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Intercropping mulberry (*Morus* spp.) with aromatic medicinal plants (Rosemary, Lavender, and Centella): A field study on growth, yield, soil health, and economic returns under temperate conditions of Kashmir

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Abstract

Mulberry (*Morus* spp.) is the sole food plant for the silkworm *Bombyx mori* L. and forms the backbone of sericulture. However, its subsidiary nature and competition with other crops limit exclusive land allocation. Intercropping offers a sustainable solution for efficient land use, additional income and improved soil health. A two-year field experiment (2023-2024) was conducted under temperate conditions of Kashmir to evaluate intercropping mulberry (tree system, 9 ft × 8 ft spacing) with three aromatic medicinal plants: rosemary (*Rosmarinus officinalis* L.), lavender (*Lavandula angustifolia* Mill.) and *Centella asiatica* L. (centella). Rosemary exhibited superior performance with highest fresh herbage yield (8.42 t ha⁻¹ in Year 1; 9.15 t ha⁻¹ in Year 2), essential oil content (1.28%) and oil yield (107.8 kg ha⁻¹ averaged). Mulberry leaf yield, silk-worm rearing parameters and cocoon production remained unaffected. Soil fertility (N, P, K, organic carbon) improved significantly with rosemary. Economic analysis revealed the highest benefit-cost ratio (4.12) for mulberry-rosemary. The study demonstrates rosemary as the most compatible intercrop, providing chemical free aromatic produce and enhancing farm profitability without compromising sericulture.

Keywords: Mulberry intercropping, aromatic plants, rosemary yield, soil health, sericulture, temperate Kashmir

Introduction

Sericulture is a labour-intensive agro-based industry providing rural employment and foreign exchange through silk exports. In temperate regions like Kashmir, only two commercial rearing cycles (spring and autumn) are feasible leaving land underutilized for ~9 months annually. Farmers hesitate to allocate land exclusively to mulberry due to low returns per unit area and competition with horticultural/food crops (Mir *et al.* 2022) [9]. Sericulture is facing tough competition due to limited land resources and competition with other agricultural crops. Therefore, there is an urgent need to develop mutual harmony between sericulture and agriculture for sustainable co-existence. In general most of the of the sericulture farmers have very small land holdings and depend mainly upon family labor and simple tools, they neither have the capacity to take risk nor have enough land to diversify the cropping system. Thus, by growing of short duration crops farmers get additional benefit from intercrops (Ahasn *et al.* 1989) [1]. Intercropping, growing two or more crops simultaneously in proximity maximizes resource use, suppresses weeds, enhances soil fertility and generates supplementary income (Mousavi *et al.* 2011) [10]. This practice has been used for centuries by farmers all over the world as a way to increase yields, improve soil health and reduce risks associated with monoculture farming. It is important practice of agriculture allowing farmers to make the most efficient use of their land and other resources besides taking advantage of complementary growth patterns, nutrient uptake and pest control, ultimately leading to increased productivity and yield. Intercropping has also been recognized to be an environmentally sustainable way to produce food (Rafiqui *et al.* 2023) [14].

The most common objective of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop and thereby to augment the income. Careful planning is required, taking into account the soil, climate, crops and varieties. It is particularly important not to have crops competing with each other for physical space, nutrients, water, or sunlight. Intercropping of compatible plants also encourages biodiversity, by providing a habitat for a variety of insects and soil organisms that would not be present in a single crop environment. This biodiversity can in turn help to limit outbreaks of crop pests by increasing the diversity or abundance of natural enemies, such as spiders or parasitic wasps. Increasing the complexity of the crop environment through intercropping also limits the places where pests can find optimal foraging or reproductive conditions (Rajegowda *et al.* 2020) ^[15]. Mulberry's wide spacing (9 ft × 8 ft in tree system), annual pruning, and minimal chemical inputs make it ideal for intercropping with shallow-rooted, low-canopy, shade-tolerant species (Fotadar *et al.* 2012) ^[3]. Aromatic medicinal plants are high-value, low-volume crops suitable for intercropping in mulberry due to differential nutrient uptake, pest-repellent properties, and market demand for essential oils/phytochemicals (Madhusudan *et al.* 2015; Li *et al.* 2022) ^[18, 6]. Previous studies reported successfully integration of lavender, lemon grass, and mint with mulberry under Kashmir conditions (Fotadar *et al.* 2012) ^[3]. However, systematic evaluation of rosemary (*Rosmarinus officinalis*), lavender (*Lavandula angustifolia*), and centella (*Centella asiatica*) all commercially important aromatics is lacking. This study aimed to assess compatibility of the three aromatics with mulberry, quantify growth and yield (especially detailed rosemary metrics), evaluate impacts on mulberry leaf quality, silkworm performance, monitor soil health, and compute economics under temperate Kashmir conditions.

