Mysore J. Agric. Sci., 59 (2) : 124-136 (2025)

Rescheduling of Brushing and Pruning Dates for Stabilization of Second Commercial Mulberry Silkworm Crop in Kashmir Valley

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Received : October 2024
Accepted : November 2024

Abstract

In Kashmir valley only spring silkworm cocoon crop has been stabilized; primarily based on the sprouting behavior of ruling mulberry varieties, pruning schedule of mulberry and silkworm brushing schedule. Autumn silkworm crop is also practiced to some extent but with limited success owing to either unavailability of mulberry leaves in certain areas or due to availability of over matured leaves in other areas. The problem of autumn crop stabilization is further propounded by clashing of autumn silkworm rearing with harvesting season (August and September) of other cash crops. However, two mulberry silkworm crops can be stabilized, if pruning of mulberry host plant and silkworm brushing are synchronized to coincide with preponing of autumn silkworm crop. With this background, the research work on rescheduling of autumn crop with four treatments and one control were carried for a period of two years from 2020 to 2022 at CSR & TI, Pampore. Data on six economic traits were recorded and the pooled data of two years was analyzed. The analyzed data revealed that timely pruning ensures the supply of quality mulberry leaves of 60-65 days old as against over mature leaf of more than 75 days in control. Further, weight of 10 mature larvae (39.94g, 34.00g), defective cocoon percentage (3.0%, 5.8%), cocoon yield per 100 DFLs (80.93kg, 77.01kg), single cocoon weight (1.68g, 1.63g) single shell weight (0.37g, 0.33g), cocoon shell ratio (22.31%, 20.41%) were found to be highest and significantly different in between brushing dates of 5th and 10th August as against control brushing date of 20th August. The study concludes that advancing autumn brushing by 10-15 days, instead of the current practice of brushing on August 20th, can stabilize the second mulberry cocoon crop in temperate areas. This change shall economically benefit eight thousand sericulture households in Kashmir valley ensuring stable production and sale of quality autumn cocoons, in addition to the spring silkworm crop.

Keywords : Brushing, Pruning, Rescheduling, Stabilizing, Silkworm rearing

Sericulture is an agro-based cottage industry practiced in more than 30 countries across the world. These nations are spread over a variety of climate zones, ranging from tropical to temperate. In terms of raw silk output; China leads the globe followed by India (Ingle *et al.,* 2022). However, India is the only country which produces all four types of silks. Among these silks only mulberry is domesticated; whereas, Muga, Eri and Tasar are semi-domesticated. The major silk producing states in India are Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu & Kashmir for mulberry

silk (Dasari and Venkataramana 2023) Bihar, Orissa, Madhya Pradesh and Jharkhand for Tasar (Rai and Satyanarayana 2022) and Assam for Eri and Muga Silk. North Western Indian states contribute only 2-5 per cent of total raw silk produced in the country and majority share of itcomes from Spring crop which is the only stable mulberry cocoon crop in the region (Mir *et al.,* 2018 and Singh & Murali 2019). Farmers mainly rely on tree type of mulberry cultivation (Illahi *et al.,* 2019; Rathore *et al.,* 2011 and Srinivasulu *et al.,* 2011) which are mainly available on the bunds of rivers, roadside, departmental nurseries and very less number on the boundaries of agriculture crops (Singhal *et al.,* 2003 and Mohan *et al.,* 2011). They hesitate to grow mulberry on their prime land due to subsidiary nature of sericulture also with stiff competition from existing cash crops *viz.,* wheat, maize, paddy & sugarcane (Mir *et al.,* 2022; Rafiqui *et al.,* 2023).

