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Spacing and Irrigation Effect on Herbage Yield and Essential Oil Content of *Mentha citrata* Ehrh.

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ABSTRACT

The aim of the study was to determine the herbage yield and oil content of *Mentha citrata* Ehrh. an important medicinal and aromatic herb in the Brahmaputra valley agro-climatic zone (northeastern India) using different spacing (density) with or without irrigation. The cultivation trials were done using vegetative sucker for two consecutive years. The size of the experimental beds was 7.2×3.6 m and these were raised (10 cm from land surface) to prevent water logging during the rainy season. Suckers were planted in them with different spacings and accommodated 285, 247, 209, 190 and 181 numbers of suckers in five different plant densities, namely, 40×25, 40×30, 40×35, 40×40 and 40×45 cm respectively with three replications. While the herbage yield varied with irrigation and without irrigation treatment respectively, no variation in oil content was, however, recorded. Herbage and oil yield in *M. citrata* were enhanced when the crop was planted in 40×35 cm spacing with irrigation in comparison to other trials. The present study shows that the herb yield percent was highest in 40×35 cm spacing during both years (21.84±0.03-21.68±0.21) and the mean oil yield percent ranged from 0.61-0.63% with or without irrigation.

Key words: *Mentha citrata*, sucker, irrigation, spacing, oil yield

INTRODUCTION

Mentha citrata Ehrh. is an important medicinal plant native to Europe which has been extensively cultivated in various parts of the world including northeastern India (Fig. 1). Although, large-scale mint cultivation has come up only recently, mankind from ancient times has used these plants (Shormin *et al.*, 2009). *M. citrata* oil is mostly used in flavouring medicines, liquor, shaving lotion and production of many other pharmaceutical products. Bergamot mint (*M. citrata*) is a succulent, multi cut crop that has a high water requirement during its active growth period in summer months. In north India, the crop is cultivated on sandy loam soils where moisture is inadequate and soil temperatures are high and frequent irrigations done to obtain good growth and essential oil yields from the crop (Ram *et al.*, 1995). The major constituents of oil are linalool and linalyl acetate and are extensively used for commercial purposes. *M. citrata* has already been introduced in India and cultivated in various places because of the commercial needs (Singh and Kewala, 1979; Vadivel and Sampath, 1981; Rajeswara Rao *et al.*, 1984). However appropriate and adequate agronomic information including plant density and irrigation requirement for this crop particularly in northeastern India is scanty. Among the various factor affecting crop production, spacing and irrigation assumes considerable significance.



Fig. 1: A sprig of *Mentha citrata* Ehrh.

The maximum oil yield percentage of *M. spicata* was recorded as 28.78 kg ha⁻¹ when the crop was planted in spaced at 40×40 cm on the other hand, herbage yield decreased with widening of row spacing (Singh and Kewala, 1979; Katoch *et al.*, 1999; Jha and Singh, 1973). In *M. spicata* a closer row spacing of 30×45 cm gave significantly higher yield over wider row spacing of 60×70 cm. The few important studies conducted on yield behaviour of *M. spicata* on spacing and observed that herb yield decreased as the spacing increased from 30 to 60 cm² (Randhawa *et al.*, 1984).

In *M. citrate* the biomass and oil yield was recorded to be the highest when the crop was planted in spaced at 45 cm row spacing. However, the herbage yield and oil content has been decreased significantly if row spacing increased (Rajeswara Rao *et al.*, 1984). Yield of Bergamot mint (*M. citata*) was planted in spaced at 40×40 cm produced maximum herbage of 197.27t ha⁻¹ while the yield percent decline in wider spacing (Vedivel *et al.*, 1981). The mint cultivation in ten irrigation trail treatments was shown that irrigation increased the yield of herbages as well as oil contents during first harvest (Duhan *et al.*, 1977). In *M. piperta* irrigation along with supplementing rainfall had increased herbage yield and oil contents during the growth season (Kerekes and Hornok, 1972). The favourable effects of irrigation in enhancing herb and essential oil yields of various mints species have been reported by Clark and Menary (1980), Kothari *et al.* (1989) and Ram *et al.* (1993). The irrigation requirements of mints differ from location to location depending on soil type, soil fertility status and climatic factors. However, little information is available on interaction effects of irrigation in sandy loam soil of sub-tropical climate (Ram *et al.*, 1995). Fresh herbage and essential oil yield of *M. citrata* increased significantly with increasing levels of irrigation up to 1.2 IW: CPE ratio (Ram *et al.*, 1995).

Keeping this view, for the benefit of mint growers, the herbage yield and essential oil content variability of *M. citrata* was studied extensively using different plant density and irrigation method at the Brahmaputra valley agro-climatic zones for the period of two years and our aim of the study was to evaluate the optimum spacing for commercial cultivation of *M. citrata* (Fig. 1).

