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Comparative analysis of rearing of silkworm, *Bombyx mori* L. under different conditions

Ravi Kant, Tajamul Islam, Kamlesh Bali, Rakesh Sharma, Permendra Singh and Mohammad Iqbal Jeelani

Abstract
The silkworm, *Bombyx mori* is an important commercial insect widely reared for its silk filament used in textile industries for manufacturing of different kinds of clothes. During its rearing it also faces many challenges like diseases, pests, fluctuations in rearing temperature, relative humidity which impacts badly its growth and development. In the current study the silkworms which were reared on scientific lines following the standard package of practices recorded significantly higher rearing, cocoon and reeling parameters than those reared on traditional lines. The rearing also differed significantly with regards to various seasons and locations. The significantly higher weight of ten mature larvae, larval survival, single cocoon weight, single shell weight, shell ratio, filament length, non-breakable filament length and cocoon yield was recorded in those which followed recommended scientific methods compared to traditional ones.

Keywords: Silkworm, disease, cocoon, district, filament length

Introduction
Cocoon is an intermediate product for silk production and it has a direct bearing on the quantitative and qualitative variation in silk production. Varying soil and climatic conditions within the regions clubbed with different levels of economic conditions among the farming population and single crop system also affects the cocoon production resulting slow growth of sericulture development. Though cocoon production in Jammu division has increased to some extent in the recent past but still there is a wide gap between the actual yield obtained by the rearers and the production level actually possible with the available technology. Hence, the bottleneck of the problem is to increase the cocoon output per unit of input and thereby reduce the gaps between achievable cocoon yield at field level. Nevertheless, to produce quality cocoons, farmers need to acquire knowledge about new technologies and also show interest to adopt such technologies in the field. It is observed that most of the farmers are reluctant to adopt recommended new technologies due to various socio-economic and biotic factors. This not only results in reduced productivity but even 95 percent of total cocoons produced by the farmers do not meet the quality standards. The farmers who do not adopt such technologies would generally lose higher income in sericulture and as such fetch low dividends (Lakshmanan, 1998) [8]. It is surprising to note that on one hand there has been a big technological breakthrough in the Jammu division due to research contribution of Sericulture Development Department, Division of Sericulture SKUAST-Jammu and Central Silk Board, Miran Sahib and yet on the other hand cocoon production shows decline along with the mulberry wealth which also indicates downward trend inspite of the fact that good number of plants are planted year after year yet it can't be ignored that majority of the farmers have lost interest with mulberry raising, their planting and the silkworm rearing thereof. It is also equally true that, much importance has not been given to dissemination of technologies to the rearers and they still continue to raise cocoons through traditional methods of raising and as such do not adopt any package of practices which eventuates in decreased cocoon production/productivity and finally less remuneration thereby loss of interest from the rearers. Sericulture plays a key role in the upliftment of rural population both socially and economically (Sreenivasa and Hiriyanna, 2014) [13].

So, many sericultural technologies have been developed and their recommendations have been made to improve the productivity and quality of cocoon at farmer's level (Kushwaha & Singhvi, 2013) [7]. For enhancing the raw silk production, the development of highly productive mulberry varieties (Islam *et al.*, 2022, Islam *et al.*, 2023) [4, 5] and silkworm hybrids which are resistant to adverse climatic conditions and diseases must be ensured (Jolly *et al.*, 1987) [6]. Inspite of well-developed extension network to transfer the technologies to the farmers, there is a wide gap in productivity of the cocoon between laboratory to land due to non or partial adoption of improved sericultural technologies. As a consequence, farmers are getting very low returns due to low productivity and poor quality of cocoons as compared to other agriculture crops and therefore looking for other crops or avenues for better income and proportionate return of their labour. There are many improved technologies developed in sericulture at a fast pace in the last three decades. Proper adoption of these modified and innovative technologies by the farmers is vital for obtaining higher and better yield and thereby reducing the yield gap in cocoon production. The success of any technology largely depends on its effective adoption and utilization in the field. Providing sericulture knowledge to farmers is the need of hour for changing their attitudes, skills and adoption level which are essential components of rural development (Gowda *et al.*, 1992) [2]. The gap between the potential and actual yield in mulberry culture is very wide. One of important factor is attributed to be ignorance and non-adoption of improved recommended technologies. Now in the current research work the comparison has been made between rearing done as per recommended package of practices and traditional means to elucidate the benefits of rearing done on modern scientific lines for the overall development of farmers and sericulture industry.

Materials and Methods

The present study was carried out during the year 2019 and 2020 in three districts *viz.*, Ramban, Doda and Kishtwar districts of Jammu division, India. The 70 farmers from each district were adopted and 35 potential farmers conducted rearing according to recommended methods while 35 farmers from same district followed local methods. Within district package versus season effect was studied between the recommended practice and the local practice. Similarly, package versus season versus location effect was also studied among each district between the recommended and the local farmers. The following parameters were analysed by using formula:

Fifth instar larval duration (days)
It is the total time taken by the larva to complete fifth instar of life cycle.