Among the states of North Western India, Jammu & Kashmir is renowned for producing high-quality bivoltine silk (Khan *et al.,* 2016). Sericulture is a source of income for around 29,400 farmer families in J&K (Kutala *et al.,* 2019). In Kashmir division of Jammu & Kashmir, sericulture is mainly practiced during spring season owing to salubrious climatic conditions and stabilized package of practices. Rearing is also practiced during summer and autumn seasons, but on a very small scale owing to unstabilized brushing and rearing schedules and climatic variability (Rai *et al.,* 2023). In recent years, although attempts for stabilization of second and third commercial rearing (summer & autumn) have been made, but the attempts have yielded mixed results (Neelaboina *et al.,* 2017; Parvez *et al.,* 2023 and Saleem *et al.,* 2023). The reason for this is that fewer than 10 per cent of silkworm farmers who practice both summer and autumn rearing do so primarily by rearing summer silkworms on the remaining spring leaves (Aslam *et al.,* 2016) and autumn silkworms on over mature leaves (Singh & Murali, 2021 and Qadri *et al.,* 2024) at a time that also conflicts with the harvesting of other field crop (Mehraj *et al.,* 2023). This has created a situation, where in certain sericultural farmers of Kashmir valley are restricting sericulture only to single spring crop and are on increasing note abandoning the sericultural practices during autumn season (Sharma *et al.,* 2022; Illahi *et al.,* 2016; Singh & Murali, 2020 and Mir *et al.,* 2024) and concentrating on other horticultural and agricultural crops.

Although concentrating on summer crop would not be feasible for second commercial crop because more than 80 per cent of leaf (at farmer's level) is consumed during spring season and only less than 20 per cent is left for summer rearing (Aslam *et al.,* 2016). Hence, in order to stabilize second commercial crop, preponing the autumn rearing by synchronizing mulberry pruning with silkworm rearing is the best option as it avoids over maturity of mulberry leaves and collision with the harvesting period of other field and horticultural crops (Ramakant *et al.,* 2011; Bindroo, 2010 and Shivkumar *et al.,* 2018). With this background, the research was carried out to reschedule autumn crop by synchronizing mulberry pruning with that of silkworm brushing for stabilization of autumn rearing and to increase the overall quality cocoon production at farmer's level in the Kashmir.

Material and Methods

The research work was carried at the Central Sericultural Research and Training Institute (CSR & TI), Pampore for a period of two years from 2020 to 2022. The mulberry plantation at CSR & TI, Pampore was pruned with five treatments including one control and maintained accordingly to the package and practices for temperate mulberry plantation (Table 1). Ichinose variety (Bush) and Goshoerami variety (Tree) were utilized for chawki rearing and late age rearing respectively, because these two mulberry varieties account for more than 55 per cent of the total mulberry varieties accessible in Kashmir (Shabnam *et al.,* 2016; Hossain *et al.,* 2016; Rohela *et al.,* 2018 and Islam *et al.,* 2022).

Ten (10) Disease Free Layings (DFLs) of FC1 x FC2 bivotine silkworm hybrid which is the ruling hybrids

Table 1

Details of mulberry experimental plantation, cultural operations and inputs

Details of Silkworm Hybrid and MulberryVarieties	Cultural operations and inputs
Name of silkworm hybrids: FC1XFC2.	FYM–10-20kg /plant/year
Number of replications: 04.	Chemical fertilizer-Perplant/year: In two split doses i.e., April and July.
Name of mulberry variety: Ichinose for Chawki and Goshoerami for late age.	Urea: 99gm (1stDose) &163gm (2ndDose). (Nitrogen-46%).
Mode of plantation: bush for Chawki and Tree for late age	DAP: 163gm (Nitrogen-16% and Phosphorous-84%) in Single Dose.
Age of plants: 8-10 years old	MoP:125 gm (Potash-100%) in Single Dose
Spacing: 3' X 3' (90 ×90 cm), 9'X 8' (270 × 240 cm)	Pruning: Top clipping during March and bottom pruning in June
No. of plants is experiment: 20	Digging/ Weeding: During March, June and November

in Jammu & Kashmir (Neelaboina *et al.,* 2019) was adopted for each treatment and brushed as per the mentioned brushing treatment schedule (Table 2) with four replications in each treatment.

Three feeds of mulberry leaves were given to silkworms at the interval of 8 hr per day. The design used for this experiment was completely randomized design. Two hundred fifty (250) larvae were retained per replication after chawki stage till the end of 5th instar and the mature larvae were collected manually and mounted on plastic collapsible mountages for cocoon spinning. Optimum temperature of 25° C and Relative Humidity of 70 per cent were maintained during spinning because appropriate temperature and humidity has a direct bearing on reelability, raw silk yield and quality of raw silk (Naik and Somashekar, 2004). Cocoon harvesting was done on 7th day of mounting. Data was recorded for six economic parameters *viz.,* weight of 10 mature larvae, defective cocoon percentage, single cocoon weight, single shell weight, cocoon shell ratio (SR%) and Cocoon yield per 100 DFLs (Productivity) as per the methods mentioned in Table 3. These parameters were recorded because they not only highlight the performance of silkworms but also play a vital role in the silk value chain.

