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Effect of Moisture Content and Moisture Retention Capacity of Five Different Elite Mulberry Varieties on Chawki and Late Age Rearing Stages of Silkworm during Spring Season under Sub Tropical Condition of Jammu (J & K)

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ABSTRACT

The present investigation was carried out during spring (2019). The collected data revealed that, Vishala recorded maximum moisture content (76.83 %) followed by C-2038 (76.61 %) whereas minimum was noticed in S-1635 (74.64 %) during chawki stage of silkworm rearing. During late age of silkworm rearing, C-2038 recorded maximum moisture content (77.24 %) followed by S-1635 (76.02 %) whereas minimum moisture content was noticed in G-4 (72.98 %). The overall mean revealed that, C-2038 recorded maximum moisture content (76.93 %) followed by Vishala (75.80 %), whereas minimum moisture content was noticed in G-4 (74.19 %) and significant differences were observed among all the varieties with respect to moisture content for chawki, late age and overall mean during complete rearing. G-4 retained maximum moisture content (95.79 %) followed by C-2038 (95.73 %) during chawki stage. During late age, Vishala retained maximum moisture content (96.16 %) followed by S-1635 (96.03 %). For overall mean, C2038 & G-4 retained maximum moisture content (95.73 %). All the varieties showed statistically non - significant among each other for moisture retention capacity at 6 h for chawki stage, late age and overall mean. All the varieties showed significant differences among each other for moisture retention capacity during chawki stage at 12 h, C-2038 retained maximum moisture retention (92.71 %) followed by G-4 (92.33 %). During late age, C-2038 retained maximum moisture (92.09 %) followed by S-146 (92.08 %) and showed non - significant among them. For overall mean, there is statistical differences among all the varieties for moisture retention capacity at 12 h, C-2038 retained maximum moisture content (92.40 %) followed by G-4 (92.13 %). During chawki stage, higher moisture was retained C-2038 (89.17 %) followed by G-4 (88.02 %) and recorded significant differences among all the varieties at 24 h. During late age rearing, higher moisture was retained in variety C-2038 (86.34 %) followed by Vishala (84.72 %) and showed non-significant among all the varieties. For overall mean, higher moisture was retained in variety C-2038 (87.76 %) followed by G-4 (85.95 %). Among all the varieties there is significant differences was observed statistically at 24 h for overall mean. During chawki rearing according to the evaluation index for moisture content and moisture retention capacity, the mulberry varieties were shortlisted as C-2038 having E.I value 59.30 followed by G-4 (54.82) respectively. During late age rearing, C-2038 having E.I value 58.75 followed by Vishala (53.32) and for overall mean, the mulberry varieties were shortlisted as C-2038 having E.I value 61.79 followed by G-4 (51.76) and S-1635 (51.33) respectively.

Keywords: *silkworm, Chawki stage, Moisture content, Varieties*

INTRODUCTION

About 92.20 per cent of the silk produced in the world is obtained from mulberry silkworm *Bombyx mori* L. reared solely on mulberry leaves (*Morus spp*.). Leaf quality is an important parameter used for evaluation of varieties aimed at selection of superior varieties for rearing performance (Yokoyama, 1963; & Bongale et al., 1997). It is well-established fact that, in sericulture, more than 60 per cent of total cost of cocoon production goes towards mulberry production alone. Hence, in recent years maximum attention has been given for the improvement of mulberry both in terms of quality and quantity. Quality of mulberry leaf was highly influenced by varieties, cultivation practices, preservation techniques, age and position of leaf and leaf quality was determined based on moisture content. Higher moisture content of mulberry leaves has a direct effect on growth and development of silkworm by favouring the ingestion, digestion and assimilation of nutrients. Mulberry leaves containing more water, total sugar and soluble carbohydrate and less mineral are best relished by silkworms. Nutritive requirement of silkworm larvae vary with the maturity of leaves fed. Chawki silkworms required leaves of high moisture content as it is easy to digest and late age silkworms required mature leaves with less moisture content as late age silkworms have the strength to digest mature leaves. On the other hand too much mature leaves do not contain sufficient biochemical contents and moisture content is not suitable to feed silkworms. Different quality traits such as leaf moisture content, proteins, carbohydrates, nitrogen, amino acids and chlorophyll are responsible for leaf quality (Bongale & Chaluvachari, 1995). About 70 per cent protein of Silk is directly derived from mulberry leaves. The nutrient contents of mulberry leaves have a great affects on the growth of Silkworm, cocoon crop and finally on raw-silk-yield. Worm health and cocoon characters are highly affected by quality and quantity of food (Koul, 1989; & Remadevi et al., 1993).

Keeping this background in mind the present study was envisaged to identify suitable mulberry varieties for commercial silkworm production under sub-tropical conditions of Jammu region with the given objective; Effect of Moisture content and moisture retention capacity of five different elite mulberry varieties on chawki and late age rearing stages of silkworm during spring season.

MATERIALS AND METHODS

The details of material used and methods adopted during the course of investigation of the effect of Moisture content and moisture retention capacity of five different elite mulberry varieties on chawki and late age rearing stages of silkworm during spring season. The hybrid viz., Double hybrid (FC1×FC2) was reared on different varieties of mulberry during spring (2019).

Preparation for rearing

The required number of disease free layings (dfl‘s) of double hybrid viz., (FC1×FC2) was obtained from National Silkworm Seed Organization, Central Silk Board, Bangalore and its characteristics features mentioned in Table 1.

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Table 1: Showing characteristics of Double Hybrid (FC1×FC2)

Sl. No.	Characters	Performance
1	Fecundity (No.)	575 - 650
2	Total Larval Span (D : h)	23:06
3	Cocoon yield/100 dfl's (Kg)	80.00
4	Pupation rate (%)	95.00
5	Cocoon shell %	23.00 – 24.00
6	Reelability (%)	80-85
7	Renditta	6.0 – 6.5
8	Filament Length (m)	1100 - 1200
9	Neatness (p)	90-95
10	Raw silk quality	2A–3A

Disinfection of rearing room

Before the commencement of silkworm rearing, the rearing room and appliances were thoroughly cleaned and the floor was washed using 5 per cent bleaching powder solution and 2.5 per cent serichlor solution. Then the whole room was disinfected with 2 per cent formalin at the rate of 1.5 ml/m2 by using rocker sprayer for effective disinfection reported by Dandin and Giridhar (2010). The rearing room was kept air tight for 24 hours. After 24 hours, the room was kept open and used for rearing.