Weight of ten mature larvae (g)
It is the average weight of ten mature larvae during fifth instar. It was calculated by weighing ten mature larvae on either third or fourth day of fifth instar selected randomly from the rearing shelf.

Bed spacing (worms per sq. ft)
It is calculated as the number of silkworms maintained in the bed space of one square feet.

Larval survival (%): It is defined as the number of larvae that spun cocoon from a given lot of larva.

$$= \frac{\text{No. of larva left at the end of fifth age}}{\text{Total no. of larva retained after 3rd moult in a given lot}} \times 100$$

Single cocoon weight (g)
25 male and 25 female cocoons were selected randomly from a given lot and weighed on a digital balance to determine average cocoon weight using the following formula:

$$= \frac{\text{weight of 25 male cocoon (g) + weight of 25 female cocoon (g)}}{\text{Total number of cocoons (50)}}$$

Single shell weight (g)
25 male and 25 female cocoon shells were selected randomly from a given lot and weighed on a digital balance to determine average cocoon weight using the following formula:

$$= \frac{\text{weight of 25 male cocoon shells (g) + 25 female cocoon shells (g)}}{\text{Total number of cocoons (50)}}$$

Shell ratio (%)
It is defined as average ratio of 25 male and 25 female cocoon shells to that of average cocoon weight of the same cocoons per replicate and was calculated by the following formula:

$$= \frac{\text{Average weight (g) of 25 cocoon shells of each sex}}{\text{Average weight of same no. of cocoons of each sex}} \times 100$$

Cocoon yield (Kg/oz.)
It is defined as the dry weight (Kg) of cocoon produced from an ounce of silkworm seed.

Grading of cocoons
It is fixed in the cocoon auction markets organized by State Sericulture Development Department before selling to fetch good price. The method adopted for grading of cocoons based on the number of cocoons per kilogram i.e., sample of cocoons containing 500-700 cocoons/kg (dry) fixed as A-grade cocoons.

Filament length (m)
It is the total reelable length of silk filament unwound from a single cocoon measured in meters.

$$= \frac{\text{Length of raw silk reeled (m)} \times \text{no. of cocoons maintained per end}}{\text{No. of reeled cocoons}}$$

Non-breakable filament length (m)
It is the average length of the filament that can be unwound from the cocoons without a break. It was calculated by the formula given by Sonwalker (1993) [12].

$$= \frac{\text{Total length of the filament}}{\text{Number of cocoons + Number of breaks}}$$

Filament size (denier)
Denier represents the size of fineness of yarn i.e., the weight in grams of 9000 meters of the filament and is indicative of uniformity and quality of the silk. It was calculated by the following formula:

$$= \frac{\text{Weight of filament in grams}}{\text{Length of filament in meters}} \times 9000$$

