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# Influence of pytomulches on soil moisture status, growth and yield of mulberry (*Morus spp*.) under rainfed conditions of Kashmir

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**Abstract**

Mulberry (*Morus spp*.), the exclusive food for silkworms (*Bombyx mori* L.), plays a vital role in cocoon production. Despite the high-quality silk produced in Kashmir, the second cocoon crop during late summer/autumn faces serious challenges due to non-availability of quality leaf as a result of water scarcity, high temperature and erratic rainfall. This decreased leaf quality has a direct bearing with silkworm growth and development leading to reduced cocoon production and non-popularization of second cocoon crop at farmers' level in the region. In the present era where water becomes a limiting factor for both domestic and agricultural purposes, mulching seems to be an effective soil management practice that will help conserve soil moisture, reduce evaporation, regulate soil temperature and improve plant growth and yield. To address the challenges faced during late summer/autumn silkworm rearing, the study involved the use of phytomulches—paddy straw, dried weeds, wood chaff, dried leaves, aquatic weeds, Typha, and sawdust— to test their efficacy in improving soil moisture, mulberry growth and leaf yield under rainfed conditions of Kashmir, Jammu and Kashmir. The experiment revealed that mulching with Typha(T6) significantly improved soil moisture content (15.74%) besides improving plant growth and yield. These findings testify that phytomulches, particularly Typha, offer a sustainable, eco-friendly solution for mitigating water stress and ensuring consistent mulberry leaf production, ultimately supporting sericulture during challenging seasons.

**Keywords:** Soil, phytomulch, mulberry, leaf, yield

## Introduction

The leaf of mulberry (*Morus spp*.), only food to mulberry silkworm (*Bombyx mori* L.), contributes the maximum (38.2%) towards the success of silkworm cocoon crop (Miyashita, 1986). The mulberry leaf yield and its quality depend on soil type, variety, availability of plant nutrients and agro-ecological conditions which have direct bearing on cocoon production and quality. Kashmir is bestowed with climatic conditions which are very much congenial for the production of cocoons of global grade. Inspite of quality silk, the production does not increase to the expected extend because of many factors. The farmers due to having small land holdings besides a short growing season in the region, prefer the cultivation of food crops on their land. This has led to a situation where the farmers though like to go for silkworm rearing, have to depend for leaf on stray plantation growing under rainfed conditions. Quality leaf shortage worsens during late summer/autumn while different institutions/organisations associated with sericulture try to popularise 2$^{nd}$ crop during this season. The precipitation in the region during this period is low while the temperature is high. Rainfall which is quite erratic and uneven, is the only source of water for the plant as mulberry in the region grows under rainfed conditions. Low and erratic rainfall, high evaporative losses and limited water holding capacity of the soil constitute the principle constraints in the crop production in rainfed areas and mulberry is not an exception. Since water is an important material for photosynthesis and an effective medium for transportation of nutrients between the soil and plant and within the plant, its preservation in the soil and its subsequent use by the plant may go a long way in improving the leaf yield and quality. Therefore, the maintenance of proper moisture status of soil, plant and leaf is of utmost importance.

Amongst many strategies that can improve the leaf yield and quality during this season, conservation of soil moisture is of utmost importance because the soil water status has a relationship with the water of the plant and the leaf, the main produce from mulberry cultivation in sericulture. Mulching which is the process of applying or spreading anything on soil surface is one of the practices which can address this problem that hinders the success of silkworm rearing during late summer/autumn. Mulching has been proved very effective to conserve the soil moisture thereby leading to better yields in sorghum (De *et al*., 1983) [5], wheat (Mittal *et al*., 1986) [15] and mustard (Mondal *et al*., 1987) [16]. Mulches have been reported to buffer soil temperature (Greenly and Rakow, 1995) [10], prevent soil water loss by evaporation (Gleason and Iles, 1998) [9] and improve soil fertility and crop productivity (Bucagu *et al*., 2013) [1]. Mulching reduces the amount of water loss from the soil due to evaporation thus helping to minimize the frequency of irrigation and even distribution of moisture in the soil. This reduces plant stress leading to better crop growth and yield. Mulching controls evaporation losses and minimizes energy supply to the evaporating site by cutting off solar radiation falling on the ground. An increase of 24.16 - 48.63 per cent in leaf yield has been realized in mulberry by the use of mulches (Purohit *et al*., 1990) [21]. Earlier plastic was used as mulch but with the environmental health concerns use of eco-friendly mulches is the need of the hour.

