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Influence of different shade levels on photosynthetically active radiation, stomatal conductance and chlorophyll content in mint (*Mentha* spp.) types

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Abstract

Fifteen accessions of Japanese mint (*Mentha arvensis* L.), pepper mint (*Mentha piperita* L.) and spear mint (*Mentha spicata* L.) were evaluated under different shade conditions (Open, 25 and 50 per cent shade). Japanese mint recorded higher Photosynthetically Active Radiation (PAR) and pepper mint recorded increased Stomatal Conductance (Cs) under 25 per cent shade condition (162.57 µ mol m^{-2} s^{-1} and 2.57 µ mol m^{-2} s^{-1}respectively). Under all the shades (open, 25 and 50 per cent), spear mint recorded higher Chlorophyll 'a' (0.601, 0.575 and 0.671 mg g^{-1} respectively) and chlorophyll 'b' (0.684, 0.764 and 0.790 mg g^{-1} respectively) contents. Accession S2A4 recorded an increased Stomatal Conductance (Cs) under open condition (10.96 µ mol m^{-2} s^{-1}).

Key words: chlorophyll content, different shades, photosynthetically active radiation, stomatal conductance

INTRODUCTION

Mint (*Mentha* spp.) a unique medicinal herb, is widely cultivated for its medicinal and aromatic leaves. It is a creeping stem but grows obliquely upwards to give rise to a leaf shoot. Growth and development of the plants are influenced by the amount of incident solar radiation as the light energy is the main input for the photosynthetic process in green plants (Zelitch, 1971). This paper describes the influence of different shade levels on photosynthetically active radiation and related parameters of mint (*Mentha* spp.).

MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala during 2003-2004, South India. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. Details of fifteen accessions of mint (*Mentha* spp.) collected for the study are presented in table 1. Rooted cuttings were planted at 10 cm spacing along the ridges. High Density Poly Ethylene (HDPE) shade nets of appropriate mesh size (25 and 50 per cent) were used for providing the required shade of 25 and 50 per cent. The three species were also grown in the adjacent open area with 100 per cent light area. The observations on Photosynthetically Active Radiation (PAR) and Stomatal Conductance (Cs) were recorded using the Steady State Porometer (T) at 120 days after planting (DAP) and expressed as µ mol m^{-2} s^{-1}. Chlorophyll contents (a and b) were estimated at 120 DAP by the method prescribed by Stranes and Hardy (1965).

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RESULTS AND DISCUSSION

Performance of different mint species in each shade condition

Chlorophyll 'a' content and stomatal conductance of the three species differed significantly when raised under open condition while no such significant difference could be observed in PAR values (Tables 1-4). *Mentha spicata* (S3) and *Mentha arvensis* (S1) recorded higher chlorophyll content and *Mentha piperita* (S2) recorded higher stomatal conductance under open condition (Table 3). Under 25 per cent shade higher PAR was recorded for *M. arvensis* (S1) while stomatal conductance was higher in *M. piperita* (S2) in similar open condition. Further, significant differences were observed in the chlorophyll "a" and "b" contents among the species under this shade condition (Tables 4 and 5). Similar findings were reported for *Littorella uniflora* by Attridge (2004), who found that the shade level when increased to 50 per cent to result in a slight change in the physiology. The highest PAR was recorded for *M. piperita* (S2) while stomatal conductance was more for *M. arvensis* (S1). The species S3 (*M. spicata*) recorded an increased content of chlorophyll fraction in open conditions.

General effect of shade on performance of mint

The PAR showed significant variation under different shade levels. The highest PAR on the leaf surface was recorded in plants grown under open condition and the values decreased with increasing shade levels. The lowest value was recorded under 50 per cent shade condition (Table 2). The photosynthetic characteristics of plants are greatly influenced by the light condition under which they are grown. The leaves absorb the light