Results and Discussion

During 2019 silkworm rearing season minimum fifth instar larval duration was recorded in district Doda (7.55 days) followed by Ramban (7.58 days) and Kishtwar (7.68 days) while in 2020 rearing season it was recorded least in district Ramban (7.90 days) followed by Doda (7.91 days) and Kishtwar (7.94 days). However, season wise fifth instar larval duration was 7.24 and 7.90 days in case of autumn season while in spring it was recorded 7.98 and 7.93 days during 2019 and 2020 rearing seasons respectively. Practice wise those rearers who adopted recommended package of practices obtained fifth instar larval duration of 7.57 and 7.71 days while others who adopted local methods recorded an average of 7.65 and 8.11 days during 2019 and 2020 rearing seasons respectively. C.D. at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 1). During 2019 rearing season maximum weight of ten mature larvae was recorded in district Ramban (43.19g) followed by Doda (39.40g) and minimum in Kishtwar (39.20g) and during 2020 rearing season it was recorded highest in district Kishtwar (45.82g) followed by Doda (43.67g) and Ramban (42.07g). However, season wise weight of ten mature larvae was recorded as 37.51g and 37.81g in autumn season while it was 43.69g and 49.90g during spring in 2019 and 2020 rearing seasons respectively. Practice wise those rearers who adopted recommended package of practice obtained weight as 44.56g and 43.85g while others who adopted local methods recorded average of 36.64g and 37.24 g during 2019 and 2020 rearing seasons respectively. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 2). During 2019 rearing season minimum bed spacing was recorded in district Kishtwar (75.68 worms/sq.ft) followed by Doda (77.03 worms/sq.ft) and maximum in Ramban (77.56 worms/sq.ft) whereas during 2020 rearing season spacing was minimum recorded in district Doda (74 worms/sq.ft) followed by Kishtwar (74.50worms/sq.ft) and maximum in Ramban (83.50 worms/sq.ft). However, season wise average spacing recorded in autumn season was 77.59 worms/sq.ft & 77.66 worms/sq.ft and it was 75.91 worms/sq.ft & 77 worms/sq.ft in spring season. Practice wise those rearers who adopted recommended package of practice obtained a bed spacing of 69.04 worms/sq.ft. & 63.33 worms/sq.ft while others who adopted local methods recorded bed spacing of 84.46 worms/sq.ft. & 91.33 worms/sq.ft during 2019 & 2020 rearing seasons respectively. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 3). In 2019, silkworm rearing season, maximum larval survival (%) was recorded in district Ramban (81.88%) followed by Doda (79.13%) and minimum in Kishtwar (78.74%) during the year 2020 and during 2019 rearing season, district wise maximum was recorded in district Kishtwar (82.58%) followed by Doda (82.01%) and minimum in Ramban (78.40%) during year 2020. However, season wise larval survival of 85.50 and 84.60% was recorded in spring season and in autumn it was recorded as 74.32 and 77.40%. Practice wise those rearers who adopted recommended package of practice obtained larval survival of 86.57% while others who adopted local methods recorded an average of 73.25%. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 4). During silkworm rearing in 2019, maximum single cocoon weight was recorded in district Kishtwar (1.48g) followed by Ramban (1.45g) and least in Doda (1.40g) while in 2020 rearing season it was recorded highest in district Kishtwar (1.43g) followed by Ramban (1.41g) and Doda (1.37g). However, season single cocoon weight of 1.53g and 1.47g was recorded in spring season and 1.36g and 1.35g in autumn during 2019 and 2020 rearing seasons, respectively. Practice wise those rearers who adopted recommended package of practice obtained single cocoon weight of 1.55g and 1.49g while others who adopted local methods recorded 1.33g and 1.32g during 2019 and 2020 rearing seasons respectively. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 5). During silkworm rearing in 2019, maximum single shell weight was recorded in district Ramban and Kishtwar (0.28g) followed by Doda (0.27g) while in rearing of 2020 season it was recorded highest in district Kishtwar (0.35g) followed by Ramban (0.33g) and Doda (0.28g). However, season wise single shell weight was 0.31g and 0.31g in spring season and in autumn it was 0.25g and 0.26g during rearing season of 2019 and 2020 respectively. Practice wise those rearers who adopted recommended package of practice obtained single shell weight of 0.34g and 0.35g while others who adopted local methods recorded single cocoon weight of 0.23g during both the rearing season of 2019 and 2020. C.D at 5% depicted significant difference between the means of seasons, practices and non-significant for their interaction (Table 6). District wise, maximum shell ratio during rearing of 2019 season was recorded in district Ramban (19.44%) followed by Doda (19.17%) and minimum in Kishtwar (18.89%) while in 2020 it was maximum in district Doda (20.28%) followed by Ramban (20.14%) and Kishtwar (20.04%). However, season wise single cocoon weight was 20.22 and 21.17% in spring season and in autumn it was recorded as 18.12 and 19.14% during rearing season of 2019 and 2020, respectively. Practice wise those rearers who adopted recommended package of practice obtained shell ratio of 21.29 and 23.28% while others who adopted local methods recorded shell ratio of 17.05 and 17.03%. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 7). During silkworm rearing season of 2019, overall maximum cocoon yield of 26.23Kg/oz. per farmer was recorded in district Ramban followed by Kishtwar (24.36Kg/oz.) and minimum in Doda (23.97Kg/oz.) and during 2020 rearing season overall maximum cocoon yield was recorded in district Kishtwar (21.55 Kg/oz.) followed by Doda (20.46 Kg/oz.) and least in Ramban (14.53 Kg/oz.). However, season wise cocoon yield was 17.18 Kg/oz and 12.08 Kg/oz. in case of autumn season while in spring the cocoon yield was 32.53 Kg/oz and 25.73Kg/oz. during 2019 and 2020 rearing seasons respectively. Practice wise those rearers who adopted recommended package of practice obtained cocoon yield of 32.39 kg/oz. and 23.58 kg/oz. while others who adopted local methods recorded on average of just 17.32 Kg/oz. and17.53 kg/oz (Table 8). during 2019 and 2020 rearing seasons. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction. (Table 9) revealed difference in cocoon grades with respect to districts and seasons. In district Ramban, only 11% of respondents produced A-grade cocoons followed by Kishtwar (8.02%) and Doda (6%) during spring season. In autumn season, 4.30% of rearers in district Doda followed by