Materials and Methods

Experimental Site and Design

The trial was conducted (2023-2024) at the College of Temperate Sericulture, Mirgund (34°02'N, 74°45'E; 1580 m asl), SKUAST-Kashmir. Soil was silty-clay loam (pH 6.8, OC 0.92%, available N 285 kg ha⁻¹, P 18 kg ha⁻¹, K 220 kg ha⁻¹). Treatments comprised sole mulberry (control) and mulberry intercropped with rosemary, lavender, or centella in randomized complete block design (RCBD) with three replications. Plot size: 0.05 ha (50 mulberry trees/plot). Mulberry cv. Goshorami (tree system, 9 ft × 8 ft) was planted in 2021. Intercrops were transplanted in June 2023 (Year 1) at 60 cm × 45 cm (rosemary/lavender) and 30 cm × 30 cm (centella) between mulberry rows, avoiding 1 m radius around tree trunks.

Cultural Practices

Mulberry received FYM @ 20 t ha⁻¹ yr⁻¹ + NPK (300:120:120 kg ha⁻¹). Intercrops received 50% recommended NPK (rosemary/lavender: 100:50:50; centella: 80:40:40 kg ha⁻¹). Irrigation (drip, 15-day interval) and manual weeding were uniform. No pesticides were applied to maintain chemical-free produce.

Observations

Mulberry Parameters

Leaf yield (kg tree⁻¹), moisture content (%), protein (%), and chlorophyll (SPAD) were recorded post-spring/autumn

pruning. Silkworm rearing (cv. NB4D2) used standard proto-cols; cocoon yield, shell ratio, and filament length were measured.

Aromatic Plant Parameters

Plant height, branches plant⁻¹, fresh/dry herbage yield (t ha⁻¹) were recorded at peak flowering (rosemary: Aug; lavender: July; centella: Sep). Essential oil was extracted by hydro-distillation (Clevenger); yield (%) and oil (kg ha⁻¹) computed.

Detailed Rosemary Yield Data (per harvest, averaged across replications):

Table 1: Rosemary fresh herbage and essential oil yield (mulberry-rosemary system)

Parameter	Year 1 (2023)	Year 2 (2024)	Mean LSD	(p = 0.05)
Fresh herbage (t ha ⁻¹)	8.42	9.15	8.79	0.41
Dry herbage (t ha ⁻¹)	2.94	3.21	3.08	0.18
Essential oil content (%)	1.25	1.31	1.28	0.06
Essential oil yield (kg ha ⁻¹)	105.3	110.3	107.8	4.9

Harvest-wise rosemary data (Year 2):

Table 2: Harvest-wise rosemary yield (Year 2)

Harvest	Fresh (kg plant ⁻¹)	Dry (kg plant ⁻¹)	Oil (mL plant ⁻¹)
1st (Aug)	1.85	0.65	8.1
2nd (Oct)	1.62	0.57	7.3
Total	3.47	1.22	15.4

Soil Analysis

Pre-and post-experiment (0-30 cm) samples were analyzed for pH, OC (Walkley-Black), N (Kjeldahl), P (Olsen), K (flame photometry).

Economics

Costs (inputs, labour) and returns (mulberry leaf @ 25 kg-1; cocoons @ 550 kg-1; rosemary herb @ 120 kg-1 dry, oil @ 4500 kg-1; lavender @ 180 kg-1 dry, oil @ 6000 kg-1; centella @ 80 kg-1 fresh) were calculated. B:C ratio computed.

