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Comparative performance of bivoltine silkworm (*Bombyx mori* L.) breeds during autumn season in Jammu region of UT J&K

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Abstract
Two bivoltine silkworm (*Bombyx mor*i L.) breeds (NB_4D_2 and SH_6) were tested for their performance in respect of 19 metric traits during autumn season; these breeds were reared at RSRS (Regional Sericulture Research Station) Miran Sahib Jammu in order to evaluate the performance of silkworm breeds in Jammu region. Nineteen metric traits viz., The data pertaining to 19 metric traits viz., Double cocoon percentage, Mute cocoon percentage, Flimsy cocoon percentage, Stained cocoon percentage, Deformed cocoon percentage, Average Filament Length, Average Non-breakable Filament Length, Average Denier, Weight of Cocoon Sample (gms), Weight of Reelable Cocoons (gms), Defective Cocoon percentage, Weight of Silk (gms), Weight of Waste (gms), Renditta on Good Cocoons, Renditta on Defective Cocoons, Waste percentage, Raw Silk percentage, Reelability percentage, Neatness percentage were studied and data revealed significant variability between the breeds. Results obtained during rearing of these breeds showed overall performance of the breed NB_4D_2 appears was better over the other one and NB_4D_2 to have potential for commercial exploitation during autumn rearing season.

Keywords: Bivoltine silkworm, performance, metric traits, seasons

1. Introduction
Sericulture is a cottage and small-scale economic activity that is based on farms, labour intensive, and economically appealing. It is particularly well suited to farmers, entrepreneurs, and craftspeople in rural areas because it involves less capital but has the potential for relatively larger returns. An analysis of international silk production trends reveals that sericulture has a higher chance of growing in underdeveloped countries than in developed countries. India is the world's second largest producer of raw silk after China, accounting for 14.57 per cent of worldwide raw silk output. It is also the world's largest consumer of raw silk and silk fabrics. Bombyx mori L., the silkworm, is a significant Lepidopteran insect used in the commercial manufacture of natural silk fibre. Jammu and Kashmir is the country's only historic bivoltine region, which can make amazing bivoltine silk due to favourable climatic conditions for silkworm rearing and mulberry agriculture. One of the key impediments in increasing cocoon output has been recognised as a lack of productive silkworm breeds/hybrids suitable to the agro-climatic conditions of J&K state (Trag *et al*., 1992) [28]. Using the genetic heterogeneity of existing germplasm resources, the Sericulture Division of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir developed some novel silkworm breeds (Kamili *et al*., 2000) [17]. Seasonal and regional studies of the silkworm Bombyx mori L. are more important for discovering and understanding the adaptability of silkworm genotypes that are impacted by climate conditions (Vijayalakshmi *et al*., 2014) [30]. Several researchers across the country have attempted to identify season/region specific breeds (Gangwar, 2012, Senapati and Hazarika, 2014, Vijayalakshmi *et al*., 2014) [14, 26, 30]. Commercial silkworm farming is currently only performed in the valley during the spring season. Extension of rearing to other seasons is a reasonable option for increasing cocoon output and sericulture's economic sustainability in the state (Raja *et al*., 1999) [25]. This involves the development/identification of breeds/hybrids that are suitable for various rearing seasons. Although Malik *et al*. (1999) and Malik *et al*. (2005) [22, 20] provided some information regarding the relative performance of a few pure breeds in different seasons, there is no information about the performance of other prospective genotypes accessible in the germplasm bank in different seasons. The purpose of this experiment was to compare the performance of two bivoltine silkworm breeds (*Bombyx mori* L.) for their adaptability for autumn rearing seasons.