Phyto-mulches such as dry grass, rice straw, wheat straw, palm leaf, compost and banana leaves are being used. Phytomulches being locally available, eco-friendly and cost effective can be used in mulberry. Certain phytomulches have been found very useful to improve soil temperature and moisture besides the growth and yield in mulberry under rain fed conditions of West Bengal (Purohit *et al*., 2006) [19]. However, mulching efficacy is greatly altered if the material to be used is not selected properly. Therefore, in any crop, screening of locally available mulches which can best serve the purpose is imperative to get maximum benefit in an economical and eco-friendly way.

With these considerations, phytomulches seem to hold great promise to enhance mulberry productivity under Kashmir climatic conditions through conservation of soil moisture thereby necessitating the conduct of such studies in the region.

## Materials and Methods

The study was conducted at College of Temperate Sericulture Mirgund, SKUAST-Kashmir during autumn 2022 and 2023 as per following details:

| | | |
|---|---|---|
| Mulberry genotype | : | Gosheorami |
| Type of plantation | : | Dwarf |
| Rainfed/irrigated | : | Rainfed |
| Number of phytomulches | : | 07 |
| Number of treatments | : | 08 |

Paddy grass
Dried weeds
Wood chaff
Dried senesced leaves of plants other than mulberry
Aquatic weeds growing in water bodies (floating and submerged)
Typha
Saw dust
Without mulch (control)

| | | |
|---|---|---|
| Number of replications per treatment | : | 03 |
| No. of plants per treatment per replication | : | 06 |
| Design of experiment | : | Randomized Complete Block Design (RCBD) |

The study was conducted on well-established dwarf plantation of Goshoerami (a popular mulberry variety used during late-age rearing of silkworms in the region) maintained under rainfed conditions with uniform growth and vigour. Seven phytomulches viz., Paddy grass, Dried weeds, Wood chaff, Dried senesced leaves of plants other than mulberry, Aquatic weeds growing in water bodies (floating & submerged), Typha and Saw dust were spread/applied in the plots in 2-inch-thick layers so as to cover the soil completely during 2022 and 2023.

The various parameters recorded included:

- **Soil moisture:** Soil moisture was estimated at four soil depths *viz*. 0-15 cm, 15-30cm, 30-45cm and 45-60 cm in the middle of every month by gravimetric method.
- **No of branches per plant:** The branches were counted manually.
- **Average shoot length (m):** All the branches during were measured by means of a measuring tape and the average was calculated by taking mean of all the values recorded.
- **Fresh weight of 100 leaves per plant (g):** For fresh weight of leaves, composite samples of 100 leaves comprising of almost equal number of tenders, medium and coarse were taken and weighed immediately.
- **Leaf area ($m^2$):** Leaf area per plant was measured by disc method as proposed by Vivekanandan *et al.* (1972) [26].
- **Leaf yield per plant (kg):** Leaf yield was taken by harvesting and weighing full leaf of 3 plants per treatment per replication.
- **Moisture status of leaf:** Moisture status of leaf was determined on dry weight basis. Fresh samples comprising of tender, medium and coarse leaves were harvested early in the morning and weighed immediately. They were then stored at room temperature and weighed again after 06 and 12 hours. Finally, the leaves were dried in hot air oven at 60° C for 48 hours (NingeGowda and Sudhakar, 2002) and the moisture status worked out as per the following formulae:

**Leaf moisture content (%)**

**(a) Moisture (%) =** 

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

**(b) Moisture retention capacity after 6 hours (%)**

$$\text{MRC after 6 hours (\%)} = \frac{(\text{Weight after 6 hrs} - \text{Dry weight})}{(\text{Fresh weight} - \text{Dry weight})} \times 100$$

**(c) Moisture retention capacity after 12 hours (%)**

$$\text{MRC after 12 hours (\%)} = \frac{(\text{Weight after 12 hrs} - \text{Dry weight})}{(\text{Fresh weight} - \text{Dry weight})} \times 100$$

## Results

### Soil moisture

The soil moisture taken during the study was pooled depth-wise, analysed and is furnished in Table-1. It was observed that the mulches in general improved the soil moisture at all the four depths (figure-1).