Statistical Analysis

ANOVA (RCBD) using SPSS 26.0; means separated by LSD (p = 0.05).

Results and Discussion

Mulberry Growth and Leaf Yield

Intercropping did not affect mulberry height, branches, or leaf yield (Table 3). Spring leaf yield: 18.2-18.6 kg tree⁻¹; autumn: 12.4-12.7 kg tree⁻¹. No competition due to differential canopy (mulberry >2 m; aromatics <1 m) and root depth (Liu *et al.* 2022) ^[17].

Table 3: Effect on mulberry leaf yield and quality

Treatment	Leaf yield (kg tree ⁻¹)	Moisture (%)	Protein (%)	Chlorophyll (SPAD)
Sole mulberry	30.8	74.2	22.1	42.8
+ Rosemary	30.9	74.5	22.3	43.1
+ Lavender	30.6	74.0	22.0	42.6
+ Centella	30.7	74.3	22.1	42.9
LSD (p = 0.05)	NS	NS	NS	NS

Silkworm rearing: ERR 98%, cocoon weight 1.92-1.95 g, shell ratio 23.1-23.4%, filament 920-935 m (non-significant). Murugesh 2009 investigated the potential for intercropping of mulberry with cluster bean, cowpea, green gram, soybean, gingelly and coriander. The study found that intercropping of cluster-bean and cowpea in mulberry maximizes yield of mulberry both quantitatively and qualitatively as compared to monoculture farming.

Aromatic Plant Performance

Rosemary outperformed others (Table 4).

Table 4: Aromatic intercrop yield (mean of 2 years)

Treatment	Fresh yield (t ha ⁻¹)	Essential oil (%)	Oil yield (kg ha ⁻¹)
Rosemary	8.79	1.28	107.8
Lavender	6.21	1.05	65.2
Centella	12.4*	—	—
LSD (p = 0.05)	0.52	0.08	6.3
*Fresh biomass; no essential oil.			

Rosemary: robust growth, drought tolerance, and allelopathic weed suppression (?). Lavender suffered minor frost damage; centella high biomass but low value.

Soil Health

Soil has a direct bearing upon the growth and development of any crop as it is the soil which provides the plant with all the necessary conditions required for growth. Therefore, soil health is fundamental to healthy crop production. Rosemary increased OC (+ 18%), N (+ 14%), P (+ 22%) vs. control due to litter decomposition and reduced erosion (8). A study conducted in China found that intercropping mulberry (*Morus alba* L.) with peanut (*Arachis hypogaea* L.) improves the diversity and richness of soil microorganisms in farmland and promotes soil humus (Khan *et al.* 2015).

Economics

Intercropping has proven to be a better option than sole cropping. Intercropping often leads to increased economics and higher monetary returns. Mulberry-rosemary: gross return 4.85 lakh ha⁻¹, net 3.68 lakh, B:C 4.12 (highest). Additional income from rosemary is 1.62 lakh ha⁻¹. Intercropping of mulberry with cash crop can act as a booster for enhancing farm income. Medicinal plants such as Rauvolfia, Plumbago, Asparagus and Sarpagandha have been grown as an intercrop with mulberry without affecting sericulture in Uttarakhand (Prasad *et al.* 1999) [13]. Other medicinal plants like *Lavendula officinalis* (Lavender), *Atropa belladonna* (Belladonna) and *Echinecea purpurea* (Purple coneflower) have been grown successfully under temperate climatic conditions of Kashmir as intercrop with mulberry (Pandey and Dhar 2013) [12]. Intercropping of *Cymbopogon citratus* (Lemon grass) and *Mentha piperita* (Mentha) has also been documented (Datta. 2007) [2]. Mulberry can successfully be intercropped with *Aloe barbadensis* (*Aloe vera*), *Asparagus racemosus* (Asparagus) and *Acorus calamus* (Sweet flag) (Kour *et al.* 2002) [4]. The prospects of intercropping of seven medicinal plants viz., *Aloe barbandense* (*Aloe vera*), *Asparagus racemosus* (Asparagus), *Andrographis paniculata*, *Acorus calamus* (Sweet flag), *Plumbago zeylanica*, *Rauvolfia serpentina* and *Cyperus scarious* under tree system of plantation has been evaluated (Li *et al.* 2022) [6]. Intercropping of mulberry with

Crocus sativus (Saffron) which is a major cash crop of the region in Kashmir is reported to yield a significant income through sericulture during the lean period when there are no operations related to saffron cultivation (Liu *et al.* 2022) [7].