2. Materials and Methods

In the present study an attempt was made to evaluate the post cocoons characters of silkworm, *Bombyx mori* L. races were selected for the study. Two silkworm races viz., NB_4D_2 and SH_6 were obtained from the germplasm banks maintained at P_2 BSF SAHASPUR. The breeds were reared during autumn season, September, 2021. Disease-free layings of these races were kept and allowed to hatch in a laboratory setting at 25 °C and 75% relative humidity. All of the silkworm breeds studied were reared according to the usual set of procedures (Raja, 2000). Each treatment had four replications in the experiment, which was set up in a completely randomised block design. After the third moult, each replication was made up of 200 silkworms of the same age and size. The information on 19 metric traits viz., Double cocoon percentage, Mute cocoon percentage, Flimsy cocoon percentage, Stained cocoon percentage, Deformed cocoon percentage, Average Filament Length, Average Non-breakable Filament Length, Average Denier, Weight of Cocoon Sample (gms), Weight of Reelable Cocoons (gms), Defective Cocoon percentage, Weight of Silk (gms), Weight of Waste (gms), Renditta on Good Cocoons, Renditta on Defective Cocoons, Waste percentage, Raw Silk percentage, Reelability percentage, Neatness percentage were recorded and put through an analysis of variance (ANOVA).

3. Results and Discussion

The results of current study revealed that the comparative performance and its statistical analysis of both races are presented in Table 1. It was found that coefficient of variation for double cocoon percentage for both the races is 0.00 and also standard deviation is 0.00. For mute cocoon percentage coefficient of variation for NB_4D_2 (6.918) is more than CV of SH_6 (1.472). Table 1 also shows that for mute cocoon percentage standard deviation of NB_4D_2 (0.215) is more than standard deviation of SH_6 (0.030).It was also found that coefficient of variation of flimsy cocoon percentage for both the races is 0.00 and also standard deviation is 0.00. For stained cocoon percentage CV of NB_4D_2 (1.292) is more than CV of SH_6 (0.196). Table 1 also shows that for stained cocoon percentage standard deviation of NB_4D_2 (0.083) is more than standard deviation of SH_6 (0.014). Many studies have found that double hybrids outperform single hybrids (Ashoka and Govindan, 1994; Bindroo *et al*., 2014), and the outcomes of our study are consistent with these findings.

Performance of the Race NB_4D_2 was compared with SH_6 to choose the promising one. Comparative performance and its statistical analysis of both races are presented in Table 2. It was found that for the character average filament length CV of NB_4D_2 (0.222) is less than CV of SH_6 (0.319). It is also evident from the data that standard deviation on average filament length of the race NB_4D_2 (1.195) is less than race SH_6 (1.607). It was also found that for the character average non-breakable filament length CV of NB_4D_2 (0.268) is less than CV of SH_6 (0.620). It is also evident from the data that standard deviation on average non-breakable filament length of the race NB_4D_2 (1.199) is less than race SH_6 (2.213). It was found that for the character average denier CV of NB_4D_2 (0.824) is less than CV of SH_6 (0.924). It is also evident from the data that standard deviation on average denier of the race NB_4D_2 (0.015) is less than race SH_6 (0.016). It was found that for the character weight of cocoon samples CV of NB_4D_2 (0.878) is less than CV of SH_6 (1.618). It is also evident from the data that standard deviation on weight of coon samples of the race NB_4D_2 (1.190) is less than race SH_6 (1.865). It was found that for the character weight of reelable cocoon samples CV of NB_4D_2 (1.001) is less than CV of SH_6 (2.129). It is also evident from the data that standard deviation on weight of reelable cocoon samples of the race NB_4D_2 (1.146) is less than race SH_6 (2.016). However, assessing the performance of genotypes based on individual features in different seasons can be problematic, especially when a silkworm genotype's yielding ability is determined by more than twenty-one component variables (Thiagarajan *et al*., 1993) [27]. When looking for potential genotypes, it's important to examine the cumulative influence of all yield component qualities, whether they're good or negative. Inherent genetic hurdles, such as unfavourable character associations, complicate the decision even further. Seed producers, rearers, reelers, and weavers are only a few of the Sericulture interest groups. While fertility and hatching % are key features for seed producers, rearers require breeds with higher cocoon weight, shell weight, survival, and reduced larval length in addition to better fecundity and hatching percentage. Reelers, on the other hand, like cocoons with a high silk content, longer filament, less boil-off loss, less renditta, and a high degree of neatness. Unfortunately, toughness and shell ratio are inversely connected with silkworm fecundity. Similarly, reelability is negatively linked with filament length. Similarly, the weight of cocoons and the shell ratio are adversely associated. As a result, finding a breed with all desirable characteristics is very impossible. As a result, a balance must be maintained by giving crucial metric qualities adequate weight when determining a genotype's superiority.