MATERIALS AND METHODS

Studies were conducted in Bajali, Assam (134 m asl between 26°31'14.40" lat. and 91°12'3.20" long.) at author's home garden, Pathsala during 2006-2008 (Fig. 2). Experimental beds of 7.2×3.6 m were prepared by digging and ploughing the land before the monsoon start. Beds were raised (10 cm from land surface) to prevent water logging during rainy season. Ridges were made vertically (ridges along the slope) and horizontally (ridges across the slope) prior to plantation. Runners/suckers were planted in experiment beds in different spacing and accommodate 285, 247, 209, 190 and 181 numbers of suckers in five different plant densities like 40×25, 40×30, 40×35, 40×40 and 40×45 cm, respectively with three replications. Suckers were placed in furrows and then covered with soil layer. The soil of the experimental plot was a sandy loam having pH 8.4. The water holding capacity of the soil was 19.5%. The important plant nutrients in the soil profile (0-15 cm) were: available N, 74; available P, 6.0; exchangeable K, 45 (mg kg^{-1}), respectively. The organic matter content of the soil was 0.28%. At the time of planting 60 kg each of P_2O_5 and K_2O and 1/4th of nitrogen as per the treatment were applied as basal dose and the remaining quantity of nitrogen was top dressed in two splits, 45 days after planting and after the first harvest. The experiment was conducted for two crop seasons in relation to herb and oil yield.

Planting were done during April, 2006 (pre-monsoon season). Harvesting of the crop was done at 180 days interval from the date of planting after full grown at mature stage. Irrigation was done once in week up to 6 cm depth (A 25.92 m^2 plot required 150 liters water) and every alternative day in dry spell. Ground water contribution to crop water use was considered to be zero as the depth of water table in the experimental field was 8 m. Effective rainfall was taken into account for computing consumptive use of water.

The essential oil obtain from freshly harvested herb during October (180 days later from plantation) was hydro-distilled for a period of 150 min utilizing 500 g fresh herb. The essential oil content of the fresh herbage was estimated by hydro-distillation method using Clevenger's apparatus. The data obtained were analyzed statistically and Least Significant Difference (LSD) at 0.05 levels was calculated. In Table 1 the yield data were presented in kg plot^{-1} , because an experiment was conducted at 25.92 m^2 experimental plots.

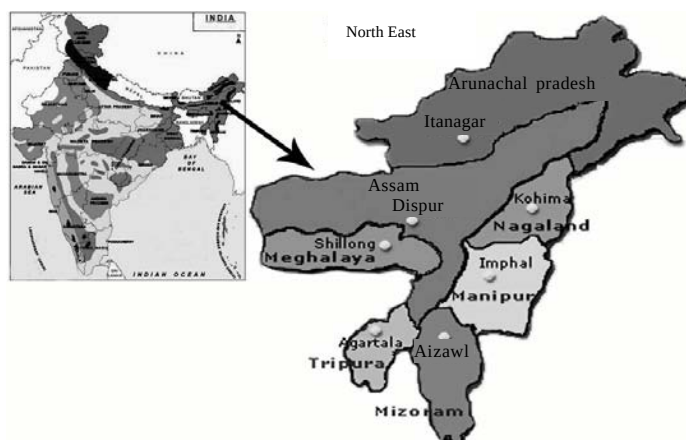


Fig. 2: Study Locations: Bajali, Assam, India

RESULTS AND DISCUSSION

The herb yield data obtained in different agronomic practices was shown in Table 1. The results indicate that the maximum herb yield (21.84 kg plot⁻¹) due to different plant densities with and without irrigation was observed. In case of 40×35 cm spacing with or without irrigation, for both the years, maximum herb yield was recorded. The minimum herb yields were recorded with 40×45 cm with or without irrigation (9.61 kg and 14.02 kg plot⁻¹, respectively) for both the years. The general low herb yield trends were recorded for the plants with no irrigation while the irrigated crop did not show such trends. Regardless of whether the crop beds were irrigated or not, herb yield pattern were increased up to the spacing of 40×35 cm and then gradual decline was noticed for the spacing up to 40×45 cm.

The effect of densities of plant population on *M. spicata* has been studied by Jha and Singh (1973), where they recorded 40 cm row spacing as the most suitable among all the spacing. Similarly, maximum output, in respect of herbage and oil yield of *M. piperta* had been recorded in a spacing of 50×15 cm (Adamovic *et al.*, 1982). In case of *M. citrata*, biomass and essential oil yield were much higher under 45 cm row spacing, as compared to the row spacing of 60 and 30 cm (Rajeswara Rao *et al.*, 1984). The concept of crop productivities of mint species has also been evaluated by Randhawa *et al.* (1984) under Punjab agro-climatic condition emphasizing irrigation treatments. The effect of irrigation with supplementary rainfall has been proved to beneficial in mint production. In Hungary some encouraging findings were reported in herbage production and essential oil yield in *M. piperta* through irrigation treatments (Kerekes and Hornok, 1972). Okwany *et al.* (2011) studied impact of sustained deficit irrigation on spearmint (*Mentha spicata* L.) biomass production, oil yield and oil quality and reported that significant reduction in fresh mint hay (harvested biomass) yield with increasing water deficit. However, spearmint oil yields remained generally uniform across irrigation treatments at the first cutting but decreased at the driest plots during the second harvest due to a loss of plant stand. Tuteja *et al.* (2005) studied effect of irrigation and nitrogen splitting on herbage and oil yield of Japanese mint