Ramban (3.22%) and (3.15%) Kishtwar harvested A-grade cocoons. The overall results of A-grade quality cocoon crop in three districts stood at 8.34% during spring and 3.55% in autumn. Overall, B-grade quality cocoons in the three districts during spring and autumn rearing was recorded as 55.79 and 30.47%, respectively. Overall C-grade quality cocoons in the three districts during spring and autumn rearing was recorded as 22.36 and 42.85% respectively. Overall D-grade quality cocoons in the three districts during spring and autumn rearing was recorded as 13.50 and 23.12%, respectively. District wise maximum filament length (m) during rearing season in 2019 was recorded in district Kishtwar (779.20 m) followed by Doda (774.25 m) and minimum in Ramban (770.75 m) and in 2020 rearing season it was recorded highest in district Ramban followed by Doda (658.63 m) and Kishtwar (653.73 m) respectively. However, season wise filament length was maximum in spring season (811.66 m and 678.94 m) and minimum in autumn (737.80 m and 647.08 m) during 2019 and 2020 rearing season respectively. Practice wise those rearers who adopted recommended package of practice obtained filament length of 856.89 m and 735.67 m while others who adopted local methods recorded filament length of 692.58 m and 590.36 m during rearing season of 2019 and 2020 respectively. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 10). Maximum non-breakable filament length (m) during rearing season of 2019 was recorded in district Doda (691.20 m) followed by Ramban (670.38 m) and Kishtwar (662.76 m) while in 2020, it was recorded highest in district Ramban (660.42 m) followed by Doda (660.13 m) and Kishtwar (641.50 m). However, season wise non-breakable filament length was maximum in spring season (702.60 m and 680.11 m) and minimum in autumn (646.95 m and 627.91 m) during rearing season of 2019 and 2020 respectively. Practice wise those rearers who adopted recommended package of practice recorded non-breakable filament length of 761.47 m and 717.67 m while others who adopted local methods recorded non-breakable filament length of 588.08 m 590.36 m during rearing season of 2019 & 2020 respectively and C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 11). Minimum filament size during rearing season of 2019 was recorded in district Doda (2.46) followed by Ramban (2.49) and Kishtwar (2.49) whereas in 2020 maximum filament size was recorded in district Doda (2.47) followed by Ramban (2.50) and Kishtwar (2.55). However, season wise filament size was minimum in autumn (2.40 & 2.46) season and maximum in spring (2.57 and 2.55) during rearing season of 2019 & 2020 respectively. Practice wise those rearers who adopted recommended package of practice obtained filament size of 2.42 and 2.46 while others who adopted local methods recorded filament size of 2.54 and 2.56 during rearing season of 2019 and 2020 respectively. C.D at 5% depicted significant difference between the means of seasons, districts, practices and their interaction (Table 12). In the present study, single cocoon weight with respect to districts was highly significant with maximum shell ratio percentage of 25.47% in cocoons of district Kishtwar during spring rearing season 2020-21. The overall grade of 'A' cocoon in the three districts among the local rearers was only 8.34% in spring and 3.55% in autumn. The reasons for lower percentage of 'A' grade cocoon particularly in autumn was high temperature and high humidity resulting into quick withering of leaves fed to the worms and as a result they spin uneven small sized cocoons. Maximum filament length (972m) and non-breakable filament (846.85m) recorded during spring season 2019-20 in district Kishtwar and Doda respectively indicated the built-up and quality of cocoons. These results are must for better price of produce in cocoon market. A wide gap in the cocoon yield was recorded for season and method of practice adopted. This gap may be due to various factors in the form of various biotic and abiotic factors that hindered the potential cocoon production. The gap in seasonal production of cocoon may be due to variations in various abiotic factors such as temperature and humidity, leaf availability, shortage of seed etc. and biotic factors like prevalence of various pests and diseases. High temperature and humidity during autumn rearing in subtropical areas of district Doda and Ramban leads to higher incidence in diseases mainly grasserie and flacherie. Occurrence of diseases especially in autumn has a direct relationship with various rearing conditions prevailing in reared dwelling type of rearing houses especially irregularities in maintenance of microclimatic conditions and hygiene which leads to outbreak of these diseases. Our results are in conformity with the findings of Rao *et al*. (1995) [10], Vijaykumari *et al.* (2001) [14], Singhal *et al*. (2003) [11], Illahi & Nataraju (2007) [3] and Balvenkatasubbaiah *et al.* (2014) [1] who reported that rearing of silkworms under unhygienic conditions without following the scientific methods of rearing deteriorates the silkworm health by outbreak of certain diseases and finally causes huge losses to farmers by decreasing the cocoon yield. The results are also supported by Qadir *et al.* (2023) [9] who stated that innovations and investment in technology, promotion of these technologies and conduction of training programs can contribute significantly for the development of sericulture.