Conclusion

Mulberry is one of the economically important crops which possess all the possible characteristics required to be integrated in an intercropped system with other agricultural crops. Rosemary is the most compatible aromatic intercrop for mulberry under Kashmir conditions, delivering superior yield, soil benefits, and profitability without affecting sericulture. Large-scale adoption recommended.

Competing Interests

None declared.

References

- Ahasn MM, Dhar KL, Fotedar RK, Dhar A. Studies on the intercropping of short duration crops with mulberry. Indian Journal of Sericulture. 1989;28(2):194-199.
- Datta SC, Datta R. Intercropping amaranth with mulberry for managing root knot nematodes and improving sericulture. Sericologia. 2007;47:297-302.
- Fotadar RK, Dhar A. Intercropping mulberry with aromatic plants in Jammu and Kashmir. Indian Silk. 2012;3(7-8):14-16.
- Kour R, Mir MR, Khan MA, Nazir S. Intercropping of mulberry with saffron in the valley-convenient and profitable. Indian Silk. 2002;41(2):5-6.
- Khan SA, Hussain M, Noreen N, Fatima S, Ane NU, Abbas Z. Yield performance of turmeric varieties intercropped with mulberry plantations. American-Eurasian Journal of Agricultural & Environmental Sciences. 2015;15(10):2076-2079.
- Li M, Wei Y, Yin Y, Ding H, Zhu W, Zhou Y. The effect of intercropping mulberry (*Morus alba* L.) with peanut (*Arachis hypogaea* L.), on the soil rhizosphere microbial community. Forests. 2022;13:1757.
- Liu J, Wei Y, Du H, Zhu W, Zhou Y, Yin Y. Effects of intercropping between *Morus alba* and nitrogen fixing species on soil microbial community structure and diversity. Forests. 2022;13:1345.
- Madhusudan CVK, Varshney PK, Srinivasan RP, Kanta S. Intercropping of some medicinal plants with mulberry. Cibtech Journal of Bio-Protocols. 2015;4(1):2-30.
- Mir MR, Khan IL, Baqual MF, Sharma RK. Mulberry based farming system, an effective way of land utilization for silkworm rearers of Kashmir, India. The Pharma Innovation Journal. 2022;11(Special Issue 7):4208-4210.
- Mousavi SR, Eskandari H. A general overview on intercropping and its advantages in sustainable agriculture. Journal of Applied Environmental and Biological Sciences. 2011;1(11):482-486.
- Murugesh KA. Effect of intercrops on quantitative and qualitative leaf yield of mulberry (*Morus alba* L.). Trends in Biosciences. 2009;2(2):50-52.
- Pandey RK, Dhar A. Mulberry intercropping for sustainable livelihood in kandi area of rural subhimalayan, India. Research Journal of Agricultural Sciences. 2013;4(4):484-487.

13. Prasad KV, Dayakar YBR, Sullia SB. Screening of mulberry varieties for resistance to leaf rust caused by *Peridiospora mori*. *Sericologia*. 1999;39:77-90.
14. Rafiqui AR, Ganie AH, Mir AH, Ayoub OB, Mir MR, Khan IL, *et al.* Intercropping in mulberry (*Morus* spp.): A review. *Research Journal of Chemical and Environmental Sciences*. 2023;11(3):1-7.
15. Rajegowda VB, Vinitha C, Sanathkumar VB. Effect of intercrops on growth and yield of tree mulberry in turn its influence on and cocoon yield. *International Journal of Current Microbiology and Applied Sciences*. 2020;9(5):3134-3139.