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Effect on herbage and oil yield in different *Mentha* species intercropped with poplar

Kuldeep Joshi, Virendra Singh, Ajit Kumar and Rajnish Tiwari

Abstract
A field experiment was carried out during the year 2016 at the Agroforestry Research Centre, Patharchatta, G.B. Pant University of Agriculture and Technology, Pantnagar to study the difference in herbage and oil yield of different *Mentha* species when intercrop with poplar. The experiment was laid out in Factorial Randomized Block Design (RBD) with two farming systems i.e. *Mentha* species intercropped with 4-year old poplar stand and *Mentha* species as sole crop with four replications. Four species of *Mentha* were *M. arvensis*, *M. piperita*, *M. spicata* and *M. citrata* in. Vegetative parameters of different *Mentha* species such as plant height and plant spread were maximum under open compared to poplar based agroforestry system. The maximum total fresh herbage yield was 263.50 q ha^{-1} in *M. arvensis* under open whereas, *M. piperita* recorded the maximum total fresh herbage yield of 122.71 q ha^{-1} under poplar. Maximum oil content of 1.24 and 1.38% was obtained in *M. arvensis* at 1st and 2nd harvest, respectively under open conditions. Similarly, under agroforestry system also, this species recorded maximum oil content of 0.91 and 0.89% at 1st and 2nd harvest, respectively. Total oil yield was maximum in open farming system as *M. arvensis* produced highest oil yield of 343.71 l ha^{-1} under open and 100.29 l ha^{-1} under poplar based agroforestry system.

Keywords: Essential oil, *Mentha*, herbage and oil yield, poplar, silvi-medicinal system

1. Introduction
India has a wide biodiversity of medicinal and aromatic plants which grow in forests and uncultivated areas. Out of 15,000.00 species of flowering plants found in India, about 17.00% have their medicinal value (Pei, 2001) [8]. There are 1,745 plant species which are reported from the Indian Himalayan region and many of these are found in Uttarakhand Aromatic plants and their products like essential oils have market of considerable size which is increasing @ of 10-15% every year. The production of essential oils is estimated around ₹ 4,500.00 crores per annum all over the world. India contributes 10.0% of essential oils production and thus occupies the third position among the developing countries after China (30.0%) and Brazil (13.0%). Health benefits through the use of medicinal and aromatic plants (MAPs) have raised their high demand in national, as well as in international market. In order to meet the growing demand, MAPs can be intercropped with tress under agroforestry. The theme of agroforestry is centred around sustainability in terms of economics, ecology and social issues that makes it an unparallel land use system (Pandey, 2007) [7].
One of such crop is *Mentha* popularly referred to as 'mint' and belongs to family Lamiaceae. India ranks first in the global production and export of mint oil as well as its derivatives (Bajeli *et al*., 2016) [1]. In India and other countries, four species are reported to be cultivated commercially i.e. menthol mint (*Mentha arvensis*), peppermint (*M. piperita*), bargamont mint (*M. citrata*) and spearmint (*M. spicata*). These four species are the source of aroma compound such as menthol, carvone, linalool and linayl acetate used widely in food, cosmetics and pharmaceutical preparation (Chand *et al*., 2004) [2]. Menthol mint is concentrated only in central part of Indo-Gangetic plains encompassing the northern states of Punjab, Haryana and Uttar Pradesh (Kumar *et al*., 2001) [6]. It is a stimulant, tonic and vermifuge, having anti-spasmodic, diaphoretic, stomachic, carminative, antiviral, antifungal, antibacterial and choleretic properties. It has wide application in pharmaceutical, agrochemical and flavouring industries worldwide (Tassou *et al*., 2004.) [14] Peppermint (*Mentha piperita*) or 'Mitcham' is native of Europe and yields sweet oil which is disliked by ants, mice and rats. Whereas, spearmint (*Mentha spicata*) is also native to Europe and Asia and its leaves can be used fresh, dried, or frozen. Mint is a money spinner crop of the farmers of Tarai region of Uttarakhand where poplar is also grown on a large scale for various paper and pulp wood industries. Possibility of growing mint as an intercrop in between the vacant space of poplar plantation can offer additional income to the farmers. Keeping in view the above facts in mind, the

present investigation was undertaken to study the comparative vegetative growth, herbage and oil yield of four *Mentha* species when intercropped with four year old poplar stand and as a sole crop.