Table 1: Fifth instar larval duration (Days)

Year	Seasons	2019			2020		
Districts		Practices			Practices		
		P0	P1	Sub Means	P0	P1	Sub Means
D1 Ramban	Spring (S1)	8.07	7.78	7.93	8.28	7.58	7.93
	Autumn (S2)	7.27	7.21	7.24	7.96	7.77	7.87
	Sub Means	7.67	7.50	7.58	8.12	7.68	7.90
D2 Doda	Spring (S1)	8.06	7.79	7.93	8.14	7.66	7.90
	Autumn (S2)	7.16	7.20	7.18	7.96	7.86	7.91
	Sub Means	7.61	7.50	7.55	8.05	7.76	7.91
D3 Kishtwar	Spring (S1)	8.06	8.07	8.07	8.44	7.45	7.95
	Autumn (S2)	7.25	7.33	7.29	7.90	7.95	7.93
	Sub Means	7.66	7.70	7.68	8.17	7.70	7.94
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		7.58	7.55	7.68	7.90	7.91	7.94
	Seasons	S1	S2		S1	S2	
		7.98	7.24		7.93	7.90	

	Practices	P0	P1		P0	P1	
		7.65	7.57		8.11	7.71	
CD(p≤0.05)		Districts (D) = 0.01 Seasons (S) = 0.13 Practices (T) = 0.02 D □ S = 0.11 D □ T = 0.02 S □ T = 0.13 D □ S □ T = 0.18			Districts (D) = 0.02 Seasons (S) = 0.06 Practices (P) = 0.01 D □ S = 0.09 D □ P = 0.01 S □ P = 0.07 D □ S □ P = 0.10		

Table 2: Weight of ten mature larvae (g)

Year		2019			2020		
Districts	Seasons	Practices			Practices		
		P0	P1	Sub Means	P0	P1	Sub Means
D1 Ramban	Spring (S1)	41.14	51.57	46.36	38.55	56.50	47.53
	Autumn (S2)	35.75	44.30	40.03	30.56	42.68	36.62
	Sub Means	38.45	47.94	43.19	34.56	49.59	42.07
D2 Doda	Spring (S1)	40.22	44.59	42.41	42.55	52.80	47.68
	Autumn (S2)	32.86	39.93	36.40	33.66	45.66	39.66
	Sub Means	36.54	42.26	39.40	38.11	49.23	43.67
D3 Kishtwar	Spring (S1)	36.93	47.64	42.29	46.33	62.66	54.50
	Autumn (S2)	32.92	39.32	36.12	31.80	42.50	37.15
	Sub Means	34.93	43.48	39.20	39.07	52.58	45.82
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		43.19	39.40	39.20	42.07	43.67	45.82
	Seasons	S1	S2		S1	S2	
		43.69	37.51		49.90	37.81	
	Practices	P0	P1		P0	P1	
		36.64	44.56		37.24	43.85	
CD(p≤0.05)		Districts (D) = 1.77 Seasons (S) = 3.54 Practices (T) = 1.58 D □ S = 1.12 D □ T = 1.27 S □ T = 1.33 D □ S □ T = 1.89			Districts (D) = 1.62 Seasons (S) = 2.11 Practices (P) = 1.27 D □ S = 1.18 D □ P = 1.16 S □ P = 1.28 D □ S □ P = 1.75		

Table 3: Bed spacing (worms per sq. ft)

Year		2019			2020		
Districts	Seasons	Practices			Practices		
		P0	P1	Sub Means	P0	P1	Sub Means
D1 Ramban	Spring (S1)	87	69.50	78.25	102	71	86.50
	Autumn (S2)	83.26	70.46	76.86	98	63	80.50
	Sub Means	85.13	69.98	77.56	100	67	83.50
D2 Doda	Spring (S1)	81.44	69.26	75.35	90	59	74.50
	Autumn (S2)	88.36	69.05	78.71	92	55	73.50
	Sub Means	84.90	69.16	77.03	91	57	74
D3 Kishtwar	Spring (S1)	83.36	64.92	74.14	80	60	70
	Autumn (S2)	83.38	71.04	77.21	86	72	79
	Sub Means	83.37	67.98	75.68	83	66	74.50
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		77.56	77.03	75.68	83.50	74	74.50
	Seasons	S1	S2		S1	S2	
		75.91	77.59		77	77.66	
	Practices	P0	P1		P0	P1	
		84.46	69.04		91.33	63.33	
CD(p≤0.05)		Districts (D) = 0.21 Seasons (S) = 1.03 Practices (T) = 1.39 D □ S = 1.33 D □ T = 1.18 S □ T = 1.46 D □ S □ T = 1.79			Districts (D) = 0.18 Seasons (S) = 0.79 Practices (P) = 1.10 D □ S = 0.21 D □ P = 1.07 S □ P = 1.28 D □ S □ P = 1.63		

Table 4: Larval survival (%)