Equipments Used

Followings are the equipments required during rearing; Feathers, rearing stand, rearing trays, ant wells, Paraffin paper, Feeding stand, Nets, Leaf basket, Leaf chamber, Chopping board, Chopping knife, Hygrometers and Thermometer, Chop-sticks and Mountages.

Incubation of eggs

The layings procured were incubated in the disinfected rearing trays by adopting standard incubation and dark treatment practices Dandin and Giridar (2010) to obtain uniform hatching, silkworm eggs at the blue egg stage were kept in block boxes. One day prior to hatching, the rearing tray was lined with polythene sheet at the bottom. Wet paper strips were placed along the edges of rearing tray. Bed was also covered with polythene sheet at the top to maintain temperature and humidity.

Mulberry garden

The mulberry varieties grown in sandy loam soil with spacing of 3x3 ft of the plantation was used for the experiment.

Mulberry varieties

Vishala: is a triploid, selected clonally from saplings obtained from farmer's field by Karnataka State Sericulture Research and Development Institute, Thalaghattapura. Vishala is a fast growing variety with early maturity of leaves. Its leaves are unlobed, broadly ovate and cordate with dendate margin, slightly rough in texture and dark green in colour. The average leaf yield in the southern test centers varied from 26,000 Kg/ha/yr in Krishnagiri to 80,960 Kg/ha/yr in

Thalaghattapura under irrigated conditions and under rain fed conditions in chamarajanagar, it yielded 11,240 Kg/ha/yr. In Northern India, the leaf yield range from 5,000 Kg/ha/yr in Mirgund (Jammu and Kashmir) to 18,700 Kg/ha/yr at Pampore (J & K) under two crop schedules in rain fed system and in eastern India.

G-4: It is a high yielding mulberry variety with a leaf yield of about 65 mt/ha/yr under assured irrigated conditions and recommended package of practices. The variety is a hybrid of M. multicaulis and S30 developed at CSR & TI, Mysore. G-4 performs on par with V1, a popular mulberry variety in South India. The foliage of G-4 is of excellent quality and ideally suited for rearing late age silkworms. The variety is characterized by erect branches, thick dark green, leaves and short inter-nodal distance. It is a diploid variety (2n=28) with high rooting ability (>90%) and survival rate in the nursery.

S-146: The mulberry breeding and genetics section have evolved S-146, a new mulberry variety suitable for temperate hills. The variety has gained popularity in J & K regions also. The leaves having serrate leaf margin, cordate type leaf base, rough surface, fleshy texture, unlobed, glossy and green in colour. Developed at CSR & TI, Berhampore, Sub tropical conditions of North India, leaf yield is about 25-35 mt/ha/yr.

C-2038: It is having serrate leaf margin, cordate type leaf base, smooth surface, fleshy texture, unlobed, glossy and green in colour. Developed at CSR & TI Berhampore, West Bengal, Sub tropical, irrigated variety, leaf yield is about 50-60 mt/ha/yr.

S-1635: It is triploid variety with higher leaf yield ability (35 mt/ha/year) has been evolved by the institute (CSR & TI, Berhampore). The variety has been considered as national check. It is becoming popular under assured irrigation among the sericulture farmers in Malda, Murshidabad, and Birbhum districts of West Bengal. The variety has also shown it‘s superiority in some pockets of South India also.

Brushing and Rearing

Mulberry leaves were cut into small squares of 0.25 cm2 and sprinkled over the brushing net covered on hatched loose eggs. The neonate larvae crawled over the tender leaves and started feeding. Later, the brushing net along with neonate larvae was separated into the rearing bed to collect the remaining worms. Another paraffin sheet was used to cover the bed to maintain required relative humidity and temperature and to keep the leaves fresh and turgid. The larvae were fed four times a day with suitable quality leaves Dandin and Giridhar (2010).

Feeding

Leaves from different mulberry varieties were used for feeding the larvae. The larvae were fed four times daily *viz.,* 6 am, 11 am, 4 pm and 9 pm.

Bed cleaning

Bed cleaning was done once during first, second and third instar and for subsequent instars, cleaning was done every day.

Moulting and Moulting care

When the worms start settling for the moult, the feeding was reduced and prior to moulting, the bed thickness is reduced as much as possible. Adequate spacing allows the left over leaf and bed for quicker drying. When all the worms settle for moult, slaked lime was dusted as per treatment details.

Feeding is resumed half an hour later after dusting bed disinfectants i.e. Vijetha when more than 95 per cent of the worms were out of moult. Care taken during moulting includes stopping and resuming feeding at appropriate time that ensures uniformity in growth. Keeping the bed dry and preventing diseases are necessary during this sensitive period.

Mounting:

When the ripen worms are mounted on the mountages they pass out last excreta in semi-solid condition. When the humidity is high, excess body moisture is also eliminated as urine. After defecation ripe worm starts spinning the cocoon by selecting a suitable place in the mountage.

Harvesting:

The silkworms complete spinning in 2 to 3 days but the cocoons should not be harvested at this time as the worms inside are still in the pre-pupal stage. The harvesting cocoons have been done on 6th day after mounting.

Sorting:

It is the process to ensure the good quality cocoons and remove the defective cocoons. It is done before reeling, to separate the defective cocoons because these are unable to reel and if reeling then the silk obtained from these cocoons are of inferior quality.

Environmental condition during silkworm rearing

During rearing, the recommended temperature and relative humidity was recorded and details have been mentioned in Table 2.

Table 2: Showing ideal temperature & humidity required during different stages of silkworm larvae

Sl. No.	Larval instar	Temperature (˚C)	Humidity (%)
1	I instar	27-28	80-85
2	II instar	26-27	80
3	III instar	24-26	75-80
4	IV instar	24-25	75
5	V instar	23-24	70

Performance of double hybrid with varieties used for the study

The five different mulberry varieties having three replications has been utilized in the experiment and details mentioned in following Table 3.