**Depth 1: -** At this depth, T6 (Typha) registered the maximum average soil moisture of 20.980 per cent being significantly higher than the rest of the treatments wherein it ranged from 19.673 per cent in T7 (Saw Dust) to 20.523 per cent in T1 (Paddy Straw). Soil moisture content in control was 17.787 per cent, the least among all the values.

**Depth 2: -** At this depth, the maximum moisture content (21.493%) was again recorded in T6 (Typha) being significantly higher than rest of the treatments wherein it ranged from 20.193 per cent in T7 (Saw Dust) to 21.083 per cent in T1 (Paddy Straw). Control registered the least average moisture of 18.073 per cent.

**Depth 3: -** At this depth, T6 (Typha) again recorded the maximum soil moisture content of 21.960 per cent being significantly higher than rest of the treatments wherein it ranged from 20.508 per cent in T7 (Saw Dust) to 21.651 per cent in T1 (Paddy Straw). The least value for average soil moisture (19.007%) was again recorded in control.

**Depth 4: -** At this depth, the maximum moisture content (22.337%) was recorded in T6 (Typha) being statistically higher than rest of the treatments wherein it ranged from 20.397 per cent in T7 (Saw Dust) to 21.342 per cent in T1 (Paddy Straw). Control had the least average moisture content of 20.098 per cent at this depth too.

**Overall improvement in soil moisture:** Mulching with Typha (T6) led to an improvement of 15.74 per cent moisture in soil. It was closely followed by an improvement of 13.88 per cent in T1 involving mulching with Paddy Straw and 11.80 per cent in T2 (Dried Weeds). In the rest of the treatments, though there was an improvement over the control, it was less than 10 per cent.

**Table 1:** Soil moisture status (%) as influenced by different phytomulches in mulberry.

| Treatments | D1 | D2 | D3 | D4 | Mean | Improvement over Control (%) |
|---|---|---|---|---|---|---|
| Paddy Straw | $20.523^{b}$ | $21.083^{b}$ | $21.651^{b}$ | $22.114^{b}$ | 21.342 | 13.88 |
| Dried Weeds | $20.074^{c}$ | $20.801^{c}$ | $21.133^{c}$ | $21.800^{c}$ | 20.952 | 11.80 |
| Wood Chaff | $18.570^{f}$ | $18.923^{f}$ | $19.616^{f}$ | $20.519^{f}$ | 19.407 | 3.55 |
| Dried Leaves | $19.163^{e}$ | $19.290^{e}$ | $19.943^{e}$ | $20.817^{e}$ | 19.803 | 5.67 |
| Aquatic Weeds | $18.143^{g}$ | $18.450^{g}$ | $19.183^{g}$ | $20.210^{g}$ | 18.997 | 1.37 |
| Typha | $20.980^{a}$ | $21.493^{a}$ | $21.960^{a}$ | $22.337^{a}$ | 21.693 | 15.74 |
| Saw Dust | $19.673^{d}$ | $20.193^{d}$ | $20.508^{d}$ | $21.212^{d}$ | 20.397 | 8.83 |
| Control | $17.787^{h}$ | $18.073^{h}$ | $19.007^{h}$ | $20.098^{g}$ | 18.741 | … |
| Mean | 19.364 | 19.788 | 20.375 | 21.138 | ... | … |
| C.D.($p \leq 0.05$) | 0.311 | 0.234 | 0.155 | 0.131 | … | … |

### Growth and yield parameters

The growth (Table-2) and yield (Table-3) parameters were recorded, coinciding with the 5$^{th}$ stage of autumn silkworm rearing.

### No. of branches per plant

The number of branches per plant, showed nonsignificant difference among different treatments. Data pertaining to No. of branches per plant and total shoot length is furnished in Table-2 and data pertaining to fresh weight of 100 leaves, leaf area per plant and leaf yield per plantis furnished in Table-3.

### Total Shoot Length per plant (m)

The maximum total shoot length per plant (47.13 m) was observed T6 (Typha), being significantly higher than the rest of the treatments. It was, however, followed by 45.80 meters shoot length per plant in T1 (Paddy Straw). In the rest of the treatments total shoot length per plant ranged from 35.69 meters in T8 (Control) 44.39 meters in T2 (Dried Weeds).