Table 1: Fresh herbage yield (kg⁻¹ 7.2×3.6 m² area) at different spacing and irrigation

Treatments	1st year herbage yield				2nd year herbage yield			
	1st October	2nd April	Total	Mean	1st October	2nd April	Total	Mean
40×25 cm No irrigation	14.99	8.44	23.43	11.71	14.33	7.37	21.7	10.85
40×30 cm No irrigation	16.44	8.08	24.52	12.26	15.81	8.61	24.42	12.25
40×35 cm No irrigation	17.28	10.40	27.68	13.84	17.81	10.57	28.38	14.19
40×40 cm No irrigation	13.55	7.31	20.86	10.43	13.24	6.84	20.08	10.04
40×45 cm No irrigation	12.66	6.57	19.23	9.61	12.48	6.04	18.88	09.44
40×25 cm Irrigation	21.50	9.47	30.47	15.48	23.87	9.37	33.24	16.62
40×30 cm Irrigation	23.95	8.80	32.75	16.37	24.35	8.97	33.32	16.66
40×35 cm Irrigation	30.13	13.55	43.68	21.84	29.64	13.72	43.3	21.68
40×40 cm Irrigation	25.50	11.06	37.01	18.55	26.71	11.64	38.35	19.17
40×45 cm Irrigation	20.00	8.04	28.04	14.02	20.0	8.17	28.17	14.08
All value Mean				14.41				14.49
±SD				3.78				4.03
LDS (p = 0.05)								
1st year yield×2nd year yield								
r value					0.992			
p-value					0.632			

All values are means of triplicate determinations±standard deviation

Table 2: Spacing and irrigation effect on oil content (%) of fresh herb yield of *M. citrata*

Treatments	1st year oil percentage			2nd year Oil percentage		
	1st hervest October	2nd hervest April	Mean	1st hervest October	2nd harvest April	Mean
40×25 cm No irrigation	0.573	0.667	0.620	0.574	0.667	0.620
40×30 cm No irrigation	0.579	0.681	0.630	0.577	0.683	0.630
40×35 cm No irrigation	0.566	0.668	0.617	0.574	0.669	0.621
40×40 cm No irrigation	0.574	0.657	0.615	0.576	0.664	0.620
40×45 cm No irrigation	0.580	0.680	0.630	0.578	0.682	0.630
40×25 cm Irrigation	0.587	0.681	0.634	0.583	0.676	0.629
40×30 cm Irrigation	0.579	0.680	0.629	0.578	0.682	0.630
40×35 cm Irrigation	0.594	0.674	0.634	0.589	0.677	0.633
40×40 cm Irrigation	0.574	0.684	0.624	0.586	0.686	0.636
40×45 cm Irrigation	0.576	0.679	0.627	0.574	0.678	0.626
All value Mean			0.626			0.627
±SD			0.006			0.005
LDS (p = 0.05)						
1st year×2nd year oil percentage						
r value			0.738			
p-value			0.015			

All values are means of triplicate determinations±standard deviation

(*Mentha arvensis*) by applying three irrigation levels (1.1, 7.8 and 4.6 IW: CPE) and recorded IW:C PE ratio of 1.1 proved beneficial, as it increased herbage and oil yields with higher net returns and benefit: Cost ratio.

Similar positive effect of irrigation on enhanced crop yield production of *M. piperta* was also examined in Israel (Putievsky, 1998). On the other hand, irrigation during monsoon period has not increased the yield in case of *M. arvensis* (Duhan *et al.*, 1977) and this has confirmatory with present investigation where irrigation was found to be necessary during the premonsoon period. It is however emphasize that irrigation at first cutting significantly increased crop yield (14.38 and 14.31 t ha⁻¹ in two different years) as compared to non-irrigated plants.

The effect on oil yield due to different plant densities along with irrigation and no irrigation treatment results has been presented in Table 2. The results exhibit that there is no significant variation of oil yield in individual plants due to irrigation and non irrigation along with spacing density effect. The average oil yield was 0.626 (±0.006) and 0.627% w/v (±0.005) with or without irrigation and different plant densities along with two different harvest schedules. The variation of total oil yield that was however observed was due to herbage yield (Table 1) from given plant densities and not a result of increased productivity of individual plants.

CONCLUSION

The present study established that herb and oil yield production in *M. citrata* has been enhanced when the crop was planted in spaced at 40×35 cm with irrigation and based on the results we accept that this is the optimum spacing. This crop can be cultivated for proper utilization of wasteland in this region along with favorable agro-climatic condition for large scale productions.

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