Table 3: Showing details of varieties used for the study

Sl. No.	Variety
1	S -146
2	S - 1635
3	G4
4	Vishala
5	C- 2038

Observations recorded

Moisture Content and Moisture Retention Capacity

The moisture content of the leaf was determined on dry weight basis. One hundred fresh leaves, comprising of tender, medium and coarse leaves were harvested early in the morning and weighed immediately. They were then kept at room temperature and weighed again after 06, 12 and 24 hours. The leaves were then dried in hot air oven at 60°C for 48 hours (Ninge Gowda & Sudhakar, 2002). The dry weight was recorded and the moisture content and moisture retention capacity calculated as per the following formulae:

$$\text{Moisture content (\%)} = \frac{\text{(Fresh weight - Dry weight)}}{\text{Fresh weight}} \times 100$$

$$\text{Moisture retention} = \frac{\text{(Weight after 6 hrs- Dry weight)}}{\text{Capacity after 6 hrs (Fresh weight - Dry weight)}} \times 100$$

$$\text{Moisture retention} = \frac{\text{(Weight after 12 hrs- Dry weight)}}{\text{Capacity after 12 hrs (Fresh weight - Dry weight)}} \times 100$$

$$\text{Moisture retention} = \frac{\text{(Weight after 24 hrs - Dry weight)}}{\text{Capacity after 12 hrs (Fresh weight - Dry weight)}} \times 100$$

Three observations per treatment per replication were recorded and an average calculated.

Rearing performance of double cross hybrid with different mulberry varieties

- **Location**

The experiment trial was undertaken at Regional Sericultural Research Station (RSRS), Miran Sahib, Jammu. The rearing was conducted in lab to know the performance of double cross hybrid reared on different mulberry varieties with chawki and late age during spring (2019).

- **Collection of data**

Suitable treatment of different varieties viz., C - 2038, S - 146, Vishala, G - 4 and S - 1635 were used for the study and collected the data to know the rearing performance of double hybrid of silkworm from five treatments with three replications, each replication having 300 worms. The rearing performance of silkworms was collected at the stage of third instars onwards. For each treatment details the following economic parameters were recorded *viz.*, larval weight, cocoon weight, shell weight, shell ratio, silk filament length and denier.

- **Statistical analysis**

The experimental data collected on various economic and yield parameters were subjected to Fisher‘s method of analysis of variance (ANOVA) as per methods outlined by Gomez and Gomez (1984). Critical difference (CD) was calculated wherever the ‗F‘ test was found significant. The data are presented with the level of significance at 5 *per cent*. Evaluation Index was workout as per the procedure suggested by Mano et al. (1993) and also same index used for moisture content and moisture retention capacity.

RESULTS

The results of experiment conducted for Effect of Moisture content and moisture retention capacity of five different elite mulberry varieties on chawki and late age rearing stages of silkworm *Bombyx mori* L. during spring season under sub-tropical condition of Jammu (J & K) are presented here under.

Moisture content and moisture retention capacity during chawki stage of silkworm rearing (2019)

The varieties which were superior with respect to yield and growth parameters were selected to assess the moisture content and moisture retention capacity at 6 h, 12 h and 24 h during spring (2019) for chawki rearing time. The results of five different elite mulberry varieties viz., S-146, S1635, G-4, Vishala and C-2038 for moisture content and moisture retention capacity at 45 days after pruning (DAP) are as follows.

Leaf moisture content (%)

Vishala recorded maximum moisture content (76.83 %) followed by C - 2038 (76.61 %), G - 4 (75.40 %), S -146 (75.20 %), whereas minimum moisture content was noticed in S - 1635 (74.64 %) (Table 4). All the varieties showing significant differences among each other for moisture content recorded during chawki stage of silkworm rearing.

Leaf moisture retention capacity (%)

a) At 6 h

Among five mulberry varieties G - 4 retained maximum moisture content (95.79 %) followed by C - 2038 (95.73 %), S -1635 (94.94 %) and S - 146 (94.67 %) whereas minimum retention was noticed in Vishala (94.07 %) (Table 4). All the varieties showed statistically non - significant among each other for moisture retention capacity.

b) At 12 h

All the varieties showed significant differences among each other for moisture retention capacity at 12 h, the variety C - 2038 retained maximum moisture retention (92.71 %) followed by G - 4 (92.33 %), S - 1635 (91.90 %) and Vishala (90.30 %), whereas minimum moisture retention at 12 h was recorded in S 146 (87.84 %) (Table 4).

c) At 24 h

Higher moisture was retained in variety C - 2038 (89.17 %) followed by G - 4 (88.02 %), S - 1635 (87.52 %) and Vishala (84.58 %), whereas, it was least in the variety S - 146 (81.97 %) (Table 4). There is significant differences were noticed among all the varieties.

Evaluation index for mulberry varieties used during chawki rearing w.r.t moisture content and moisture retention capacity

The mulberry varieties *viz.*, S - 146, S - 1635, G - 4, Vishala and C - 2038 were fed with double hybrid FC1 × FC2 and the same varieties used for recording of moisture content and moisture retention capacity during chawki rearing and according to the evaluation index, the mulberry varieties were shortlisted as C - 2038 having E.I value 59.30 followed by G - 4 (54.82) respectively (Table 5; Fig. 1).

Moisture content and moisture retention capacity during late age silkworm rearing (2019)

The varieties which were superior with respect to yield and growth parameters were selected to assess the moisture content and moisture retention capacity at 6 h, 12 h and 24 h during spring (2019) for late age rearing time. The results of five different elite mulberry varieties viz., S - 146, S - 1635, G - 4, Vishala and C - 2038 for moisture content and moisture retention capacity at 55 days after pruning (DAP) are as follows.

Leaf moisture content (%)

All the varieties showed significant differences statistically among each other for moisture content recorded during late age of silkworm rearing. The variety C - 2038 recorded maximum moisture content (77.24 %) followed by S - 1635 (76.02 %), Vishala (74.76 %) and S - 146 (74.47 %), whereas minimum moisture content was noticed in G - 4 (72.98 %) (Table 6).