2. Materials and Methods

Experimental site

The field experiment was conducted out in the year 2016 at the Agroforestry Research Centre, Patharchatta, G.B. Pant University of Agriculture and Technology, Pantnagar, district Udham Singh Nagar (Uttarakhand), 29^0 N latitude and 79.3^0 E longitude at an altitude of 243.84 m AMSL at the foot hills of Himalayas in Tarai region of Uttarakhand. The climatic conditions are humid sub-tropical with hot and dry summers, cold winters along with the frost. Maximum temperature ranges from 30 - 43^0C while minimum temperature ranges from 4.5 - 26.7^0C. The mean annual rainfall is about 1400 mm. The soil of the experimental site was silty clay, neutral in reaction (pH 7.35), high in organic carbon (1.08%), medium in available nitrogen (236.32 kg ha^{-1}), high in available phosphorus (23.65 kg ha^{-1}) and medium in available potassium (275.92 kg ha^{-1}).

Experimental details

The experiment was laid out in factorial randomized block design with 8 treatments. Four species of mint *viz*., i) Japanese mint (*Mentha arvensis* L. cv. CIM-Kranti), ii) peppermint (*M. piperita* L. cv. Kukrail), iii) spearmint *(M. spicata* L. cv. Arka) and iv) bergamot mint *(M. citrata* L. cv. Kiran) were taken as intercrops with poplar and as sole crops in 4 replications. The size of the sample plots were 3.0 m x 1.0 m keeping 60 cm row to row distance with end to end planting of root suckers and runners. The poplar stand was 4-year old with 7 m x 3 m planting spacing.

Cultural operations

The field was ploughed with tractor and then levelled. Well rotten FYM @ 10 t ha^{-1} of was applied along with N:P:K @ 120:80:60 kg ha^{-1}. NPK mixture of ratio 12:32:16 (N:P:K), MoP (Muriate of potash) and urea were used. Only 30 kg ha^{-1} of nitrogen was applied as basal dose along with entire full dose of P_2O_5 and K_2O. Remaining nitrogen was applied in three equal split dosages i.e. 30 kg ha^{-1} at an interval of 45, 75 and 105 days after sowing (DAS). The irrigation, insecticide application, weeding and hoeings were done as and when required. Healthy and disease free suckers of *Mentha arvensis* and runners for *M. piperita*, *M. spicata* and *M. citrata* were procured from CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Field Station, Nagla, Pantnagar. Sowing was done on 15th Jan., 2016 through suckers and runners keeping their length 3-4 cm in furrows at a depth of 4-5 cm in end to end fashion with a row distance of 60 cm and covered with a thin layer of soil and application of immediate light irrigation. The crop was harvested twice 4-5 cm above ground with the help of sickle at 100 and 160 days after sowing and semi-dried under shade for few hours before oil extraction.

Observation Recorded

Growth parameters of poplar tree

Observations on 40 trees surrounding the experimental plot were done at the time of sowing and at final harvest of *Mentha*. Tree height was measured with the help of bamboo pole, whereas tree calliper was used to measure diameter at breast height. Following regression equation formulated by Dhanda and Verma (2001) [4] was used for calculating the total volume of poplar trees over bark.

$$V = 0.00703 + 0.32224 * D^2H$$

Where V = Total volume of the poplar tree (m^3), D = Diameter at breast height (m) and H = Tree height (m).

Observation on *Mentha* species

The crop was harvested twice after 100 and 160 DAS. Observations on vegetative parameters (plant height and plant spread) and yield parameters (fresh herbage yield, oil content and oil yield) were recorded. The essential oil was extracted by hydro-distillation method with the help of Clevenger apparatus (Clevenger, 1928) [3]. Oil content (%) was estimated by extraction of oil from 100 gm of semi-dried sample and applying the following formula:

$$Oil\ content\ on\ fresh\ weight\ (\%) = \frac{Volum\ of\ oil}{Weight\ of\ fresh\ herb}\ X\ 100$$

Oil content was multiplied with fresh herbage yield to determine oil yield per hectare.

