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Evaluation of promising species of mint in terms of growth, herbage and oil yield under open and shade net conditions

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Abstract

The present research titled Evaluation of promising species of mint in terms of growth, herbage and oil yield under open and shade net conditions was executed utilizing a split-plot design within the medicinal block at Dr. YSRHU - College of Horticulture (COH), Anantharajupeta, Annamaya district, Andhra Pradesh, *rabi* season 2023-24. This investigation aimed to assess the performance of four mint species (japanese mint, spear mint, pepper mint and bergamot mint) under varying cultivation conditions (open and 50% shade net). The findings indicated that among the treatments, growth metrics such as plant height, plant spread and leaf: stem fresh weight ratio, as well as yield metrics *i.e.* fresh and dry herbage yield and oil yield demonstrated significantly superior performance in japanese mint grown under 50% shade net. Conversely, pepper mint exhibited the highest number of internodes (in 50% shade net), whereas bergamot mint outperformed in leaf area under 50% shade net. The study revealed that japanese mint thrives best in 50% shade net. This finding was significant as it highlights the adaptability of japanese mint to different light conditions, which can be crucial for optimizing yield in diverse agricultural settings.

Keywords: Japanese mint, pepper mint, open field, 50% shade net, herbage

Introduction

Mint (*Mentha* spp.) is a diverse genus of perennial herbs belonging to the Lamiaceae family, widely valued for its aromatic properties and culinary, medicinal and industrial applications. Originating in temperate regions, mint is cultivated globally for its essential oils, which are rich in menthol, menthone and other bioactive compounds used in pharmaceuticals, cosmetics and flavouring industries (Maheshwari *et al.*, 2020) ^[14]. Among the species, japanese mint (*Mentha arvensis*), spear mint (*Mentha spicata*), pepper mint (*Mentha piperita*) and bergamot mint (*Mentha citrata*) are highly regarded for their commercial importance due to their unique oil compositions (Lawrence, 2007) ^[13].

India's annual mint production ranges between 35,000 and 40,000 metric tons, with Uttar Pradesh accounting for approximately 80% of this output. The remaining 20% is attributed to Madhya Pradesh, Bihar, Punjab and Haryana. As a prominent global exporter, India provides nearly 80% of the world's essential oils, menthol crystals, and associated products, with over 95% of mint varieties cultivated by CSIR – CIMAP. Since the mid-2000s, India has consistently upheld its status as a leading global supplier of mint oil and its derivatives.

Mint plants thrive in varied agro – climatic conditions but show significant variation in growth and secondary metabolite production depending on environmental factors such as light, temperature, and humidity (Singh *et al.*, 2018) ^[19]. Recent studies have explored the impact of controlled environments, including shade nets, on mint growth and oil composition, demonstrating that optimized conditions can enhance both yield and quality (Sharma *et al.*, 2021) ^[17]. Mint growth differs significantly between open and shade net cultivation. In open conditions, mint grows rapidly due to abundant sunlight, but excessive heat can cause stress and water loss, affecting productivity. Shade nets, on the other hand, regulate sunlight and temperature, reducing heat stress and promoting consistent growth and healthier foliage. They also offer protection from pests and diseases, enhancing plant vigour and yield. Proper ventilation and soil management are essential in both settings.

Environmental conditions also influence the essential oil yield, which has seen increased demand due to its industrial applications.

This research offers valuable insights for enhancing cultivation practices and maximizing yield potential for mint farming under the specific growing conditions of the Rayalaseema region.

Materials and Methods

The experiment was set up in a split – plot design, with three replications, within the medicinal block at Dr. YSRHU-College of Horticulture (COH), Anantharajupeta, Annamaya district, Andhra Pradesh, *rabi* season 2023-24. The main – plots were designated to distinct cultivation environments (M_1 : Open, M_2 : Shade net at 50%), whereas the sub – plots were allocated to various species of mint (S_1 : Japanese mint, S_2 : Spear mint, S_3 : Pepper mint, S_4 : Bergamot mint). The experimental plant material – japanese mint, spear mint, pepper mint and bergamot mint were obtained from the Indian Institute of Horticultural Research (IIHR) and Gandhi Krishi Vigyana Kendra (GKVK), Bengaluru, Karnataka. The experimental fields (open and 50% shade net) were levelled and thoroughly ploughed for a fine soil texture. Plots were marked manually using rope and bamboo pegs, and beds were prepared accordingly. Seedlings were cut into 7–10 cm pieces and planted in shallow furrows, 7–10 cm deep, with a spacing of 30 cm between rows and 15 cm between plants. The observations were recorded at various crop growth stages i.e. 60, 90 DAP and at harvest for growth metrics like plant height (cm), plant spread (cm^2), leaf area (cm^2), number of internodes per plant. Parameters like leaf: stem fresh weight ratio, fresh and dry herbage yield and oil yield were recorded at harvest stage of the crop. The essential oil was extracted using a hydro – distillation method with a clevenger apparatus, using fresh plant material from all four species.