Leaf moisture retention capacity (%)

a) At 6 h

Among five mulberry varieties, Vishala retained maximum moisture content (96.16 %) followed by S - 1635 (96.03 %), C - 2038 (95.73 %) and G - 4 (95.68 %), whereas minimum retention was noticed in S - 146 (95.21 %) (Table 6).

b) At 12 h

The variety C - 2038 retained maximum moisture (92.09 %) followed by S - 146 (92.08 %), Vishala (92.06 %) and G - 4 (91.93 %) whereas minimum moisture retention at 12 h was recorded in S - 1635 (91.28 %) (Table 6).

c) At 24 h

Higher moisture was retained in variety C - 2038 (86.34 %) followed by Vishala (84.72 %), S - 146 (84.60 %) and S - 1635 (84.26 %), whereas, it was least in variety G - 4 (83.88 %) (Table 6).

The moisture retention capacity for all the varieties recorded at different hrs of the day at 6, 12 and 24 h was observed that there are statistically non - significant differences among them (Table 6).

Evaluation index for mulberry varieties used during late age rearing w.r.t moisture content and moisture retention capacity

The mulberry varieties viz., S - 146, S - 1635, G - 4, Vishala and C - 2038 were fed with double hybrid FC 1× FC 2 and the same varieties used for recording of moisture content and moisture retention capacity during late age rearing time and according to the evaluation index, the mulberry varieties were shortlisted as C - 2038 having E.I value 58.75 followed by Vishala (53.32) respectively (Table 7; Fig. 2).

Overall mean of moisture content and moisture retention capacity during silkworm rearing (2019)

Leaf moisture content (%)

C - 2038 recorded maximum moisture content (76.93 %) followed by Vishala (75.80 %), S - 1635 (75.33 %) and S - 146 (74.84 %), whereas minimum moisture content was noticed in G - 4 (74.19 %) (Table 8). There is significant differences were recorded among all the varieties with respect to moisture content for overall mean during complete rearing.

Leaf moisture retention capacity (%)

a) At 6 h

Among five mulberry varieties C - 2038 & G - 4 retained maximum moisture content (95.73 %) followed by S - 1635 (95.48 %) and Vishala (95.12 %), whereas minimum retention was noticed in S - 146 (94.94 %) (Table 8).

There is non-significant differences among all the varieties were recorded statistically.

b) At 12 h

There is statistical differences was observed among all the varieties for moisture retention capacity at 12 h, the variety C - 2038 retained maximum moisture content (92.40 %) followed by G - 4 (92.13 %), S - 1635 (91.59 %) and Vishala (91.18 %), whereas minimum moisture retention at 12 h was recorded in S - 146 (89.96 %) (Table 8).

c) At 24 h

Higher moisture was retained in variety C - 2038 (87.76 %) followed by G - 4 (85.95 %), S - 1635 (85.89 %) and Vishala (84.65 %), whereas, it was least in variety S - 146 (83.28 %) (Table 8). Among all the varieties there is significant differences was observed statistically at 24 h for overall mean.

Evaluation index for mulberry varieties used during rearing w. r. t overall mean for moisture content and moisture retention capacity

The mulberry varieties viz., S - 146, S - 1635, G - 4, Vishala and C - 2038 were fed with double hybrid FC1 × FC2 and the same varieties used for recording of moisture content and moisture retention capacity during chawki & late age rearing and according to the evaluation index, the mulberry varieties were shortlisted as C - 2038 having E.I value 61.79 followed by G - 4 (51.76) and S - 1635 (51.33) respectively (Table 9; Fig. 3).

Table 4: Moisture content and moisture retention capacity of five different elite mulberry varieties for Chawki stage of silkworm, *Bombyx mori* L. during spring season (2019)

Variety	Moisture content (%)	Moisture retention capacity (%)		
		6 h	12 h	24 h
S 146	75.20 (60.10)	94.67 (76.68)	87.84 (69.57)	81.97 (64.85)
S1635	74.64 (59.74)	94.94 (77.16)	91.90 (73.52)	87.52 (69.30)
G4	75.40 (60.24)	95.79 (78.17)	92.33 (73.89)	88.02 (69.73)
Vishala	76.83 (61.20)	94.07 (75.92)	90.30 (71.83)	84.58 (66.85)
C 2038	76.61 (61.05)	95.73 (78.04)	92.71 (74.30)	89.17 (70.76)
CD@5(%)	0.98	-	2.08	1.44
Sem±	0.31	0.97	0.65	0.45
CV (%)	0.88	2.19	1.55	1.15

Note: Values in parentheses are statistically transformed

Table 5: Evaluation index for moisture content and moisture retention capacity of five different elite mulberry varieties evaluated during chawki stage of silkworm, *Bombyx mori* L. during spring season (2019)

Variety	Moisture content (%)	Moisture retention capacity (%)			Average
		6 h	12 h	24 h	
C 2038	59.25	59.50	58.48	59.95	**59.30**
S 146	44.32	44.95	34.11	35.40	**39.69**
Vishala	61.61	36.70	46.41	44.28	**47.25**
G4	46.42	60.27	56.57	56.02	**54.82**
S1635	38.40	48.59	54.43	54.34	**48.94**

Table 6: Moisture content and moisture retention capacity of five different elite mulberry varieties for Late-age rearing of silkworm, *Bombyx mori* L. during spring season (2019)

Variety	Moisture content (%)	Moisture retention capacity (%)		
		6 h	12 h	24 h
S 146	74.47 (59.63)	95.21 (77.33)	92.08 (73.63)	84.60 (66.87)
S1635	76.02 (60.66)	96.03 (78.48)	91.28 (72.88)	84.26 (66.60)
G4	72.98 (58.66)	95.68 (77.99)	91.93 (73.46)	83.88 (66.30)
Vishala	74.76 (59.82)	96.16 (78.70)	92.06 (73.64)	84.72 (66.97)
C 2038	77.24 (61.48)	95.73 (78.11)	92.09 (73.63)	86.34 (68.28)
CD@5(%)	1.30	-	-	-
Sem±	0.41	0.60	0.72	0.42
CV (%)	1.18	1.34	1.71	1.09