Table 2

Pruning, brushing treatments along with age of mulberry leaf

Treatments	Date of pruning (Chawki)	Date of Pruning (Late age)	Date of brushing	Late age rearing	Age of leaf
Control	05th June	15th June	20th Aug	30th Aug	75 days
T-1	10th June	20th June	15th Aug	25th Aug	65 days
T-2	05th June	15th June	10th Aug	20th Aug	65 days
T-3	01st June	10th June	05th Aug	15th Aug	65 days
T-4	01st June	10th June	01st Aug	10th Aug	60 days

Table 3

Details of economic parameter calculation methods

Parameter	Method / process of calculating
Weight of 10 mature larvae	Ten larvae were randomly selected and weighted on digital balance to determine weight of 10 mature larvae
Defective cocoon percentage	The total defective cocoons were calculated among the available cocoons from 250 larvae by the following formula and were expressed as a percentage using the following equation, Defective cocoon (%) = {No. of good cocoons - No. of (flimsy + double + stained) cocoons × 100.
Cocoon yield per100 DFLs	It was calculated by weighing cocoons harvested from the 250 larvae and converting (Productivity) it into cocoons harvested from 40000 larvae.
Single Cocoon Weight(g)	Ten cocoons were randomly selected and weighted on digital balance to determine the single cocoon weight by using the following formula Single cocoon weight = Weight of 10 cocoon (g) /10
Single cocoon Shell Weight (g)	Ten cocoon shells from each replicate were weighted on digital balance to determine single shell weight. Single cocoon shell weight = Weight of 10 cocoon shells (g) /10
Cocoon Shell Ratio	The total quantity of silk available from a single cocoon was expressed as a percentage using the following equation, Shell ratio = (Single cocoon shell weight (g)/ Single cocoon weight (g)) × 100

Statistical Analysis

The effect of different pruning and brushing dates on six economic parameters weight of 10 mature worms (g), defective cocoon percentage, cocoon yield per 100 DFLs (Kg), single cocoon weight (g), single shell weight (g) and cocoon shell ratio were subjected to one way analysis of variance followed by post-hoc test (Tukey test) for comparison of means (Ostertagova and Ostertag, 2013).

Results and Discussions

Weight of 10 Mature Larvae (Larval Weight)

The data of two years was pooled and results revealed that the date of pruning and brushing had significant effect (F=28.005., df=4., P=0.000) on the weight of 10 mature larvae. The highest (39.942g) and lowest (34g) weight of 10 mature larvae was observed from the brushing dates of 5th August and 20th August (Control) respectively and the difference was significant. Further, Tukey test for larval weight parameter revealed that the treatment with pruning of mulberry on 1st June for Chawki leaves and on 10th June for late age leaf and subsequent brushing and late age rearing on 5th August and 15th August is significantly different from all other treatments (Fig. 1). Tukey test also revealed that two treatments with pruning dates of 1st June and 5th June for Chawki leaves supply and 10th June and 15th for late age leaves and subsequent brushing on 1st August and 10th August and Chawki distribution on 10th August and 20th August did not have significant differences but these two were significantly different from control and the pruning dates of 10th June for chawki leaves supply, 20th June for late age leaves supply and subsequent brushing and chawki distribution in between 15th to 25th August.