Statistical analysis

The data was analysed using online OPSTAT software and CD was calculated at 5% level of significance (Snedecor and Cochran, 1967) [12].

3. Results and Discussion

Growth parameters of poplar trees

The average tree diameter of popular tree at breast height during the time of sowing of crop and at the time of harvesting was 0.15 and 0.16 m, respectively, exhibiting an increment of 5.05% in diameter at breast height. The average tree height measured at the time of sowing was 13.99 and 14.62 m at the time of harvesting of crop, resulting in 4.50% increment in tree height. The average volume at the time of sowing of crop was 0.11 m^3, whereas the average volume at the time of harvesting was 0.13 m^3. There was an increment of 14.38% in the tree volume (Table 1). Results are in accordance with the earlier study made by Dhanda and Verma (2001) [4] in different tree species.

Table 1: Yield attributes of poplar trees under agroforestry

Average tree height (m)			Average tree diameter at breast height (m)			Tree volume (m^3)		Volume increment (%)
At sowing	At harvesting	Height increment	At sowing	At harvesting	Diameter increment	At sowing	At harvesting	
13.9975	14.6285	0.631	0.15418	0.16196	0.007782	0.11431	0.13075	14.3822

Volume (V) = $0.00703 + 0.32224 * D^2H$

Vegetative parameters of *Mentha* species

Plant height measured at 100 DAS i.e. on first harvesting showed a significant difference, as a sole crop *Mentha piperita* recorded maximum plant height of 60.75 cm and minimum plant height of 52.00 cm was recorded in *M. citrata* as an intercrop (Table 2). Similarly, at 160 DAS i.e. after 1st cutting, the difference in plant height between both the systems increased. Maximum plant height (41.50 cm) was recorded in *Mentha arvensis* as a sole crop and minimum (30.25 cm) in M. piperita under poplar based agroforestry system.

Table 2: Effect on plant height (cm) of different *Mentha* species intercropped with poplar

Treatments (T)	100 DAS			160 DAS		
	Poplar	Open	Mean	Poplar	Open	Mean
M. arvensis	57.25	60.50	58.88	37.75	41.50	39.63
M. piperita	56.50	60.75	58.63	30.25	40.38	35.63
M. spicata	52.75	55.00	53.88	32.13	40.38	36.26
M. citrata	52.00	55.00	53.50	32.25	40.75	36.50
Mean	54.63	57.82	56.23	33.10	40.76	36.93
Analysis	T	GC*	T x GC	T	GC	T x GC
SEm±	0.45	0.32	0.65	0.38	0.27	0.54
CD (0.05)	1.31	0.93	1.92	1.12	0.79	1.58

*GC: Growing conditions (poplar and open)
DAS: Days after sowing

Similarly, plant spread was maximum (51.15 cm) under open condition in *M. arvensis* and minimum (34.70 cm) in *M. citrata* at 100 DAS (Table 3). Whereas after first harvesting i.e. at 160 DAS, *M. arvensis* continued to show maximum plant spread under sole cropping Both, plant height and plant spread decreased under agroforestry at first and second cutting due to competition for space, light, water and nutrients (Sanwal *et al*., 2016) [10].

Table 3: Effect on plant spread (cm) of different *Mentha* species intercropped with poplar

Treatments (T)	100 DAS			160 DAS		
	Poplar	Open	Mean	Poplar	Open	Mean
M. arvensis	44.38	51.15	47.77	23.33	50.43	36.88
M. piperita	44.00	51.03	47.52	21.25	44.58	32.92
M. spicata	38.60	43.96	41.28	31.83	44.05	37.94
M. citrata	37.40	43.83	40.62	23.68	31.18	27.43
Mean	41.10	47.50	44.30	25.03	42.56	33.80
Analysis	T	GC	T x GC	T	GC	T x GC
SEm±	0.73	0.51	1.03	1.18	0.83	1.66
CD (0.05)	2.14	1.52	NS	3.45	2.44	4.87