Note: Values in parentheses are statistically transformed

Table 7: Evaluation index for moisture content and moisture retention capacity of five different elite mulberry varieties evaluated during late age of silkworm, *Bombyx mori* L. during spring season (2019)

Variety	Moisture Content (%)	Moisture retention capacity			Average
		6 h	12 h	24 h	
C 2038	63.28	49.09	55.87	66.77	**58.75**
S 146	46.15	35.04	55.61	48.27	**46.27**
Vishala	47.93	60.78	54.97	49.60	**53.32**
G4	36.90	47.74	51.10	40.64	**44.10**
S1635	55.75	57.34	32.45	44.72	**47.56**

Table 8: Overall mean of moisture content and moisture retention capacity of five different elite mulberry varieties for silkworm, *Bombyx mori* L. during spring season (2019)

Variety	Moisture content (%)	Moisture retention capacity (%)		
		6 h	12 h	24 h
S -146	74.84 (59.86)	94.94 (76.99)	89.96 (71.50)	83.28 (65.84)
S -1635	75.33 (60.19)	95.48 (77.74)	91.59 (73.13)	85.89 (67.91)
G-4	74.19 (59.44)	95.73 (78.06)	92.13 (73.67)	85.95 (67.96)
Vishala	75.80 (60.50)	95.12 (77.23)	91.18 (72.71)	84.65 (66.90)
C – 2038	76.93 (61.26)	95.73 (78.06)	92.40 (73.97)	87.76 (69.49)
CD@5(%)	0.76	-	1.27	0.95
Sem±	0.24	0.61	0.39	0.30
CV (%)	0.69	1.38	0.94	0.76

Note: Values in parentheses are statistically transformed

Table 9: Evaluation index of overall mean for moisture content and moisture retention capacity of five different elite mulberry varieties evaluated for silkworm, *Bombyx mori* L. during spring season (2019)

Variety	Moisture content (%)	Moisture retention capacity (%)			Average
		6 h	12 h	24 h	
C 2038	64.61	59.14	59.90	63.52	**61.79**
S 146	44.39	37.22	34.44	36.65	**38.18**
Vishala	53.68	42.08	47.15	44.85	**46.94**
G4	38.13	59.22	57.06	52.65	**51.76**
S1635	49.19	52.34	51.45	52.32	**51.33**

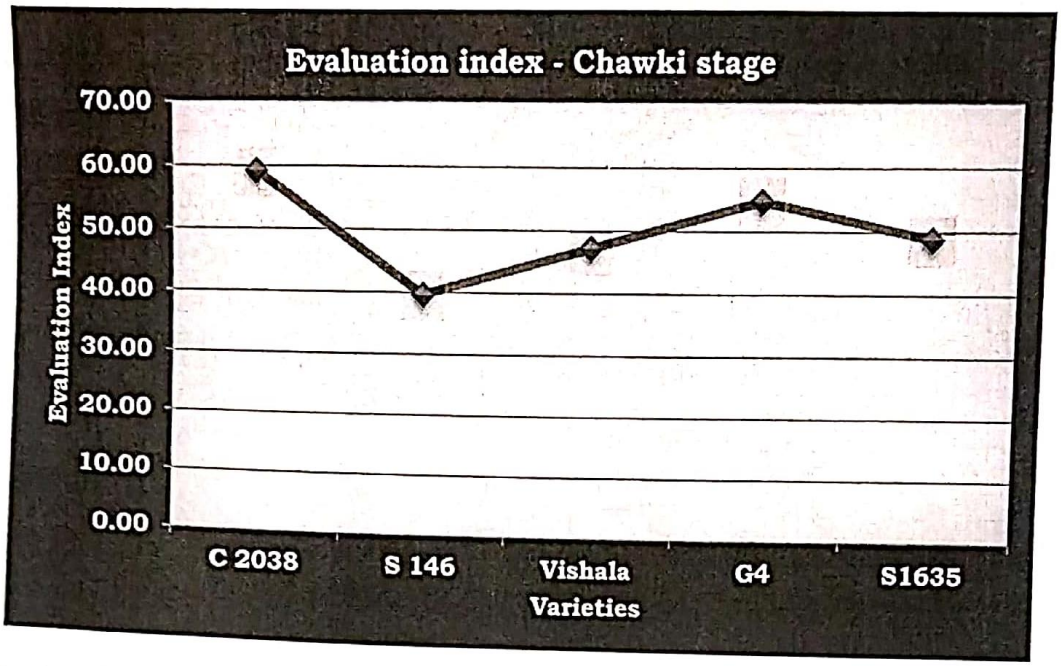

Fig 1. Evaluation index for moisture content and moisture retention capacity of five different elite mulberry varieties evaluated during chawki stage of silkworm, *Bombyx mori* L. during spring season (2019)