The results are consistent with Neelaboina *et al.,* 2017; Borah & Boro 2020; Maske *et al.,* 2020; Magadum *et al.,* (2021) and Natarajan & Borpuzari (2022) who reported that optimum feeding for mulberry leaves in case of commercial silkworm rearing includes healthy host plant, leaves of appropriate age with essential nutrients and other agronomic practices. This optimum feeding has an influence on the sustainability and profitability of the

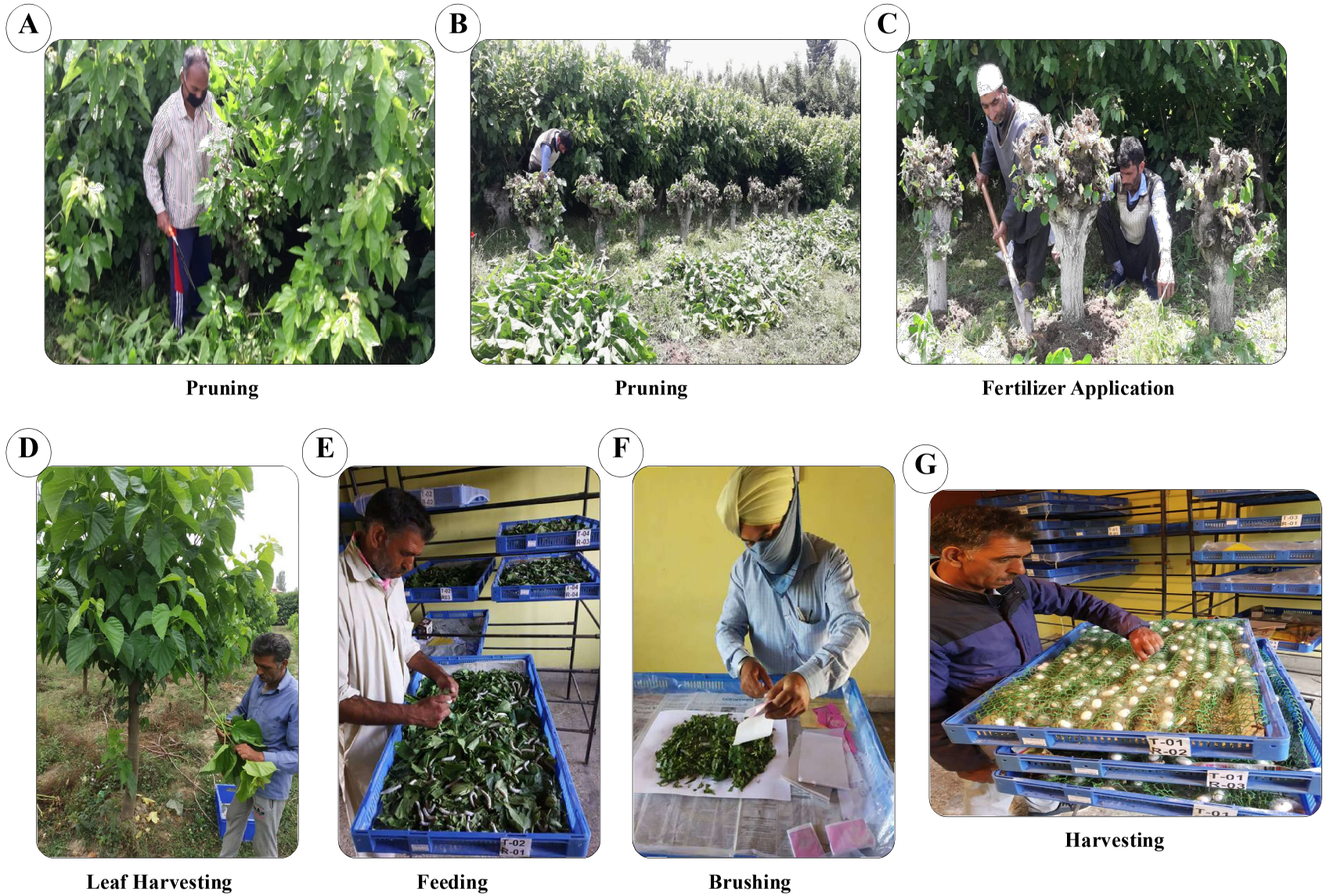

Fig. 1 : Rescheduling of brushing and pruning for stabilization of second commercial mulberry silkworm crop in Kashmir Valley; Bottom pruningof branches in mulberry plants for rescheduled autumn season; Bottom pruning of branches in mulberry plants for rescheduled autumn season; Fertilizer application for rescheduled autumn season; Leaf harvesting for late age rearing from rescheduled autumn season; Feeding during chawki rearing of rescheduled autumn season; Feeding during late age rearing of rescheduled autumn season; Harvesting of cocoon crop from rescheduled autumn season