Results and Discussion

Morphological attributes

Data related to morphological parameters which include growth habit, plant height (cm), plant spread (cm^2), leaf area (cm^2), number of internodes per plant and leaf: stem fresh weight ratio were detailed in Table 1 and 2.

Growth habit

Under both open field and 50% shade net conditions, japanese mint, spear mint, and bergamot mint consistently demonstrated an erect growth pattern, while pepper mint displayed a notable spreading growth form.

The growth habits of mint species under both open field and 50% shade net conditions reflect species-specific traits. Japanese mint, spear mint and bergamot mint exhibited erect growth habit, enhancing light capture and airflow, promoting efficient photosynthesis. This helped them thrive in competitive environments. Pepper mint's spreading growth habit improved ground coverage, enhancing competition for water and nutrients while retaining soil moisture, vital for its growth. The results are consistent with those reported by Hoque *et al.* (2014)^[9] in twenty-two mint germplasm and Hoque and Sigma (2016)^[10] in six mint genotypes.

Plant height (cm)

Japanese mint grown under 50% shade recorded the tallest height (M_2S_1 – 78.16 cm), followed by japanese mint in

open fields (M_1S_1 – 66.23 cm) and pepper mint under 50% shade (M_2S_3 – 65.19 cm). In contrast, bergamot mint showed the shortest plant height in open conditions (M_1S_4 – 36.28 cm). Overall, plant height under 50% shade net (M_2) and japanese mint (S_1) yielded the highest results among all cultivation conditions and species.

Plants grown under a 50% shade net were taller as they stretched to reach more light, while those in open conditions were shorter due to ample light availability. The shade net induced a phototropic response, where plants adjusted their growth to maximize light capture. This taller growth under shade is similar to etiolation, with increased apical dominance. Variations in plant height among mint species may result from genetic differences or geographical factors. Japanese mint's adaptability to varying light conditions and efficient nutrient uptake likely contributed to its taller height. The results are consistent with the inferences made from Singh *et al.* (2019)^[18] in mint varieties and Duwal *et al.* (2019)^[7] in coriander.

Plant spread (cm^2)

Japanese mint grown under 50% shade recorded the largest plant spread (M_2S_1 – 962.87 cm^2), followed by japanese mint in open fields (M_1S_1 – 912.22 cm^2) and pepper mint under 50% shade (M_2S_3 – 901.17 cm^2). In contrast, bergamot mint showed the shortest plant height in open conditions (M_1S_4 – 557.22 cm^2). Plant spread was highest under 50% shade net (M_2) and in japanese mint (S_1) and achieved the best results among all cultivation conditions and species.

The greater plant spread of mint species under shade net conditions was due to the controlled microclimate, including moderated temperatures, improved soil moisture and optimized light. These conditions supported better shoot and root growth, allowing plants to use resources more efficiently. Japanese mint showed the highest plant spread, thriving in lower light, stable temperatures and efficient moisture use. Whereas, in the open field, higher temperatures and direct sunlight can cause increased water loss and stress, limiting plant spread. The outcomes align with the deductions made from Desai *et al.* (2018)^[6] in menthol mint and Singha *et al.* (2022)^[20] in japanese mint.

Leaf area (cm^2) (East – West and North – South)

Throughout all stages of crop growth, bergamot mint exhibited the largest leaf area under 50% shade net (M_2S_4 – 16.46 cm^2), significantly surpassing japanese mint (M_2S_1 – 14.35 cm^2) under 50% shade net and japanese mint (M_1S_1 – 10.63 cm^2) in open field. The smallest leaf area was recorded in pepper mint (M_1S_3 – 9.31 cm^2) grown in open field. There were no statistical variations among the growing conditions evaluated.

Bergamot mint's larger leaf area is likely due to its adaptation to capture more light in shaded environments, optimizing growth. This trait may have evolved for a competitive edge in low-light conditions. Ribeiro *et al.* (2021)^[16] noted that shaded environments prompt plants to enlarge leaves for better energy capture. Species-specific traits play a bigger role in leaf size than environmental factors. Favourable conditions also contributed to increased leaf area. The results are consistent with the inferences made from Ribeiro *et al.* (2021)^[16] in patchouli and Chandel *et al.* (2024)^[4] in ornamental basil.