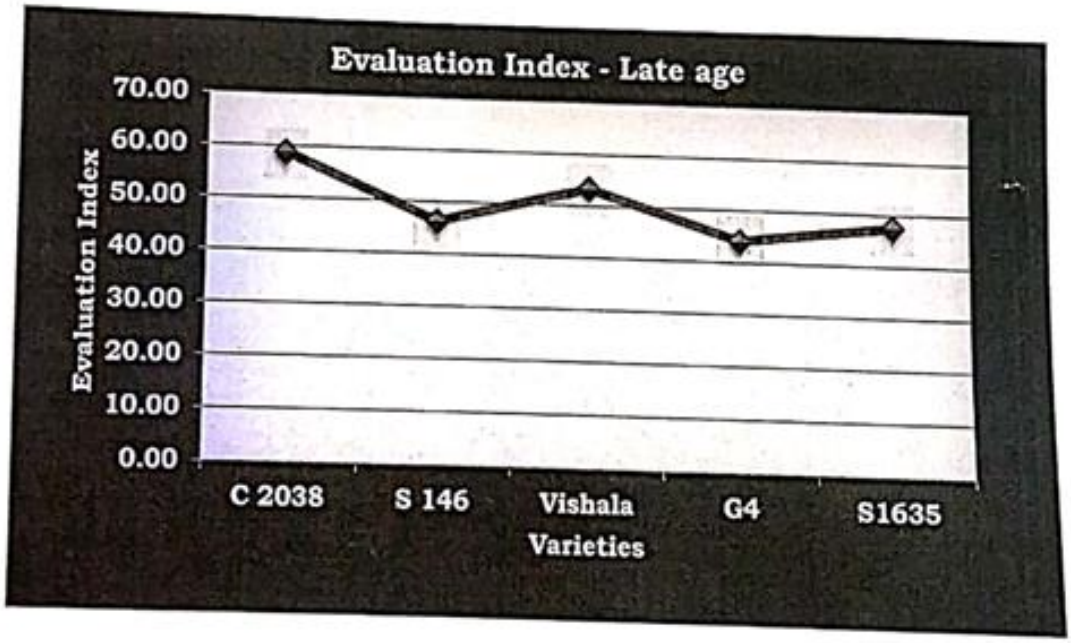

Fig 2. Evaluation index for moisture content and moisture retention capacity of five different elite mulberry varieties evaluated during late age of silkworm, *Bombyx mori* L. during spring season (2019)

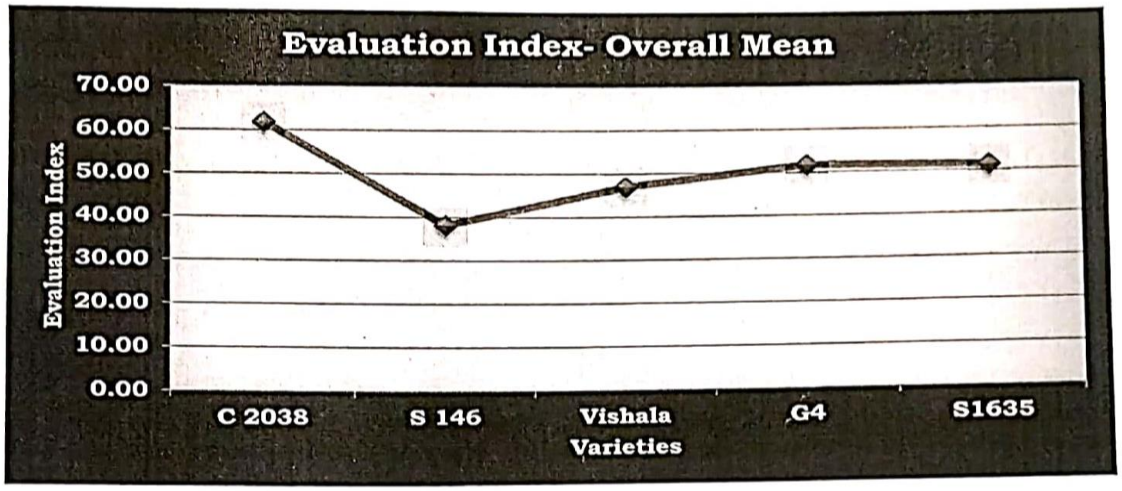

Fig 3. Evaluation index of overall mean for moisture content and moisture retention capacity of five different elite mulberry varieties evaluated for silkworm, *Bombyx mori* L. during spring season (2019)

DISCUSSION

The results of the investigation are discussed in the light of available literature with the following subheadings.

Moisture content and moisture retention capacity during chawki stage and late age silkworm rearing (2019)

High leaf moisture content and moisture retention capacity of the mulberry genotypes have a positive influence on the growth and development of silkworm. For successful rearing, the maintenance/retention of sufficient moisture content in the leaves for prolonged periods is of immense importance Legacy (1958), Hamamura et al. (1962), Mandal and Krishnaswami (1965). Different genotypes are said to influence the leaf moisture content and its retention in harvested leaf. Besides, environmental factors, leaf anatomical parameters like stomatal size, stomatal frequency, mesophyll tissue, cuticle thickness and leaf thickness also influence the moisture content of the leaf and its retention capacity.

Further Hamamura (1959) and Waldbauer (1964) have stated that silkworm *B. mori* being monophagus insect, consumes only mulberry leaves. Ueda and Suzuki (1967); Paul et al. (1992) reported that nutritional quality of the leaves play a important role in silkworm rearing, higher moisture content is known to increase the amount of ingestion and digestability of silkworm because moisture act as olfactory and gustatory stimulant. Kasiviswanathan and Iyengar (1965); Kasiviswanathan et al. (1977; 1979) have carried out studies on the leaf yield and bioassay of mulberry varieties through silkworm rearing which clearly indicated varietal difference in all parameters regulating leaf quality. Terkaraptyan et al. (1966); Narayanan et al. (1967); Krishnaswami et al. (1970); Koul et al. (1980); Sastry et al. (1988) studied the effect of mulberry varieties on the growth and economic characters of silkworm. These studies showed that quality of mulberry leaf is one of the major deciding factors for healthy growth of silkworms and success of cocoon crops. The quality of leaf is influenced by a number of factors such as variety, cultural practices, incidence of pest and diseases, method of harvesting and preservation of leaves.

The varieties which were superior with respect to yield and growth parameters were selected to assess the moisture content and moisture retention capacity at 6 h, 12 h and 24 h during spring (2019) for chawki and late age rearing time. The results of five different elite mulberry varieties viz., S146, S-1635, G-4, Vishala and C-2038 for moisture content and moisture retention capacity at 45 days after pruning (DAP) are as follows.

Leaf moisture content (%)

Vishala recorded maximum moisture content (76.83 %) followed by C - 2038 (76.61 %), G - 4 (75.40 %), S -146 (75.20 %), whereas minimum moisture content was noticed in S - 1635 (74.64 %). All the varieties showing significant differences among each other for moisture content recorded during chawki stage of silkworm rearing. During late age of silkworm rearing, all the varieties showed significant differences statistically among each other for moisture content, the variety C - 2038 recorded maximum moisture content (77.24 %) followed by S - 1635 (76.02 %), Vishala (74.76 %) and S - 146 (74.47 %), whereas minimum moisture content was noticed in G - 4 (72.98 %). The overall mean revealed that, C-2038 recorded maximum moisture content (76.93 %) followed by Vishala (75.80 %), S-1635 (75.33 %) and S-146 (74.84 %), whereas minimum moisture content was noticed in G - 4 (74.19 %) and observed significant differences among all the varieties with respect to moisture content for overall mean during complete rearing.