sericulture sector. Therefore synchronizing pruning with brushing in autumn is one of the methods of improving cocoon quality and quantity. Because pruning increases absorption in the main trunk of plant and encourages secondary branches with healthy leaves and brushing ensures uptake of leaf of appropriate age, as ageing and maturity of mulberry leaf decreases its uptake by silkworm larva, thereby lowering the overall larval weight. From these results it is evident that even an autumn crop can be taken at the same level as that of spring crop with a weight of 10 mature larvae greater than 39g if quality of leaves are maintained by synchronizing pruning and brushing, along with maintenance of proper hygiene inside the rearing room.

Defective Cocoon Percentage

Data on defective cocoon percentage revealed that the date of pruning and brushing had significant effect (F=17.694., df=4., P=0.000) on the defective cocoon percentage. The highest percentage of defective cocoons (5.8%) was observed on brushing date of 20th August and lowest (3%) on 5th August and the difference was significant. Further, Tukey test for defective cocoon (%) parameter revealed that three treatments with pruning dates of 1st June to 5th June for Chawki leaves supply and 10th June to 15th for late age leaves supply and subsequent brushing and Chawki distribution in between 1st to 20th August did not have significant differences but these three were significantly different from the pruning dates of 5th to 10th June for chawki leaves supply and 15th to 20th June for late age leaves supply and subsequent brushing and chawki distribution in between 15th to 30th August.

The results are in confirmation with the studies of Hassan & Mir 2017; Mir Hosseini *et al.,* (2017); Ganaie *et al.,* (2020); Sharma *et al.,* (2020); Diga (2021) and Imtiyaz *et al.,* (2021) who reported that pruning methods on mulberry determines leaf re-growth that influence the quality of leaves available for silkworm feeding. However, without timely pruning the infestation of mulberry leaves by *Glyphodes* reaches to more than 40 per cent of mean infestation in September and peak in October and can cause a significant damage to mulberry foliage and increase in defective cocoon percentage which can be a major hurdle in successful autumn rearing. Weather is also one of the important factors that influences disease incidence in silkworm and the weather fluctuations during autumn is one of the major reason for crop loss and higher defective cocoon percentage. In general, the quantity and quality of the cocoons produced by silkworm during autumn decreases due to increasing mortality and access to mulberry leaves with low nutritive quality.

Cocoon Yield per100 DFLs (Cocoon Productivity)

In case of cocoon yield, results revealed that there was significant effect (F=33.864., df=4., P=0.000) of pruning and brushing date on cocoon yield per 100 DFLs. The cocoon yield was highest (80.93kg) on the brushing date of 5th August and lowest (77.01kg) on brushing date of 20th August and the difference was significant. Further, Tukey test for cocoon yield revealed that two treatments with pruning dates of 1st June to 5th June for chawki leaves supply and 10th June to 15th June for late age leaves supply and subsequent brushing and chawki distribution in between 5th August to 20th August did not have significant differences. However these two were significantly different from three treatments in which pruning dates were 1st-10th June, 5th-15th June, 10th-20th June with subsequent brushing and chawki distribution in between 1st-10th August, 20th-30th August and 15th-25th August.

The results are consistent with Alebiosu *et al.,* (2014); Singh *et al.,* (2017); Hadimani *et al.,* (2018), Khan *et al.,* (2018), Aadil *et al.,* (2020); Sharma *et al.,* (2022) and Nila and Jones 2023, who reported that over-matured leaves lack sufficient biochemicals and moisture and are unsuitable for feeding silkworms. However matured mulberry leaves are high in nutritional qualities and silkworm larvae fed on matured leaves has high assimilation and conversion efficiencies. Also the date of brushing has a significant effect on cocoon quality and quantity because it avoids both immature and over mature mulberry leaves. Therefore pruning of mulberry plants and synchronization with brushing date should be

encouraged to achieve a high silkworm cocoon yield. Furthermore, along with pruning and quality mulberry leaf production, season-specific silkworm hybrid will not only enhance cocoon productivity during the autumn season, but will also help to open up for two stable silkworm crops in Kashmir region.