Year		2019			2020		
Districts	Seasons	Practices			Practices		
		P0	P1	Sub Means	P0	P1	Sub Means
D1 Ramban	Spring (S1)	84	92	88	77.17	85.66	81.42
	Autumn (S2)	66	85.50	75.75	60.45	90.33	75.39
	Sub Means	75	88.75	81.88	68.81	88	78.40
D2 Doda	Spring (S1)	81.50	87.50	84.5	80.33	89.66	85
	Autumn (S2)	64	83.50	73.75	71.50	86.55	79.03
	Sub Means	72.75	85.50	79.13	75.92	88.10	82.01
D3 Kishtwar	Spring (S1)	77.50	90.50	84	82.20	92.56	87.38
	Autumn (S2)	66.52	80.42	73.47	67.08	88.50	77.79
	Sub Means	72.01	85.46	78.74	74.64	90.53	82.58

Factor Means	Districts	D1	D2	D3	D1	D2	D3
		81.88	79.13	78.74	78.40	82.01	82.58
	Seasons	S1	S2		S1	S2	
		85.50	74.32		84.60	77.40	
	Practices	P0	P1		P0	P1	
		73.25	86.57		73.12	88.88	
CD(p≤0.05)		Districts (D) = 0.11 Seasons (S) = 3.03 Practices (T) =1.22 D □ S = 0.77 D □ T = 1.03 S □ T = 2.44 D □ S □ T = 3.12			Districts (D) = 0.02 Seasons (S) = 1.05 Practices (P) = 0.52 D □ S = 0.33 D □ P = 1.05 S □ P = 1.11 D □ S □ P = 1.22		

Table 5: Single cocoon weight (g)

Year		2019			2020		
Districts	Seasons	Practices			Practices		
		P0	P1	Sub Means	P0	P1	Sub Means
D1 Ramban	Spring (S1)	1.39	1.68	1.54	1.36	1.59	1.48
	Autumn (S2)	1.29	1.43	1.36	1.30	1.39	1.35
	Sub Means	1.34	1.56	1.45	1.33	1.49	1.41
D2 Doda	Spring (S1)	1.36	1.57	1.47	1.35	1.48	1.42
	Autumn (S2)	1.26	1.39	1.33	1.29	1.36	1.33
	Sub Means	1.31	1.48	1.40	1.32	1.42	1.37
D3 Kishtwar	Spring (S1)	1.42	1.71	1.57	1.39	1.61	1.50
	Autumn (S2)	1.28	1.49	1.39	1.24	1.49	1.37
	Sub Means	1.35	1.60	1.48	1.32	1.55	1.43
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		1.45	1.40	1.48	1.41	1.37	1.43
	Seasons	S1	S2		S1	S2	
		1.53	1.36		1.47	1.35	
	Practices	P0	P1		P0	P1	
		1.33	1.55		1.32	1.49	
CD(p≤0.05)		Districts (D) = 1.02 Seasons (S) = 0.11 Practices (T) = 0.13 D □ S = 0.10 D □ T = 0.11 S □ T = 0.12 D □ S □ T = 0.16			Districts (D) = 0.05 Seasons (S) = 0.13 Practices (P) = 0.15 D □ S = 0.11 D □ P = 0.13 S □ P = 0.10 D □ S □ P = 0.18		

Table 6: Single shell weight (g)

Year		2019			2020		
Districts	Seasons	Practices			Practices		
		P0	P1	Sub Means	P0	P1	Sub Means
D1 Ramban	Spring (S1)	0.25	0.39	0.32	0.24	0.36	0.30
	Autumn (S2)	0.19	0.30	0.25	0.21	0.33	0.26
	Sub Means	0.22	0.35	0.28	0.23	0.35	0.28
D2 Doda	Spring (S1)	0.25	0.35	0.30	0.25	0.37	0.31
	Autumn (S2)	0.20	0.28	0.24	0.21	0.29	0.25
	Sub Means	0.23	0.35	0.27	0.23	0.33	0.28
D3 Kishtwar	Spring (S1)	0.24	0.37	0.31	0.25	0.41	0.33
	Autumn (S2)	0.21	0.29	0.25	0.19	0.32	0.26
	Sub Means	0.23	0.33	0.28	0.22	0.37	0.30
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		0.28	0.27	0.28	0.33	0.28	0.35
	Seasons	S1	S2		S1	S2	
		0.31	0.25		0.31	0.26	
	Practices	P0	P1		P0	P1	
		0.23	0.34		0.23	0.35	
CD(p≤0.05)		Districts (D) = ns Seasons (S) = 0.03 Practices (T) = 0.09 D □ S = ns D □ T = ns S □ T = ns D □ S □ T = ns			Districts (D) = 0.01 Seasons (S) = 0.03 Practices (P) = 0.05 D □ S = ns D □ P = ns S □ P = ns D □ S □ P = ns		