Yield parameters of *Mentha* species

The total fresh herbage yield (Table 4) was maximum (263.50 q ha^{-1}) in *M. arvensis* followed by *M. piperita* (238.06 q ha^{-1}), *M. citrata* (166.0 q ha^{-1}) and *M. spicata* (165.0 q ha^{-1}) as a sole crop, whereas, under agroforestry *M. piperita* recorded the maximum yield (122.71 q ha^{-1}) and *M. spicata* the least (79.92 q ha^{-1}). After 1st harvesting, under agroforestry the reduction in herbage yield was 37.23% for *M. arvensis*, 50.36% for *M. piperita*, 59.79% for *M. spicata* and 50.49% for *M. citrata*. As a sole crop, *M. arvensis* showed an increment of about 4.0% in herbage yield while other three species showed a declination. *M. citrata* recorded the maximum decline of about 34%.

Table 4: Effect on fresh herbage yield (q ha^{-1}) of different *Mentha* species intercropped with poplar

Treatments (T)	I harvest (100 DAS)			II harvest (160 DAS)			Total (I + II)		
	Poplar	Open	Mean	Poplar	Open	Mean	Poplar	Open	Mean
M. arvensis	68.50	129.25	98.88	42.95	134.25	88.60	111.45	263.50	187.48
M. piperita	82.00	122.25	102.13	40.71	115.81	78.26	122.71	238.06	180.39
M. spicata	57.00	88.75	72.88	22.92	76.25	49.59	79.92	165.00	122.46
M. citrata	59.25	99.75	79.50	29.34	66.24	47.79	88.60	166.00	127.30
Mean	66.69	110.00	88.35	33.98	98.14	66.07	100.67	208.14	154.41
Analysis	T	GC	T x GC	T	GC	T x GC	T	GC	T x GC
SEm±	1.08	0.77	1.53	1.00	0.71	1.41	1.54	1.09	2.17
CD (0.05)	3.19	2.26	4.52	2.96	2.09	4.18	4.54	3.21	6.42

Essential oil content (%) in *Mentha* species under both the growing conditions showed a decreasing trend at second cutting except for *M. arvensis* as a sole crop where a slight increase of 1.38% from 1.24% was observed (Fig. 1). Under poplar, *M. arvensis* recorded the maximum oil content of 0.91% on first and 0.89% on second harvest. *M. piperita* recorded the minimum oil content in both the systems, reduction from 0.44 to 0.38% under poplar and 0.61 to 0.45% under open condition was observed. *M. citrata* did not show a significant difference.