Single Cocoon Weight (g)

In case of single cocoon weight results revealed that there was significant effect (F=8.834., df=4, P=0.001) of pruning and brushing date on single cocoon weight. Highest single cocoon weight (1.68g) was observed in case of brushing date of 10th August and lowest (1.635g) in case of brushing date of 20th August and the difference was significant. Further, Tukey test for single cocoon weight parameter revealed that two treatments with pruning dates of 1st June to 5th June for Chawki leaves supply and 10th June to 15th for late age leaves supply and subsequent brushing and Chawki distribution in between 5thAugust to 20th August did not have significant differences. These two were significantly different from three treatments in which pruning dates were 1st-10th June, 5th-15th June, 10th-20th June with subsequent brushing and chawkei distribution in between 1st-10th August, 20th-30th August and 15th-25th August.

The findings are consistent with Qader *et al.,* (1992); Thiagarajan *et al.,* (1993); Sajgotra *et al.,* (2017); Bhaskar *et al.,* (2020) and Bekkamov 2023, who reported that mature leaves show higher cocoon weight as compared to mature coarse leaves which might be due to the nutritive value of mulberry leaves. Since, nutritional value of mulberry leaves has a substantial impact on the growth dynamics, biological markers and silk gland activity of mulberry silkworms, the growth is determined. Pruning is one of the cultural activities that improves mulberry leaf quality and productivity. Along with pruning, the brushing date has a direct impact on availability of quality mulberry leaf, because appropriate brushing date ensures mulberry leaf of appropriate age as against immature and over mature leaf which adversely affect the economic parameters of cocoon like cocoon weight, cocoon shell ratio particularly during autumn. In addition to the nutritional value of mulberry leaves, temperature and humidity variations during different seasons also influence commercially important economic parameters of cocoons which are significantly more infor early brushing in autumn as compared to late brushing.

Single Shell Weight (g)

Results for single shell weight revealed that pruning and brushing date had significant effect (F=10.989, df=4., P=0.00) on shell weight. Maximum single shell weight (0.3725g) was observed in case of 5th August and lowest (0.3375g) in case of 20th August and the difference was significant. Further, Tukey test for single shell weight parameter revealed that two treatments with pruning dates of 1st June to 5th June for Chawki leaf supply and 10th June to 15th June for late age leaf supply and subsequent brushing and Chawki distribution in between 5th August to 20th August did not have significant differences but these two were significantly different from three treatments in which pruning dates were 1st-10th June, 5th-15th June, 10th-20th June with subsequent brushing and chawkei distribution in between 1st-10th August, 20th-30th August and 15th-25th August.

Results are in confirmation with Yao *et al.,* (2000); Ramachandra *et al.,* (2008); Mohan *et al.,* (2015); Kumar *et al.,* (2018); Angotra *et al.,* (2021) and Lavanya and Bhaskar 2023 who reported that higher values of total soluble sugars, total nitrogen and total chlorophyll in mulberry are associated with significantly maximum; larval weight, single cocoon weight, single shell weight, CSR percentage and filament length. Good quality leaf is the prerequisite for production of quality cocoons, which can be maintained by application of fertilizers and manures along with other agronomic practices of timely pruning and harvesting of leaves. If pruning is not carried out, the leaves become coarser with less concentration of protein, sugar, amino acid and moisture content. In general, during autumn chlorophyll content decreasesin mulberry leaf with the stage of maturity and is higher at early stage in autumn than in later stages and also nitrogen content

shows a steep decline after 75 days of spring pruning. Therefore, agronomic practices in mulberry along with pruning if not synchronized with the appropriate brushing date, even then the qualitative and quantitative improvement in the form of economic parameters of silkworms cocoon weight, shell weight, shell ratio cannot be expected in autumn crop.