Table 7: Shell ratio (%)

Year		2019			2020		
Districts	Seasons	Practices			Practices		
		P0	P1	Sub Means	P0	P1	Sub Means
D1 Ramban	Spring (S1)	17.99	23.21	20.60	17.65	22.64	20.15
	Autumn (S2)	15.57	20.97	18.27	16.54	23.74	20.14
	Sub Means	16.78	22.09	19.44	17.10	23.19	20.14
D2 Doda	Spring (S1)	18.38	22.29	20.34	18.25	25	21.63
	Autumn (S2)	15.87	20.14	18.01	16.54	21.32	18.93

	Sub Means	17.13	21.22	19.17	17.40	23.16	20.28
D3 Kishtwar	Spring (S1)	17.78	21.63	19.71	17.99	25.47	21.73
	Autumn (S2)	16.67	19.46	18.07	15.20	21.48	18.34
	Sub Means	17.23	20.55	18.89	16.60	23.48	20.04
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		19.44	19.17	18.89	20.14	20.28	20.04
	Seasons	S1	S2		S1	S2	
		20.22	18.12		21.17	19.14	
	Practices	P0	P1		P0	P1	
		17.05	21.29		17.03	23.28	
CD(p≤0.05)		Districts (D) = 0.09 Seasons (S) = 1.81 Practices (T) = 0.17 D □ S = 0.11 D □ T = 0.13 S □ T = 0.16 D □ S □ T = 1.32			Districts (D) = 0.06 Seasons (S) = 1.03 Practices (P) = 0.14 D □ S = 0.13 D □ P = 0.12 S □ P = 0.15 D □ S □ P = 0.87		

Table 8: Cocoon yield (Kg)

Year	**Seasons**	**2019**			**2020**		
Districts		**Practices**			**Practices**		
		P0	**P1**	**Sub-Means**	**P0**	**P1**	**Sub-Means**
D1 Ramban	Spring (S1)	22.37	48.50	35.44	21.90	35.50	28.70
	Autumn (S2)	10.40	23.66	17.03	11.64	9.55	10.59
	Sub Means	16.39	36.08	26.23	16.77	22.53	14.53
D2 Doda	Spring (S1)	25.88	36.33	31.11	24.28	31.75	28.15
	Autumn (S2)	11.18	22.50	16.84	12.14	13.66	12.90
	Sub Means	18.53	29.42	23.97	18.21	22.71	20.46
D3 Kishtwar	Spring (S1)	22.74	39.33	31.04	24.36	36.33	30.35
	Autumn (S2)	11.36	24	17.68	10.84	14.66	12.75
	Sub Means	17.05	31.67	24.36	17.60	25.50	21.55
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		26.23	23.97	24.36	14.53	20.46	21.55
	Seasons	S1	S2		S1	S2	
		32.53	17.18		25.73	12.08	
	Practices	P0	P1		P0	P1	
		17.32	32.39		17.53	23.58	
CD(p≤0.05)		Districts (D) = 0.05 Seasons (S) = 0.02 Practices (T) = 0.03 D □ S = 0.08 D □ T = 0.06 S □ T = 0.07 D □ S □ T = 0.13			Districts (D) = 0.01 Seasons (S) = 0.02 Practices (P) = 0.01 D □ S = 0.05 D □ P = 0.03 S □ P = 0.05 D □ S □ P = 0.09		

Table 9: Grading of cocoons

Parameter		**Ramban**		**Doda**		**Kishtwar**		**Overall**	
		Spring (n=75)	**Autumn (n=41)**	**Spring (n=75)**	**Autumn (n=32)**	**Spring (n=75)**	**Autumn (n=27)**	**Spring (n=225)**	**Autumn (n=100)**
Grade	A	11.00	3.22	6.00	4.30	8.02	3.15	8.34	3.55
	B	68.00	32.96	46.40	23.45	52.98	35.00	55.79	30.47
	C	16.5	42.16	34.60	42.55	16.00	43.85	22.36	42.85
	D	4.50	21.66	13.00	29.70	23.00	18.00	13.50	23.12

Table 10: Filament length (m)