Number of internodes per plant

Pepper mint grown under a 50% shade net ($M_2S_3 - 23.60$) had the highest number of internodes, significantly more than pepper mint in an open field ($M_1S_3 - 21.14$) and japanese mint under the shade net ($M_2S_1 - 20.34$). The lowest number of internodes was recorded in bergamot mint grown in open conditions ($M_1S_4 - 10.26$). The number of internodes per plant was highest in peppermint grown under a 50% shade net among all evaluated growing conditions and four species.

Mint species exhibited higher number of internodes under shade net conditions due to reduced light intensity, which promoted stem elongation. The humid environment further supported this growth. In contrast, open field conditions with higher light intensity limited stem elongation and resulted in fewer internodes. Peppermint had more internodes than other species, likely due to its genetic predisposition and responsiveness to light conditions. Its growth strategy favours frequent internode development. The observations are consistent with the insights derived from Gupta *et al.* (2017) [8] in mint species and Tajzadah *et al.* (2024) [21] in pepper mint.

Leaf: Stem fresh weight ratio

The highest leaf: stem fresh weight ratio was observed in japanese mint grown under 50% shade net ($M_2S_1 - 1.32$), which was notably higher than spear mint ($M_2S_2 - 1.17$) and pepper mint ($M_2S_3 - 1.12$). In contrast, the lowest leaf: stem fresh weight ratio was recorded in bergamot mint grown in the open field ($M_1S_4 - 0.78$).

The leaf: stem fresh weight ratio was highest under shade net conditions due to the favourable microclimate of reduced light, cooler temperatures and increased humidity, promoting efficient leaf growth. These conditions minimized heat stress, supporting optimal photosynthesis and greater leaf biomass. In contrast, open field conditions with higher light and temperature directed more resources toward stem growth. Japanese mint's higher leaf: stem fresh weight ratio is likely due to its genetic predisposition for greater leaf production, making it more responsive to the shade net environment. The results are in agreement with the deductions made from Venkatesha *et al.* (2020) [22] in menthol mint and Kumar *et al.* (2022) [11] in spear mint.

Yield attributes

Data related to yield parameters which include fresh and dry herbage yield and oil yield were detailed in Table 3.

Fresh herbage yield (g plant⁻¹)

The influence of growing conditions and plant species showed that the highest fresh herbage yield was recorded in japanese mint ($M_2S_1 - 424.74$ g plant⁻¹) grown under a 50% shade net which was followed by spear mint ($M_1S_2 - 377.23$ g plant⁻¹) under the shade net and japanese mint ($M_1S_1 - 348.71$ g plant⁻¹) grown in open conditions. The lowest yield was observed in bergamot mint ($M_1S_4 - 92.69$ g plant⁻¹) grown in open conditions. Where, results align with the deductions made from Palanikumar and Jessykutty (2007) [15] in *Mentha* sp. and Kumar *et al.* (2020) [12] in mint.

Table 1: Morphological attributes of mint species influenced by growing conditions

Treatments	Growth habit		Plant height (cm)			Plant spread (cm ²) (E – W and N – S)		
	M ₁	M ₂	M ₁	M ₂	Mean	M ₁	M ₂	Mean
S ₁	Erect	Erect	66.23	78.16	72.20	912.22	962.87	937.54
S ₂	Erect	Erect	55.59	60.43	58.01	814.74	862.16	838.45
S ₃	Spreading	Spreading	61.45	65.19	63.32	871.94	901.17	886.56
S ₄	Erect	Erect	36.28	46.69	41.49	557.22	618.49	587.85
Mean			54.89	62.62		789.03	836.17	
Factors			S. Em±		CD @ 5%	S. Em±		CD @ 5%
M			1.22		4.33	9.89		34.91
S			1.63		4.64	9.74		27.67
M at S			3.47		9.59	17.99		48.39

Table 2: Morphological attributes of mint species influenced by growing conditions

Treatments	Leaf area (cm ²)			Number of internodes plant ⁻¹			Leaf: stem fresh weight ratio		
	M ₁	M ₂	Mean	M ₁	M ₂	Mean	M ₁	M ₂	Mean
S ₁	13.09	14.35	13.72	19.13	20.34	19.74	0.97	1.32	1.15
S ₂	10.45	10.81	10.63	15.63	16.72	16.17	0.89	1.17	1.03
S ₃	9.31	10.21	9.76	21.14	23.60	22.37	0.87	1.12	1.00
S ₄	15.43	16.46	15.95	10.26	12.17	11.22	0.78	0.82	0.80
Mean	12.07	12.96		16.54	18.21		0.88	1.11	
Factors	S. Em±		CD @ 5%	S. Em±		CD @ 5%	S. Em±		CD @ 5%
M	0.82		NS	0.011		0.074	0.003		0.020
S	0.70		2.16	0.004		0.014	0.001		0.003
M at S	1.18		NS	0.012		0.074	0.003		0.020