TABLE 4

Analysis of two year pooled data

Name of parameter	Treatment/ Brushing date	Mean ± SE	F/df/P(Sig)
Weight of 10 mature worms (g)	1st August	37.8500 ± .217 c	28.005/4/0.00
	5th August	39.9425 ± .473 d	
	10th August	38.2600 ± .391 c	
	15th August	35.8750 ± .554 b	
	20th August	34.0000 ± .456 a	
Defective cocoon percentage	1st August	4.0000 ± .454 a	17.694/4/0.000
	5th August	3.0000 ± .270 a	
	10th August	3.5875 ± .248 a	
	15th August	5.3500 ± .095 b	
	20th August	5.8000 ± .216 b	
Cocoon yield/100DFLs	1st August	79.4300 ± .414 b	33.864/4/0.000
	5th August	80.9300 ± .297 c	
	10th August	80.8525 ± .366 c	
	15th August	77.8475 ± .231 a	
	20th August	77.0100 ± .095 a	
Single cocoon weight (g)	1st August	1.6600 ± .004 b,c	8.883/4/0.001
	5th August	1.6725 ± .009 c	
	10th August	1.6800 ± .007 c	
	15th August	1.6475 ± .002 a,b	
	20th August	1.6350 ± .005 a	
Single shell weight (g)	1st August	.3600 ± .004 b,c	10.9894/0.000
	5th August	.3725 ± .002 c	
	10th August	.3700 ± .004 c	
	15th August	.3500 ± .004 a,b	
	20th August	.3375 ± .006 a	
Cocoon shell ratio	1st August	21.7175 ± .275 b,c	14.997/4/0.000
	5th August	22.3175 ± .032 c	
	10th August	21.9050 ± .108 c	
	15th August	21.0300 ± .164 a,b	
	20th August	20.4100 ± .273 a	

Cocoon Shell Ratio (SR%)

The findings for cocoon shell ratio revealed that date of pruning and brushing had a significant effect (F=14.997., df=4., P=0.000) on cooon shell ratio. The maximum cocoon CSR (22.317%) was recorded in case of brushing date of 5th August while the lowest CSR (20.41%) was reported for the brushing date of 20th August and the difference was significant. Further, Tukey test for CSR parameter revealed that two treatments with pruning dates of 1st June to 5th June for Chawki leaf supply and 10th June to 15th for late age leaf supply and sub sequent brushing and Chawki distribution in between 5th August to 20th August did not have significant differences. But these two were significantly different from three treatments in which pruning dates were 1st-10th June, 5th-15th June, 10th-20th June with subsequent brushing and chawki distribution in between 1st-10th August, 20th-30th August and 15th-25th August.

Results are in confirmation with Sabhat *et al.,* (2012); Rahmathulla (2012); Nooruldin *et al.,* (2015); Gupta and Dubey (2021); Suresh *et al.,* (2022) and Akarsha *et al.,* (2023) who reported that growth of the silkworm, cocoon parameters and silk quality very much depends on the quality of leaves fed to them. The leaf quality is influenced by various factors suchas soil, pruning, fertilizer, irrigation etc.Timely mulberry pruning provides optimum growing period for the mulberry even during unfavorable seasons which leads to more biomass. Seasonal differences also considerably affect the genotypic expression in the form of phenotypic output of silkworm crop such as cocoon weight, shell weight and cocoon shell ratio. However, when conditions are optimum for mulberry leaf regrowth and silkworm rearing, commercial value in the form of cocoon shell ratio is comparable to favorable seasons also. Further, under Kashmir conditions, concentration of all the nutrients in mulberry leaves have been either highest or stable in between 1st to 15th August, hence this period can be suitable for taking up 2nd commercial silkworm crop on June pruned mulberry trees.

High yielding mulberry varieties and season specific silkworm hybrids will only exhibit their true potential when the management of mulberry plantation and silkworm rearings is done as per the scientific methods. By focussing on the challenges posed by temperature fluctuations, pests, diseases, clashes with harvesting of field crops and the use of over-mature mulberry leaves during autumn, this research aimed to stabilize the autumn silkworm crop (*Bombyx mori* L.) through rescheduling of pruning and brushing dates in temperate areas. The study provided valuable in sights into the management practices like optimal timing for mulberry pruning and silkworm brushing and their synchronization, which significantly influences the quality and quantity of cocoon production. The pooled data revealed that the four treatments on all economic parameters were on par or better than control. Hence the study concludes that for stabilizing second crop in temperate areas, autumn brushing can be preponed by 10-15 days as against the ongoing practice of brushing on 20th August. This intervention shall have positive economic implications on more than eight thousand sericulture households in Kashmir valley by stabilizing production and sale of quality cocoons from autumn crop in addition to production of cocoons during spring silkworm crop.

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