In the case of defective cocoon percentage it was found that CV of NB_4D_2 (0.082) is less than CV of SH_6 (0.218). It is also evident from the data that standard deviation on defective cocoon percentage of the race NB_4D_2 (0.008) is less than race SH_6 (0.026). It was found that for the character weight of silk CV of NB_4D_2 (0.126) is less than CV of SH_6 (9.873). It is also evident from the data that standard deviation on average filament length of the race NB_4D_2 (0.054) is less than race SH_6 (2.430). It was found that for the character weight of waste CV of NB_4D_2 (0.288) is less than CV of SH_6 (0.413). It is also evident from the data that standard deviation on weight of waste of the race NB_4D_2 (0.016) is less than race SH_6 (0.021). It was found that for the character renditta on good cocoons CV of NB_4D_2 (1.550) is more than CV of SH_6 (1.142). It is also evident from the data that standard deviation on renditta on good cocoons of the race NB_4D_2 (0.029) is more than race SH_6 (0.027). It was found that for the character renditta on defective cocoons CV of NB_4D_2 (0.730) is less than CV of SH_6 (1.385). It is also evident from the data that standard deviation on renditta on defective cocoons of the race NB_4D_2 (0.016) is less than race SH_6 (0.041). It was found that for the character waste percentage CV of NB_4D_2 (0.160) is less than CV of SH_6 (0.810). It is also evident from the data that standard deviation on waste percentage of the race NB_4D_2 (0.015) is less than race SH_6 (0.102). It was found that for the character raw silk percentage CV of NB_4D_2 (1.550) is less than CV of SH_6 (2.514). It is also evident from the data that standard deviation on raw silk percentage of the race NB_4D_2 (0.411) is less than race SH_6 (0.512). It was found that for the reelability character CV of NB_4D_2 (0.685) is more than CV of SH_6 (0.590). It is also evident from the data that standard deviation on reelability character of the race NB_4D_2 (0.406) is more than race SH_6 (0.338). (Gangwar, 2012, Senapati and Hazarika, 2014, Vijayalakshmi *et al*., 2014) [14, 26, 30] have found similar results. It was found that from the Table 3 coefficient of variation for neatness percentage of NB_4D_2 (2.075) is less than CV of SH_6 (3.590). Table 3 also shows that for neatness percentage standard deviation of NB_4D_2 (1.358) is less than standard deviation of SH_6 (2.280). (Gangwar, 2012, Senapati and Hazarika, 2014, Vijayalakshmi *et al*., 2014) [14, 26, 30] have found similar results.

Table 1: Mean performance of silkworm breeds for nineteen metric traits during autumn season