Dry herbage yield (g plant⁻¹)

The interaction between growing conditions and species revealed that the highest dry herbage yield was recorded in japanese mint ($M_2S_1 - 97.69$ g plant⁻¹) under a 50% shade net, which was significantly superior than spear mint grown in same conditions ($M_2S_2 - 86.76$ g plant⁻¹) and spearmint ($M_2S_2 - 63.38$ g plant⁻¹) under a shade net. The lowest yield was observed in bergamot mint ($M_1S_4 - 17.61$ g plant⁻¹)

grown in open conditions. Similar results were reported by Chauhan *et al.* (2012) [5] in japanese mint and Aswani *et al.* (2020) [2] in japanese mint.

The use of shade nets in agriculture significantly enhances both fresh and dry herbage yields compared to open field conditions. Shade nets create a favourable microclimate by reducing light intensity and temperature while increasing humidity, which promotes better plant growth and

chlorophyll content. Improved plant height, plant spread and branch number under shade nets contribute to higher biomass and yield, as taller plants with greater ground coverage and more branches capture more light and absorb nutrients efficiently.

Japanese mint produced the highest fresh and dry herbage yields, attributed to its superior growth characteristics, such as greater height, spread and branching. In contrast, bergamot mint had the lowest yield, likely due to less favourable growth traits or lower adaptability. This highlights the productivity potential of japanese mint and the need for strategies to improve bergamot mint's yield.

Oil yield (kg ha⁻¹)

Oil yield varied between 148.66 kg ha⁻¹ and 22.70 kg ha⁻¹ across different growing conditions and mint species. The highest oil yield was recorded in japanese mint (M₂S₁ – 148.66 kg ha⁻¹) grown under 50% shade net, significantly outperforming other species. It was followed by pepper mint

(M₂S₃ – 139.43 kg ha⁻¹) grown under the same conditions and japanese mint (M₁S₁ – 134.25 kg ha⁻¹) grown in open fields. The lowest oil yield was observed in bergamot mint (M₁S₄ – 22.70 kg ha⁻¹) grown in open conditions. Comparable results were documented by Abbaszadeh *et al.* (2009) ^[1] in *Mentha* sp., and Mirudhula *et al.* (2023) ^[3] in basil.

Japanese mint showed the highest oil yield under shade net conditions, likely due to the favourable microclimate, which optimizes temperature, light and humidity for essential oil production. The reduced light intensity under the shade net promotes balanced plant growth and enhances oil accumulation by minimizing stress. Japanese mint's adaptability to these conditions, along with its vigorous growth and efficient resource use, further contributes to its superior oil yield. This demonstrates the effectiveness of shade nets in maximizing oil production, especially for species like japanese mint that thrive in moderated environments.

Table 3: Yield attributes of mint species influenced by growing conditions

Treatments	Fresh herbage yield (g plant ⁻¹)			Dry herbage yield (g plant ⁻¹)			Oil yield (kg ha ⁻¹)		
	M ₁	M ₂	Mean	M ₁	M ₂	Mean	M ₁	M ₂	Mean
S ₁	348.71	424.74	386.72	80.20	97.69	88.95	134.25	148.66	141.45
S ₂	301.68	377.23	339.46	63.35	86.76	75.06	91.51	96.82	94.17
S ₃	276.63	341.54	309.09	55.33	71.72	63.53	127.46	139.43	133.44
S ₄	92.69	125.57	109.13	17.61	23.86	20.73	22.70	26.37	24.53
Mean	254.93	317.27		54.12	70.01		93.98	102.82	
Factors	S. Em±		CD @ 5%	S. Em±		CD @ 5%	S. Em±		CD @ 5%
M	2.67		7.93	1.65		4.92	0.56		3.65
S	3.23		9.59	2.28		6.77	0.87		2.72
M at S	4.53		13.45	2.38		7.06	1.21		4.64

Conclusion

This study highlights that japanese mint performs best under 50% shade net conditions, showing superior growth and yield compared to other mint species. Pepper mint, however, thrives in open field conditions, achieving optimal oil content. Overall, a 50% shade net effectively enhances the cultivation of japanese mint, while open fields provide the ideal environment for pepper mint. These findings suggest that adapting cultivation practices to the specific needs of each mint species can maximize both growth and productivity.

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