Year	**Seasons**	**2019**			**2020**		
Districts		**Practices**			**Practices**		
		P0	**P1**	**Sub-Means**	**P0**	**P1**	**Sub-Means**
D1 Ramban	Spring (S1)	691	896	793.50	580.66	780	680.33
	Autumn (S2)	710.67	785.33	748	598	748	673
	Sub Means	700.84	840.67	770.75	589.33	764	676.67
D2 Doda	Spring (S1)	698	908	803	545	760	652.50
	Autumn (S2)	685	806	745.50	626.5	703	664.75
	Sub Means	691.5	857	774.25	585.75	731.50	658.63
D3 Kishtwar	Spring (S1)	705	972	838.50	672	736	704
	Autumn (S2)	665.81	774	719.91	520	687	603.50
	Sub Means	685.41	873	779.20	596	711.50	653.75
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		770.75	774.25	779.20	676.67	658.63	653.75
	Seasons	S1	S2		S1	S2	
		811.66	737.80		678.94	647.08	
	Practices	P0	P1		P0	P1	
		692.58	856.89		590.36	735.67	
CD(p≤0.05)		Districts (D) = 10.55 Seasons (S) = 23.43 Practices (T) = 42.51 D □ S = 50.77 D □ T = 48.64 S □ T = 57.32 D □ S □ T = 59.77			Districts (D) = 8.71 Seasons (S) = 17.34 Practices (P) = 32.34 D □ S = 37.59 D □ P = 32.52 S □ P = 37.59 D □ S □ P = 41.99		

Table 11: Non-breakable filament length (m)

Year / Districts	Seasons	2019			2020		
		Practices			Practices		
		P0	P1	Sub-Means	P0	P1	Sub-Means
D1 Ramban	Spring (S1)	579.75	820.01	699.88	580.66	776	678.33
	Autumn(S2)	627	654.74	640.87	598	687	642.50
	Sub Means	603.38	737.38	670.38	589.33	731.50	660.42
D2 Doda	Spring (S1)	609	846.85	727.93	545	798	671.50
	Autumn(S2)	568	740.94	654.47	626.5	671	648.75
	Sub Means	588.5	793.90	691.20	585.75	734.50	660.13
D3 Kishtwar	Spring (S1)	532	828	680	672	709	690.50
	Autumn(S2)	612.76	678.28	645.52	520	665	592.50
	Sub Means	572.38	753.14	662.76	596	687	641.50
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		670.38	691.20	662.76	660.42	660.13	641.50
	Seasons	S1	S2		S1	S2	
		702.60	646.95		680.11	627.91	
	Practices	P0	P1		P0	P1	
		588.08	761.47		590.36	717.67	
CD(p≤0.05)		Districts (D) = 0.01 Seasons (S) = 0.02 Practices (T) = 0.01 D □ S = 0.02 D □ T = 0.02 S □ T = 0.02 D □ S □ T = 0.03			Districts (D) = 0.02 Seasons (S) = 0.01 Practices (P) = 0.02 D □ S = 0.01 D □ P = 0.01 S □ P = 0.01 D □ S □ P = 0.01		

Table 12: Filament size (D)

Year / Districts	Seasons	2019			2020		
		Practices			Practices		
		P0	P1	Sub-Means	P0	P1	Sub-Means
D1 Ramban	Spring (S1)	2.61	2.53	2.57	2.63	2.54	2.59
	Autumn (S2)	2.51	2.32	2.42	2.46	2.38	2.42
	Sub Means	2.56	2.43	2.49	2.55	2.46	2.50
D2 Doda	Spring (S1)	2.62	2.51	2.57	2.57	2.36	2.47
	Autumn (S2)	2.43	2.29	2.36	2.48	2.45	2.47
	Sub Means	2.53	2.40	2.46	2.53	2.41	2.47
D3 Kishtwar	Spring (S1)	2.58	2.55	2.57	2.67	2.52	2.60
	Autumn (S2)	2.50	2.33	2.42	2.52	2.48	2.50
	Sub Means	2.54	2.44	2.49	2.60	2.50	2.55
Factor Means	Districts	D1	D2	D3	D1	D2	D3
		2.49	2.46	2.49	2.50	2.47	2.55
	Seasons	S1	S2		S1	S2	
		2.57	2.40		2.55	2.46	
	Practices	P0	P1		P0	P1	
		2.54	2.42		2.56	2.46	
CD(p≤0.05)		Districts (D) = 0.01 Seasons (S) = 0.02 Practices (T) = 0.01 D □ S = 0.01 D □ T = 0.01 S □ T = 0.01 D □ S □ T = 0.02			Districts (D) = 0.02 Seasons (S) = 0.01 Practices (P) = 0.01 D □ S = 0.02 D □ P = 0.01 S □ P = 0.01 D □ S □ P = 0.02		

Conclusion

The silkworm, *B mori* which is a domesticated insect is susceptible to various biotic and abiotic factors thereby hindering its healthy growth and development and eventually reflects in poor silk production. As silkworms are prone to many life-threatening diseases like grasserie, muscardine, pebrine etc. and fluctuations in rearing temperature, relative humidity, poor leaf quality etc., the silkworm rearing must be carried out on scientific lines as per standard package of practices. The proper dissemination of information from lab to land is the need of hour by involving the extension workers to ensure the acceptability of new technologies by farmers developed by the research institutes to enhance the total cocoon yield at the farmers level.

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