Ueda and Suzuki (1967) and Paul et al. (1992) observed that availability of moisture content in the leaves enhances the feeding efficiency of larvae which in turn increases the growth rate. Parpiev (1968) reported that the leaf moisture content may serve as one of the criteria in estimating the leaf quality. Anonymous (1970 b) noticed wide range of variation for moisture content in tender (61.58 to 74.17 %), medium (58.48 to 70.35 %) and coarse mulberry leaves (53.36 to 69.00 %).

Sengupta et al. (1971) also reported that the low moisture adversely affects the growth and development of silkworm. Kasiviswanathan et al. (1973) demonstrated that moisture loss can be minimized over a certain period of time using wet gunny cloth or alkathene sheet. The moisture content of the leaf fit for young age silkworm rearing ranged from 75 (Ber S1) to 78 per cent (S-41) whereas S-30 and S-36 showed 74 per cent leaf moisture (Anon.,1983b). Maximum moisture content in Chawki leaf was recorded in Kosen (77.34 %) followed by Ber C-799 (77.30 %) out of 25 varieties except in S-1 where the moisture content was not above 70 per cent (Anon., 1983c).

Thangamani and Vivekanandan (1984) observed wide range of variation in eight varieties of mulberry for moisture content (63.67 to 70.60 %) and total sugars (8.64 to 15.58 %). Sujathamma and Dandin (2000) studied 23 elite mulberry genotypes and observed wide range of variation in moisture content of fresh leaves which ranged from 64.4 to 76.94 per cent. The maximum value was found in Tr-10 followed by Tr-4 (75.99 %) and minimum moisture percentage was recorded in Sujanpur-5. The moisture retention ranged from 57.39 to 71.41 per cent in 23 elite genotypes. Higher moisture retention was found in Tr-10 (71.41 %) followed by Tr-4 (70.14 %) and the minimum was noticed in Sujanpur-5 (57.39 %).

Leaf moisture retention capacity (%)

Among five mulberry varieties G - 4 retained maximum moisture content (95.79 %) followed by C - 2038 (95.73 %), S -1635 (94.94 %), S - 146 (94.67 %) whereas minimum retention was noticed in Vishala (94.07 %) during chawki stage. During late age, among five mulberry varieties, Vishala retained maximum moisture content (96.16 %) followed by S - 1635 (96.03 %), C - 2038 (95.73 %) and G - 4 (95.68 %), whereas minimum retention was noticed in S - 146 (95.21 %) at 6 h. For overall mean, among five mulberry varieties C - 2038 & G - 4 retained maximum moisture content (95.73 %) followed by S - 1635 (95.48 %) and Vishala (95.12 %), whereas minimum retention was noticed in S - 146 (94.94 %). All the varieties showed statistically non - significant among each other for moisture retention capacity at 6 h for chawki stage, late age and overall mean.

All the varieties showed significant differences among each other for moisture retention capacity during chawki stage at 12 h, the variety C - 2038 retained maximum moisture retention (92.71 %) followed by G - 4 (92.33 %), S - 1635 (91.90 %) and Vishala (90.30 %), whereas minimum moisture

retention at 12 h was recorded in S 146 (87.84 %). During late age, the variety C - 2038 retained maximum moisture (92.09 %) followed by S - 146 (92.08 %), Vishala (92.06 %) and G - 4 (91.93 %) whereas minimum moisture retention at 12 h was recorded in S - 1635 (91.28 %) at 12 h and showed non - significant among them. For overall mean, there is statistical differences was observed among all the varieties for moisture retention capacity at 12 h, the variety C - 2038 retained maximum moisture content (92.40 %) followed by G - 4 (92.13 %), S - 1635 (91.59 %) and Vishala (91.18 %), whereas minimum moisture retention at 12 h was recorded in S - 146 (89.96 %).

During chawki stage, higher moisture was retained in variety C - 2038 (89.17 %) followed by G - 4 (88.02 %), S - 1635 (87.52%) and Vishala (84.58 %), whereas, it was least in the variety S - 146 (81.97 %) and recorded significant differences among all the varieties at 24 h. During late age rearing, higher moisture was retained in variety C - 2038 (86.34 %) followed by Vishala (84.72 %), S - 146 (84.60 %) and S - 1635 (84.26 %), whereas, it was least in variety G - 4 (83.88 %) at 24 h and showed non-significant among all the varieties. For overall mean, higher moisture was retained in variety C - 2038 (87.76 %) followed by G - 4 (85.95 %), S - 1635 (85.89 %) and Vishala (84.65 %), whereas, it was least in variety S - 146 (83.28 %). Among all the varieties there is significant differences was observed statistically at 24 h for overall mean.

Higher moisture content and its retention capacity of leaves help to remain fresh for longer time acceptable to silkworms are related to thickness of leaves which in turn due to the ratio of palisade to parenchyma cells found in were recorded by Hesketh et al. (1985). Size of the stomata and its frequency‘s role in moisture retention, transportation and CO2 exchange rate was discussed by Susheelamma and Jolly (1986).

Jolly and Dandin (1986) have reported that the moisture content and moisture retention capacity of leaves were higher in triploid genotypes even after the 12 hours of excision may be due to lower number of stomata per mm2. Similar observations were made by Geok and Dunn (1975), Sikdar et al. (1986) and Sharma (1986). Krishnaswami (1986); Chaudhury and Giridhar (1987) framed the package of practices for cultivating five mulberry varieties viz., S30, S36, S41, S54 and K2.

Ninge Gowda et al. (2002) studied fifteen exotic mulberry varieties for moisture content. Results revealed that Okinawa-2, *Morus* lambing, Thailand, Papuva, *Morus nigra*, *Morus multicaulis* varieties have higher moisture content compared to control K-2 variety. Govindan et al. (1988) observed significant difference in moisture content at 8 and 24 h after harvest in leaves of six varieties of mulberry like Mysore local, Kanva-2, S-30, S-36, S-41 and S-54.