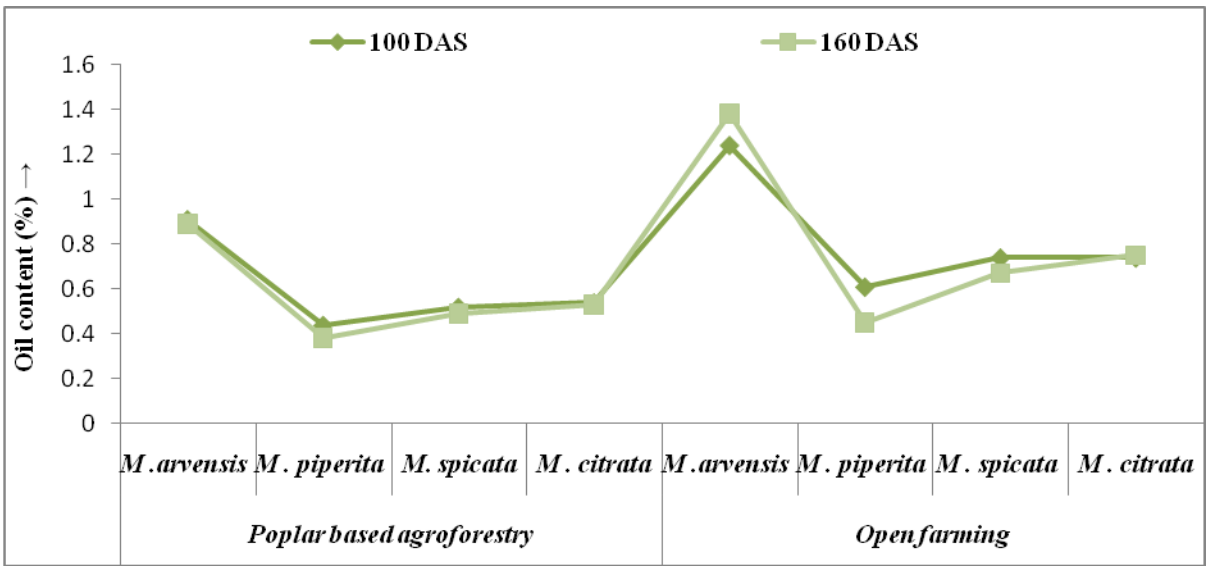

Fig 1: Effect on oil content (%) in different *Mentha* species at1st and 2nd harvest when intercropped with poplar

Oil yield as a sole crop was higher as compared to intercropping (Table 5). Reduction in oil yield was observed at second cutting among all the species except *M. arvensis* under open where an increase of about 16.0% was seen. At first cutting, maximum oil yield of 159.10 l ha^{-1} under open was recorded in *M. arvensis* and minimum of 29.23 l ha^{-1} in *M. spicata* under poplar. Whereas at second cutting, similar trend was observed but reduction under agroforestry was more as compared to first cutting. Under open condition, maximum oil yield of 184.61 l ha^{-1} was recorded in *M. arvensis* and minimum of 11.04 l ha^{-1} in *M. spicata* under poplar.

Table 5: Effect on oil yield (l ha^{-1}) in different *Mentha* species intercropped with poplar

Treatments (T)	I harvest (100 DAS)			II harvest (160 DAS)			Total (I + II)		
	Poplar	Open	Mean	Poplar	Open	Mean	Poplar	Open	Mean
M. arvensis	62.13	159.10	110.62	38.16	184.61	111.38	100.29	343.71	222.00
M. piperita	35.89	74.10	55.00	15.24	52.15	33.70	51.12	126.25	88.69
M. spicata	29.23	64.87	47.05	11.04	50.51	30.78	40.26	115.37	77.82
M. citrata	31.50	72.95	52.22	15.44	49.66	32.55	46.94	122.61	84.78
Mean	39.69	92.76	66.23	19.97	84.24	52.11	59.66	176.99	118.32
Analysis	T	GC	T x GC	T	GC	T x GC	T	GC	T x GC
SEm±	0.98	0.69	1.38	1.09	0.77	1.54	1.55	1.10	2.19
CD (0.05)	2.88	2.04	4.07	3.22	2.28	4.55	4.58	3.24	6.48

Overall the total oil production for *M. arvensis*, *M. piperita*, *M. citrata* and *M. spicata* was 343.71, 126.25, 122.61, 115.37 l ha^{-1} under open and 100.29, 51.12, 46.94 and 40.26 l ha^{-1} under poplar, respectively. Results are in accordance with the similar type of studies made on *Mentha* intercropping under agroforestry by Singh *et al*., (1990) [11], Gill *et al*., (2008) [5] and Rathi *et al*., (2008) [9]. Venkatesh and Nagarajaih (2010) [15] have also reported the decrease in oil yield in case of lemongrass when intercropped with teak and Suvera *et al*., (2015) [13] reported the decrease in oil yield of *Ocimum gratissimum* intercropped with *Pongamia pinnata*.

4. Conclusion

From the present study, it can be concluded that, growth of all the *Mentha* species was severely affected when intercropped with poplar. Also the reduction in vegetative parameters and yield, increase at second cutting due to new flush of leaves in poplar. Reduction in oil yield for *M. arvensis*, *M. piperita*, *M. citrata* and *M. spicata* was 70.83, 59.51, 61.72 and 65.12%, respectively under poplar based agroforestry system as compared to open farming system so no species of *Mentha* is profitable under four year old poplar plantation as oil yield is below 50%. However, Japanese mint (*Mentha arvensis* L.) cv. CIM-Kranti is high yielding and can be recommended to the farmers as sole crop under irrigated conditions.

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