Treatments	Double Cocoon %		Mute Cocoon %		Flimsy Cocoon %		Stained Cocoon %		Deformed Cocoon %	
	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6
	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E
T_1	0.00 ± 0.000	0.00 ± 0.000	4.82 ± 0.023	2.85 ± 0.035	0.00 ± 0.000	0.00 ± 0.000	9.09 ± 0.031	10.14 ± 0.012	0.56 ± 0.009	4.07± 0.009
T_2	0.00 ± 0.000	0.00 ± 0.000	4.20 ± 0.222	2.85 ± 0.022	0.00 ± 0.000	0.00 ± 0.000	9.06 ± 0.036	10.13 ± 0.006	0.55 ± 0.006	4.04± 0.008
T_3	0.00 ± 0.000	0.00 ± 0.000	4.20 ± 0.106	2.91 ± 0.005	0.00 ± 0.000	0.00 ± 0.000	9.24 ± 0.107	10.13 ± 0.004	0.58 ± 0.005	4.04± 0.003
T_4	0.00 ± 0.000	0.00 ± 0.000	4.35 ± 0.177	2.92 ± 0.010	0.00 ± 0.000	0.00 ± 0.000	9.16 ± 0.016	10.14 ± 0.014	0.56 ± 0.005	4.04 ± 0.011
C.D.	0.00	0.00	0.473	N/A	0.00	0.00	N/A	N/A	0.020	N/A
SE(m)	0.00	0.00	0.152	0.021	0.00	0.00	0.059	0.010	0.006	0.008
SE(d)	0.00	0.00	0.215	0.030	0.00	0.00	0.083	0.014	0.009	0.011
C.V.	0.00	0.00	6.918	1.472	0.00	0.00	1.292	0.196	2.297	0.394
DF	0.00	0.00	15	15	0.00	0.00	15	15	15	15
SS	0.00	0.00	2.139	0.037	0.00	0.00	0.242	0.005	0.004	0.005
F-Value	0.00	0.00	3.720	02.917	0.00	0.00	1.784	0.513	3.886	2.538
Significance	0.00	0.00	0.04223	0.0772	0.00	0.00	0.20374	0.68071	0.03749	0.10571

Table 2: Mean performance of silkworm breeds for nineteen metric traits during autumn season

Treatment	Average Filament Length		Average NB Filament Length		Average Denier		Weight of cocoon sample (gms)		Weight of reelable cocoon (gms)		Defective Cocoon %		Weight of silk (gms)		Weight of waste (gms)		Renditta on good cocoons		Renditta on defective cocoons		Waste %		Raw silk %		Reelability	
	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6
	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E	Mean ± S.E
T_1	761.75± 0.479	711.0± 0.913	633.75± 0.629	506.50± 1.555	2.52± 0.010	2.51± 0.004	191.5± 0.645	164.2± 1.109	161.2± 0.479	133.0± 0.913	14.5± 0.009	17.16± 0.011	60.03± 0.019	35.50± 1.708	8.01± 0.007	7.01± 0.005	2.59± 0.035	3.37± 0.035	3.15± 0.010	4.14± 0.056	13.32± 0.011	17.73± 0.140	37.1± 30.418	28.56± 0.516	83.85± 0.295	80.66± 0.292
T_2	762.75± 0.479	714.00± 1.080	631.25 ±0.479	503.50 ± 1.555	2.53± 0.012	2.51 ± 0.018	191.50± 0.645	162.75 ± 1.548	162.25± 0.250	132.75 ± 1.250	14.49 ± 0.004	17.12 ± 0.022	60.10 ± 0.066	33.75 ± 1.797	8.03 ± 0.010	7.03 ± 0.003	2.64 ± 0.017	3.40 ± 0.006	3.12 ± 0.013	4.22 ± 0.009	13.32 ± 0.016	17.86 ± 0.033	37.53 ± 0.285	29.06 ± 0.364	83.84 ± 0.286	81.27 ± 0.158
T_3	760.75± 0.479	711.50± 0.866	632.00 ± 0.913	503.75 ± 0.946	2.52± 0.010	2.51 ± 0.005	192.00± 0.913	163.00 ± 1.472	161.50± 1.190	135.00± 2.041	14.50 ± 0.005	17.15 ± 0.026	60.04 ± 0.018	34.00 ± 1.683	8.04 ± 0.018	7.05 ± 0.014	2.60 ± 0.006	3.43 ± 0.012	3.17 ± 0.013	4.23 ± 0.012	13.31 ± 0.003	17.09 ± 0.010	37.62 0.239±	28.86 ± 0.230	83.83 ± 0.278	81.25 ± 0.250
T_4	763.00± 1.472	711.50 ± 1.555	631.50 ± 1.190	504.25 ± 2.016	2.52± 0.008	2.50 ± 0.013	192.00± 1.080	162.00± 1.080	162.50± 0.957	134.75 ± 1.250	14.51 ± 0.004	17.11 ± 0.012	60.04 ± 0.026	36.00 ± 1.683	8.03 ± 0.009	7.05 ± 0.025	2.61 ± 0.009	3.41 ± 0.009	3.14 ± 0.009	4.25 ± 0.006	13.31 ± 0.008	17.92 ± 0.014	37.83 0.159±	28.08 ± 0.271	83.83 ± 0.289	80.07 ± 0.236
C.D.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.019	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SE(m)	0.845	1.137	0.848	1.565	0.010	0.012	0.842	1.319	0.810	1.425	0.006	0.019	0.038	1.718	0.012	0.015	0.020	0.019	0.011	0.029	0.011	0.072	0.291	0.362	0.287	0.239
SE(d)	1.195	1.607	1.199	2.213	0.015	0.016	1.190	1.865	1.146	2.016	0.008	0.026	0.054	2.430	0.016	0.021	0.029	0.027	0.016	0.041	0.015	0.102	0.411	0.512	0.406	0.338
C.V.	0.222	0.319	0.268	0.620	0.824	0.924	0.878	1.618	1.001	2.129	0.082	0.218	0.126	9.873	0.288	0.413	1.550	1.142	0.730	1.385	0.160	0.810	1.550	2.514	0.685	0.590
DF	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
SS	46.938	84.000	49.750	140.000	0.005	0.007	35.000	94.000	35.750	113.750	0.003	0.023	0.090	156.438	0.008	0.015	0.024	0.025	0.010	0.060	0.007	0.336	5.098	6.812	3.966	4.091
F-Value	1.482	1.419	1.768	1.766	0.150	0.081	0.118	0.503	0.540	0.667	4.181	1.561	1.214	0.414	0.843	1.811	0.909	1.433	2.584	0.915	0.830	1.359	1.024	0.325	0.006	1.971
Significance	0.26915	0.28538	0.20665	0.53474	0.92751	0.96902	0.94801	0.68735	0.66410	0.58847	0.03050	0.24988	0.34689	0.74573	0.49638	0.19880	0.46536	0.28162	0.10175	0.18096	0.50274	0.30204	0.41625	0.80697	0.99927	0.17215