**Table 2:** Growth of mulberry (*Morus spp.*) as influenced by different phytomulches during autumn

| Treatments | No. of branches per plant | Total shoot length (m) | Fresh weight of 100 leaves (g) | Leaf area per plant ($m^2$) |
|---|---|---|---|---|
| Paddy Straw | 30.27 | $45.80^{b}$ | $418.54^{b}$ | $14.36^{b}$ |
| Dried Weeds | 31.45 | $44.39^{c}$ | $414.78^{c}$ | $14.18^{b}$ |
| Wood Chaff | 31.59 | $39.45^{f}$ | $400.23^{f}$ | $12.72^{e}$ |
| Dried Leaves | 31.34 | $41.14^{e}$ | $406.32^{e}$ | $13.23^{d}$ |
| Aquatic Weeds | 31.93 | $37.04^{g}$ | $396.03^{g}$ | $12.57^{ef}$ |
| Typha | 30.82 | $47.13^{a}$ | $423.12^{a}$ | $14.74^{a}$ |
| Saw Dust | 31.01 | $42.48^{d}$ | $410.86^{d}$ | $13.68^{c}$ |
| Control | 30.61 | $35.69^{h}$ | $376.28^{h}$ | $12.31^{f}$ |
| C.D.($p \leq 0.05$) | N. S. | 1.10 | 3.364 | 0.42 |

### Fresh Weight of 100 Leaves (g)

The highest fresh weight of 100 leaves (423.12g) was recorded in T6 (Typha) being, significantly higher than the rest of the treatments with least weight (376.28g) in T8 (Control).

### Leaf Area per Plant ($m^2$)

T6 (Typha) recorded the largest leaf area per plant (14.74 $m^2$) being, significantly higher than the rest of the treatments. It was the least (12.31 $m^2$) in Control. In rest of the treatments, it ranged between12.57-meter square in T5

(Aquatic Weeds) and 14.36-meter square in T1 (Paddy Straw).

### Leaf Yield per Plant (kg)
Leaf yield per plant was the highest (5.433 kg) inT6 (Typha) being statistically significant over the rest of the treatments where it ranged from 4.263 in T8 (Control) to 5.280 kilograms leaf per plant in T1 (Paddy Straw).

### Moisture status of leaf
The data pertaining to moisture status is described here under and is furnished in Table-3.

a) **Leaf moisture content (%):** The highest leaf moisture content (76.375%) was registered by T6 (Typha) being, significantly higher than the rest of the treatments. It was, however, followed by 75.650 per cent in T1 (Paddy Straw) and 74.834 per cent in T2 (Dried Weeds). T8 (Control) again had the lowest (70.124%) leaf moisture content.

b) **Moisture Retention Capacity after 6 and 12 Hours (%):** Studies revealed that though there was a slight difference in moisture retention capacity after 6 and 12 hours among different treatments yet the differences were statistically non-significant among the treatments.

**Table 3:** Leaf moisture status and yield in mulberry (*Morus spp.*) as influenced by phytomulches during autumn

| Treatments | Leaf moisture status | | | Leaf yield | |
|---|---|---|---|---|---|
| | Leaf moisture content (%) | Retention capacity after 6 hrs (%) | Retention capacity after 12 hrs (%) | Per plant (Kg) | Improvement over control (%) |
| Paddy Straw | 75.650$^{b}$ | 89.61 | 84.92 | 5.280$^{b}$ | 23.86 |
| Dried Weeds | 74.834$^{c}$ | 89.57 | 84.89 | 5.113$^{c}$ | 19.94 |
| Wood Chaff | 72.055$^{f}$ | 89.71 | 84.68 | 4.613$^{e}$ | 8.21 |
| Dried Leaves | 72.855$^{e}$ | 89.47 | 84.71 | 4.823$^{d}$ | 13.14 |
| Aquatic Weeds | 71.025$^{g}$ | 89.40 | 84.96 | 4.427$^{f}$ | 3.85 |
| Typha | 76.375$^{a}$ | 89.38 | 84.87 | 5.433$^{a}$ | 27.45 |
| Saw Dust | 73.910$^{d}$ | 89.35 | 84.99 | 5.017$^{c}$ | 17.69 |
| Control | 70.124$^{h}$ | 89.31 | 85.03 | 4.263$^{g}$ | .... |
| C.D.($p \leq 0.05$) | 0.716 | N.S. | N.S. | 0.115 | .... |