Susheelamma et al. (1988) utilized twelve drought resistant mulberry varieties along with two cultivars for evaluation under natural stress (rain fed) condition. Moisture per cent and moisture retaining capability of leaves after 6, 12 and 24 h of excision were estimated. It was observed that the new mulberry varieties DTS-14, DRS-28, DRS-3, and DRS-34 retained more moisture in the leaves after 6, 12 and 24 hours of excision.

Sikdar (1986) observed that the leaves of polyploidy possess thickest cuticle, maximum thickness of upper and lower epidermis, and maximum thickness of palisade tissues which are responsible for higher moisture retention capacity of polyploidy. Since Goshoerami is also triploid mulberry genotype, this may be the reason for its higher moisture retention percentage reported by Baksh et al. (2001).

Mala et al. (1992) studied moisture per cent and moisture retention capacity in five mulberry varieties and concluded that S-36, S-30, K-2 varieties possessed maximum moisture per cent and moisture retention capacity as compared to other varieties. Bongale and Chaluvachari (1995) reported that Mysore local variety possessed lower leaf moisture content and moisture retention, while

English Black, KNG, Berhampore-5 variety had relatively higher moisture and moisture retention capacity out of eight mulberry varieties used for the study.

Mallikarjunappa et al. (2000) evaluated four improved mulberry genotypes namely S-30, S-36, Viswa and M-5 for moisture content and moisture retention capacity. The leaf moisture content was significantly higher in Viswa (77.74 %) and S36 (77.24 %) genotypes. Leaf moisture loss at 6 h after harvest was significant loss in S-36 and S-30 genotypes (13.46 and 13.92 % respectively). Basavaiah and Murthy (2001) studied 16 diploid mulberry genotypes, 4 triploid genotypes and 5 induced tetraploids for leaf anatomical features. The results showed direct correlation between anatomical features, moisture content and moisture retention capacity of leaf are genotype specific.

Tikader and Roy (2003) conducted the experiment on 15 accessions for moisture per cent and recorded maximum values for Senmates (81.40 %) and lower in Kajli (56.83 %), moisture retention capacity was higher in Senmates (88.07 %) and lower in *M. indica* (35.21 %). Susheelamma and Dandin (2006) studied five mulberry varieties for moisture per cent and moisture retention capacity which ranged from 74.15 to 79.00 per cent, 61.60 to 66.15 per cent respectively. The improved cultivars like S-13, S-34 and V-1 exhibited higher moisture content and moisture retention capacity of leaf compare to commercial cultivars like Kanva-2 and S-36.

Jalaja Kumar and Ram Rao (2008) studied leaf quality parameters in seven mulberry genotypes viz., V-1, V-2, V-4, K-2, S-13, S-36 and S-54 and reported higher leaf moisture content (LMC) and moisture retention capacity (MRC) in V-1 (75.93 and 82.17 %) followed by V-4 (75.67 and 81.64 %) and S36 (75.14 and 81.27 %), while these two traits were found to be lowest in K-2 (69.50 and 76.25 %). Leaves characterized by higher LMC and MRC were identified as superior quality leaves (Bongale & Chaluvachari, 1995). Also the above two traits are closely associated with the feeding efficiency and growth rate of silkworm larvae (Paul et al., 1992 and Chaluvachari & Bongale, 1995).

Mamrutha et al. (2010) studied variability for moisture retention capacity (MRC, measured as leaf relative water content after one to five hours of air drying) by screening 250 diverse mulberry accessions and the relationship between MRC and leaf surface (cuticular) wax was determined. Leaf MRC was significantly different among accessions and was found to correlate strongly with leaf surface wax. Moisture contents were high in tender followed by medium and coarse leaves. Moisture content and moisture retention capacity were significantly high in S1708 and lowest in C6 leaves (Murthy et al., 2013).

Evaluation index for mulberry varieties used during chawki and late age rearing w.r.t moisture content and moisture retention capacity

The mulberry varieties *viz.*, S-146, S-1635, G-4, Vishala and C-2038 were fed with double hybrid FC1×FC2 and the same varieties used for recording of moisture content and moisture retention capacity. During chawki rearing according to the evaluation index, the mulberry varieties were shortlisted as C-2038 having E.I value 59.30 followed by G-4 (54.82) respectively. During late age rearing, according to the evaluation index, the mulberry varieties were shortlisted as C - 2038 having E.I value 58.75 followed by Vishala (53.32) respectively. According to the evaluation index for overall mean, the mulberry varieties were shortlisted as C – 2038 having E.I value 61.79 followed by G-4 (51.76) and S-1635 (51.33) respectively.

Mulberry (*Morus spp.*) is an important plant forming the backbone of sericulture as it is the only food for silkworm. Due to its importance in silk producing areas, multiple varieties of mulberry have been developed suited to different agro climates and topographies. Fotadar and Dandin (1997) reported that due to heterozygous nature of mulberry, variability is high. Variations in characters have also been reported by Dorcus

and Vivekanandan (1991). Munshi et al. (2001) and Pandit et al. (2006) reported that for multiple character analysis, evaluation index formed a good tool for determining the superiority of mulberry varieties. They however advocated the inclusion of feeding response to give the holistic results.

Seven mulberry varieties recorded mean evaluation index (E.I.) values of >50 ranging from 50.01 to 60.29, whereas, control (Sujanpur) scored E.I. value of 35.10 only. Three mulberry varieties, S-146 (60.29), Tr- 8 (52.42) and Tr-10 (52.17) recorded average E.I. value >52 for all the characters under subtropical conditions (Sajgotra et al., 2018).

CONCLUSION

According to the evaluation index, during chawki rearing the mulberry varieties were shortlisted as C - 2038 followed by G - 4. During late age rearing, the mulberry varieties were shortlisted as C - 2038 followed by Vishala and overall mean, the mulberry varieties were shortlisted as C - 2038 followed by G-4 and S-1635 w.r.t. moisture content and moisture retention capacity.

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