Table 1. Details of mint accessions collected for the study

Sl. No	Accession number	Date of collection	Source/Place of collection in India (from different parts of the State of Tamil Nadu, India)
1	S_1A_1	01.08.2003	Horticultural Research station, Ooty
2	S_1A_2	13.08.2003	Vilpatty, Kodaikanal
3	S_1A_3	16.08.2003	Agricultural College and Research Institute, Madurai
4	S_1A_4	06.09.2003	Horticultural Research Station, Yercaud
5	S_1A_5	29.08.2003	Thrissur
6	S_2A_1	01.08.2003	Horticultural Research Station, Ooty
7	S_2A_2	13.08.2003	Poomparai, Kodaikkanal
8	S_2A_3	22.08.2003	Karipatty, Salem
9	S_2A_4	31.08.2003	Valparai, Coimbatore
10	S_2A_5	06.09.2003	Thrissur
11	S_3A_1	15.08.2003	Seelayampatty, Theni
12	S_3A_2	16.08.2003	Kallupatty, Madurai
13	S_3A_3	05.09.2003	Vayalur, Trichy
14	S_3A_4	13.09.2003	Pullarai, Tenkasi
15	S_3A_5	20.09.2003	Thevaram, Cumbum

Table 2. Mean photosynthetically active radiation (µ mol m^{-2} s^{-1}) of mint accessions under different shade levels at 120 days after planting

Accession number	Shade levels (%)			Mean of accessions
	0	25	50	
S_1A_1	965.50	688.33	118.16	590.67
S_1A_2	1337.16	717.33	140.16	731.56
S_1A_3	959.33	708.36	163.83	610.51
S_1A_4	1033.83	745.33	136.50	638.56
S_1A_5	957.66	709.66	157.33	608.22
Mean (S_1)	1050.70	713.81	143.20	
S_2A_1	987.00	513.66	199.46	566.71
S_2A_2	1026.83	568.33	208.16	601.11
S_2A_3	1012.66	585.00	193.50	597.06
S_2A_4	942.83	515.50	190.66	549.67
S_2A_5	1000.16	524.33	206.16	576.89
Mean (S_2)	993.90	541.37	199.59	
S_3A_1	950.46	515.66	124.33	530.16
S_3A_2	948.00	485.83	174.50	536.11
S_3A_3	1034.50	517.50	128.83	560.28
S_3A_4	956.66	498.66	224.83	560.06
S_3A_5	1041.33	526.66	160.33	576.11
Mean (S_3)	986.19	508.87	162.57	
Mean (Shade levels)	1010.26	588.01	168.45	
S.E.	89.97	31.91	17.69	
CD (Species)	NS	41.337	22.912	
Pooled analysis				
CD Accessions			NS	
Shades			67.161*	
Shade x accession			NS	

NS – Non Significant; *significant at 5% level

Table 3. Mean stomatal conductance (µ mol m^{-2} s^{-1}) of mint accessions under different shade levels at 120 days after planting

Accession number	Shade levels (%)			Mean of accessions
	0	25	50	
S_1A_1	5.56	4.48	2.60	4.22
S_1A_2	5.50	5.33	2.61	4.48
S_1A_3	5.27	4.29	2.65	4.07
S_1A_4	5.39	4.85	2.42	4.22
S_1A_5	5.17	4.11	2.58	3.95
Mean (S_1)	5.38	4.61	2.57	
S_2A_1	9.73	6.78	2.52	6.34
S_2A_2	10.76	7.23	2.41	6.80
S_2A_3	9.20	7.26	2.47	6.31
S_2A_4	10.96	6.89	2.46	6.77
S_2A_5	10.47	7.33	2.50	6.77
Mean (S_2)	10.22	7.10	2.47	
S_3A_1	2.97	2.32	1.79	2.36
S_3A_2	3.26	2.12	1.85	2.41
S_3A_3	3.10	1.74	1.86	2.53
S_3A_4	2.81	2.00	1.92	2.25
S_3A_5	2.79	1.10	1.80	2.19
Mean (S_3)	3.17	2.04	1.84	
Mean (Shade levels)	6.26	4.58	2.30	
S.E.	0.45	0.28	0.08	
CD (Species)	0.579	0.356	0.110	
Pooled analysis				
CD Accessions				2.437*
Shades				1.090*
Shade x accession				4.221*

