (150.00 gm), NB18 (155.00 gm), KA (160.00 gm), NB7 (168.00 gm) and Pure Mysore (175.00 gm). For the mean of 20 larval weights was observed significantly superior of Pure Mysore races over the rest of races followed by NB4D2, NB18, KA and NB7. The lowest mean of 20 pupal weights was recorded in NB18 races (22.58gm) as shown in bellow.

Table 1: Performance of different silkworm races on mulberry, covering larval feeding duration, fecundity, hatchability, moulting, and cocoon yield

Mulberry Silkworm Races (Bivoltine & Multi voltine)	Larval Feeding Duration (days)	Fecundity No. eggs Laid by Female moth	Hatchability (%)	1 st instar Larvae moulted out of 200	2 nd instar Larvae moulted out of 200	3 rd instar Larvae moulted out of 200	4 th instar Larvae moulted out of 200	5 th instar Larvae moulted out of 200 (Matured)	Weight of 20 larvae (gm)	Total days taken to harvest cocoon	Weight of 20 cocoons (gm)	Weight of 20 pupae (gm)	Weight 20 shell cocoon without pupae	Weight of 20 shell to 20 cocoon Ratio (%)
NB4D2	21-22	405	84	175	170	162	158	150	190	46	30.50	23.01	5.42	13.02
NB18	21-22	350	83	180	175	165	164	155	205	52	27.50	22.58	5.33	12.80
KA	21-23	360	84	185	180	170	165	160	210	50	28.40	23.62	5.44	13.20
NB7	21-22	400	85	190	188	175	170	168	220	49	30.40	24.55	5.52	14.40
Pure Mysore (Yellow)	23-25	505	89	198	195	185	178	175	240	48	32.50	25.64	6.01	15.40

Larval duration (Days): The data on the larval duration of silkworm *Bombyx mori* L. are presented in Table Larval duration was observed in the range of 25 days to 21 days. In all bivoltine varieties (21 - 23 days) and multivoltine (yellow) race 23-25 days larval duration were recorded (from 1st instar to moulting stage). It is similar to work done by (Pakhale, 2014) [20] in India that is larval duration of mulberry silk worms observed was in the range of 21-23 days in bivoltine races and in multivoltine races ranges to 23-25 days. Daily mean temperature, photoperiod and relative humidity of rearing room during larval duration were weight of 20 shell to 20 cocoon was highest 15.40% in Pure Mysore while lowest in 12.80% NB18 race of cocoon shell ratio respectively during this rearing time. Work was carried out to evaluate rearing performance of silkworm (Gawade, 2006) [10]. As showed in the longest time in days taken for the silk worms to harvest cocoon was for Yellow silk worm races. Concerning hatchability the highest percentage observed was 90% (Pure Mysore) while the lowest hatchability was 78% (NB18). A single female moth can lay an average of maximum 505 eggs Pure Mysore race and a minimum of 350 eggs NB18 race was observed. That is, there is also no significant difference of fecundity among the silk worm races $P = 0.535$.

Means with the same letter(s) in the same column are not significantly different from each other at $P < 0.05$. As shown in mean separation of 20 cocoons, 20 pupa and 20 shell weight in gm, ANOVA test among the five mulberry silk worm races. For both weight of 20 cocoons and 20 pupa yellow silk worms race was significantly difference among the rest silk worm races ($p < 0.05$) for weight of 20 shell yellow silk worm race was significantly difference among the rest silk worm races and there is also significance difference between NB4D2 and NB18 silk worm races. The mean of 20 cocoon weight was recorded in the range of 12.80 gm to 15.40 gm. The highest was recorded in the race Pure Mysore (15.40 gm) over the rest of the races tested. Whereas, the highest mean of 20 cocoon weight was recorded in the Yellow race (15.40 gm). There is significant of cocoon weight ($P = 0.000$). The mean of 20 shell weight was recorded in the range of 5.33 gm to 6.01 gm. The highest mean of 20 shell weight was recorded in the races Pure Mysore (6.01 gm) and lowest weight in NB18 races (5.33 gm) of the races tested. There is significant of shell weight at $P < 0.05$. Cocoon weight and shell weight are the most important characters evaluated for productivity (Gaviria *et al.*, 2006) [9]. Shell weight percentage indicates the amount of raw silk can be reeled from the given quantity of fresh cocoons and shell weight percentage varies according to age and breed of silkworm. The study showed that there is significance of cocoon weight, shell weight and pupa weight among those mulberry silk worm races

($P = 0.000$). Yellow mulberry silk worm race was significantly difference among the rest silk worm races in cocoon weight, shell weight and pupa weight and there was also significance difference between NB4D2, NB18, KA and NB7 silk worm races. According to (Bothikar *et al.* 2014) [7] suggestion to increase cocoon production and to reduce labour cost, it is advisable to choose silkworm strains and mulberry variety which is suitable for particular set of a condition hence, the investigations were made to evaluate superior variety by further evaluation. As indicated in mean of 20 shell weight to 20 cocoon weight ratio percentage the maximum was 20% Pure Mysore and the minimum was NB18 race, the bivoltine races. Similar result was reported that the shell cocoon percentage of mulberry silk worm races ranges between 12.80% to 15.40%.

Conclusion

The consequences acquired from the take a look at suggests that the effectiveness multivoltine (natural Mysore) mulberry silk malicious program races for cocoon manufacturing. Sericulture industry can develop the agricultural economy of any kingdom as it's miles a part of the tradition and way of life of the nearby populace and therefore is an eco-pleasant production procedure with skilled families. Typically the ones silk computer virus races carry out well and feature right promise to make investments in this region and the environment is right for mulberry plant life. Sericulture program have to be advocated and supported by using NGOs as a terrific opportunity for supply of income generation and process advent for teenagers and women and poverty comfort in rural, city and semi urban areas of the United State America. Being the sector is new in most regions of the use of a, rearers, extension workers, urban agriculture offices, urban kids and women need to be supported in terms of schooling and sources. The findings of the present examine can form a platform for similarly studies on silkworm distinctive styles of silkworm races specifically beneath the agro meteorological conditions. Such mulberry sorts and silkworm strains may be advocated for extra field trials through rearers and can be used for sustainable boom and improvement of the sericulture industry.

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