## Discussion
The observations recorded during the study are discussed here under:
The moisture content in soil influences the development, distribution and evolution of vegetation (Youn *et al* 2021; Du *et al* 2023) [30, 7]. The study revealed that soil moisture increased by all the phytomulches with T6 (Typha) registering the highest soil moisture (20.980, 21.493, 21.960 and 22.337 per cent respectively at D1, D2, D3 and D4) which was closely followed by 20.523, 21.083, 21.651 and 22.114 per cent at depth 1, 2, 3 and 4 respectively in T1 (Paddy Straw) as against the Control where soil moisture was below 20.100 per cent irrespective of all the depths. Mulching with agricultural waste (straw, compost, grass clippings, leaves, etc.) has been reported to improve water retention and reduce soil evaporation (Steiner, 1989) [23]. This improvement in soil moisture is because mulching keeps soil moisture from evaporating by covering the soil and also condensing the vapours to return to the soil as minute droplets of water (Yang *et al.*, 2015; Kader *et al.*, 2017) [28, 11]. As per Tuure *et al.*, (2021) [25], mulching helps to keep moisture around plants root zone, making water available to them for longer durations. Moreover, under rainfed conditions phytomulches not only help to retain moisture but prevent surface runoff of rain water and enhance its infiltration. The study is in conformity with the findings of Dahiya *et al.*, (2003) [3]; Taparauskiene and Miseckaite (2013) [24] and Zhang *et al.*, (2023) [31] who reported similar improvement in soil moisture by the use of phytomulches.
The application of phytomulches significantly influenced various growth and yield parameters of mulberry, except the number of branches per plant, which was statistically nonsignificant. Among the treatments, the highest fresh weight of 100 leaves (423.12 g), leaf area per plant (14.74 $m^2$) and leaf yield per plant (5.433 kg) were recorded in T6 (Typha) whereas the lowest fresh weight of 100 leaves (376.28g), leaf area per plant (13.31$m^2$) and leaf yield per plant (4.263kg) were recorded in T8 (Control). The study is also supported by Mir *et al.*, (2010) [14] who reported improvement in various growth parameters when different mulches were applied in mulberry under temperate conditions. The results are in conformity with Gangwar *et al.*, (2000) [8]; Purohit *et al.*, (2006) [19] and Dilip (2007) [6] in mulberry, Kumar *et al.*, (2018) in strawberry and Chandra and Govind (2001) [2] in ginger. Ramya *et al.*, (2023) [22] also reported improvement in growth and yield in mulberry under cowpea live mulching as against Control. The improvement in growth and yield could be due to enhanced soil moisture, soil organic matter and nutrient availability besides regulation of soil temperature.
Leaf moisture plays a vital role in improving the nutritional levels of mulberry leaves which in turn improve the palatability of leaves to silkworm. Many scientists have reported favourable effect of high moisture content of the leaves on their palatability and digestibility of silkworms (Waldbaurer, 1968; Yokoyama, 1975 and Paul *et al.*, 1992) [27, 29, 18]. Similarly, moisture retention capacity of leaves is also important parameter as the leaves with high moisture retention remain acceptable to worms after long time of harvest (Das and Vijayaraghavan, 1990) [4]. In the present investigation the moisture content in fresh leaf showed significant difference among different phytomulches on the other hand moisture retention capacity after 6 and 12 hours was nonsignificant among the treatments. The moisture content was the highest (76.375%) in T6 (Typha) while as the lowest (70.124%) in T8 (Control). The results are in conformity with the results of Mir *et al.*, (2010) [14] and Mir *et al.*, (2015) [13] who reported improvement in moisture content of leaf in various mulches as against control. The improvement in moisture content by the use of mulches may be because of improved soil moisture and temperature which play an important role in water absorption and the water status of plants.

## Conclusion

The study highlights the effectiveness of phytomulches in overcoming the challenges of late summer/autumn silkworm rearing under rainfed conditions of Kashmir. Among the tested mulches, Typha proved to be the most efficient, achieving 15.74 per cent improvement in soil moisture and 27.45 per cent increase in leaf yield over the control. By conserving soil moisture and improving mulberry growth and leaf quality, phytomulches provide a practical, cost-effective and eco-friendly approach to mitigate water stress. Based on the study, Typha, when used as mulch, demonstrated the highest efficiency in improving soil moisture, mulberry leaf yield and overall plant growth thereby providing an effective way to improve leaf yield and quality which will go a long way in popularization of second cocoon crop at farmers' level in the region.

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