* significant at 5% level

Table 4. Mean chlorophyll 'a' (mg g^{-1}) content of mint accessions under different shade levels at 120 days after planting

Accession Number	Shade levels			Mean of accessions
	0%	25%	50%	
S_1A_1	0.579	0.533	0.466	0.526
S_1A_2	0.579	0.655	0.486	0.573
S_1A_3	0.481	0.632	0.424	0.512
S_1A_4	0.477	0.508	0.408	0.464
S_1A_5	0.500	0.512	0.396	0.469
Mean (S_1)	0.523	0.568	0.436	
S_2A_1	0.355	0.588	0.717	0.553
S_2A_2	0.366	0.587	0.719	0.557
S_2A_3	0.375	0.593	0.588	0.518
S_2A_4	0.381	0.574	0.609	0.521
S_2A_5	0.379	0.499	0.521	0.467
Mean (S_2)	0.371	0.568	0.631	
S_3A_1	0.374	0.707	0.698	0.593
S_3A_2	0.470	0.592	0.718	0.593
S_3A_3	0.704	0.466	0.714	0.628
S_3A_4	0.724	0.516	0.610	0.617
S_3A_5	0.732	0.597	0.614	0.648
Mean (S_3)	0.601	0.575	0.671	
Mean (Shade levels)	0.498	0.570	0.579	
S.E.	0.09	0.07	0.09	
CD (Species)	0.117	NS	0.113	
Pooled analysis				
CD Accessions				2.437*
Shades				1.090*
Shade x accession				4.221*

* significant at 5% level

Table 5. Mean chlorophyll 'b' (mg g^{-1}) content of mint accessions under different shade levels at 120 days after planting

Accession number	Shade levels (%)			Mean of accessions
	0%	25%	50%	
S_1A_1	0.509	0.573	0.641	0.574
S_1A_2	0.494	0.580	0.671	0.582
S_1A_3	0.552	0.628	0.530	0.570
S_1A_4	0.534	0.619	0.529	0.561
S_1A_5	0.547	0.662	0.509	0.573
Mean (S_1)	0.528	0.612	0.576	
S_2A_1	0.365	0.763	0.779	0.635
S_2A_2	0.360	0.671	0.806	0.613
S_2A_3	0.374	0.728	0.831	0.644
S_2A_4	0.377	0.699	0.805	0.627
S_2A_5	0.360	0.723	0.665	0.582
Mean (S_2)	0.367	0.717	0.777	
S_3A_1	0.381	0.883	0.744	0.669
S_3A_2	0635	0.888	0.778	0.767
S_3A_3	0.792	0.650	0.874	0.772
S_3A_4	0.829	0.636	0.774	0.746
S_3A_5	0.784	0.762	0.782	0.776
Mean (S_3)	0.684	0.764	0.790	
Mean (Shade levels)	0.526	0.697	0.714	
S.E.	0.14	0.13	0.14	
CD (Species)	0.185	NS	0.178	
Pooled analysis				
CD Accessions			NS	
Shades			0.155*	
Shade x accession			NS	

NS – Non Significant; *significant at 5% level

in the range of 400-700 nm wave bands preferentially and the PAR incident on the plants under shaded condition might be substantially lower than that under full sunlight (Singh *et al*., 2004). A tendency of the plants to decrease the stomatal conductance with increase in shade levels was observed (Table 3). The change in stomatal frequency and hence the higher stomatal pore area per unit area of leaf is positively correlated with higher stomatal conductance as observed by Forseth *et al*. (2004). This is further supported by the findings of Attridge (2004) who reported that the chlorophyll 'b' content was higher under shade conditions. The present study recorded the same pattern (Table 5).

Comparison of accessions between shade levels

The accession, S2A4 recorded higher stomatal conductance (10.96 µ mol m^{-2} s^{-1}) under open condition (Table 3). This is in confirmity with the findings of Jifon and Syvestsen (2004) who reported a three fold increase in stomatal conductance in *Atriplex* leaves grown at high light intensity than the leaves grown at low light intensity.

It is concluded that the mint sp. could be successfully grown under shaded conditions of up to 25% of the normal light situation with insignificant decline in the chosen physiological parameters.

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