Table 3: Mean performance of silkworm breeds for nineteen metric traits during autumn season

Treatment	Date of Testing		Type of Reeling		Visual		Skein		Neatness %	
	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2	SH_6	NB_4D_2 Mean ± S.E	SH_6 Mean ± S.E
T_1	31-10-2021	31-10-2021	Reeling machine	Reeling machine	Good	Good	Fair	Fair	92.25±0.854	89.50 ±0.645
T_2	31-10-2021	31-10-2021	Reeling machine	Reeling machine	Good	Good	Fair	Fair	93.000±0.913	88.50±3.014
T_3	31-10-2021	31-10-2021	Reeling machine	Reeling machine	Good	Good	Fair	Fair	92.750±1.109	90.25 ±0.854
T_4	31-10-2021	31-10-2021	Reeling machine	Reeling machine	Good	Good	Fair	Fair	92.250±0.946	91.00 ±0.408
C.D.	-	-	-	-	-	-	-	-	N/A	N/A
SE(m)	-	-	-	-	-	-	-	-	0.960	1.612
SE(d)	-	-	-	-	-	-	-	-	1.358	2.280
C.V.	-	-	-	-	-	-	-	-	2.075	3.590
DF	-	-	-	-	-	-	-	-	15	15
SS	-	-	-	-	-	-	-	-	45.938	138.438
F-Value	-	-	-	-	-	-	-	-	0.153	0.439
Significance	-	-	-	-	-	-	-	-	0.92605	0.72933

4. Conclusion
The present study results obtained during rearing of these breeds also recommends showed overall performance of the breed NB_4D_2 appears was better over the other one and moreover, this data may be applied for evolving new season unique breeds with accumulation of most applicable traits.

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