Indian Journal of Agronomy **68** (3): 338–341 (September 2023)

Research Communication

Effect of land configuration, irrigation regimes and nitrogen application on growth, yield and quality of Japanese mint *(Mentha arvensis)*

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Received: August 2021; Revised accepted: September 2023

ABSTRACT

An experiment was conducted during *summer* season of 2016–17 at the Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, to study the effect of land configuration, irrigation regimes and nitrogen application on growth, yield and quality of Japanese mint (*Mentha arvensis*). The treatments consisted of 3 land configurations (flat-bed planting, ridge planting and raised-bed planting), 3 irrigation regimes 0.8 irrigation water: cumulative pan evaporation (IW: CPE), 1.0 IW: CPE and 1.2 IW: CPE ratio) and 3 nitrogen levels recommended dose of nitrogen [(RDN) 160 kg N/ha], 75% RDN (120 kg N/ha) and 125% RDN (200 kg N/ha)] in a split-plot design with 3 replications. Raised-bed planting recorded the maximum leaves/plant (188.8), plant fresh weight (1868 g/m^2), leaf: stem ratio (1.84), herbage (1.80 t/ha) and oil yield (136.5 lit./ha) than the ridge and flat-bed planting. Irrigating the crop at an IW: CPE ratio of 1.2 resulted in the highest growth parameters, herb (1.71 t/ha) and oil yield (130.1 lit./ha) and quality parameters over other irrigation regimes. Significantly the maximum crop growth [leaves/plant (189.8), plant fresh weight (1784 g/m^2), leaf: stem ratio (1.77)], herbage (1.71 t/ha) and oil yield (131.9 lit./ha); and quality parameters [carotenoid content (2.66 mg/g fresh weight), menthone content (6.23%), menthol content (72.0%) and oil content (0.77%)] were recorded with the application of 125% RDN over 75% RDN and it was at par with 100% RDN. This study indicated that planting on raised bed, irrigation at 1.2 IW: CPE ratio and the application of 125% RDN (200 kg N/ha) gave higher yield and quality of Japanese mint.

Key words: Irrigation, Land configuration, Mentha, Nitrogen, Yield

Japanese mint (*Mentha arvensis* L.) is the source of menthol rich essential oil which has a variety of industrial applications. The essential oil, menthol crystals, dementholated oil and its minor monoterpenes fractionates find uses in the food, flavour, pharmaceutical, cosmetic and agrichemical industries. India is one of the largest producers and exporter of mentha oil and its derivatives. Its cultivation supports livelihoods of more than 1 million small-holder farmers in India (Singh *et al*., 2018a). Indo-Gangetic plains of India, especially the water rich areas of Uttar Pradesh and Punjab has seen a phenomenal growth in production of mentha in the last couple of decades. Uttar Pradesh accounts for around 80% of Indian mint production. The sowing of the crop starts from January and continue till March while harvesting during May-June (Choudhary *et al*., 2018). Planting methods play a key role in the establishment of seedlings besides affecting soil aeration, temperature, root development and water use. The flat planting followed by flooding is the common practice of raising mint crop in India. In Uttar Pradesh, mint generally planted on flat beds in rows spaced at 45 cm ×20 cm. Ridge and bed plantings have been shown to be more efficient than flat planting in relation to water and nutrient use (Kaur *et al*., 2013).

Mint being a leafy herb, responds to frequent irrigation during dry season's months to obtain good growth and high yields. It absorbs substantial quantities of N, P and K as compared to other mint species. Water and nitrogen are important to influence the essential oil production in mint besides phosphorus and potassium (Behera *et al*., 2013; Singh *et al*., 2015). It responds well to high levels of nitrogen fertilizer, between 0.15 and 0.25 t/ha, depending on different agro-climatic conditions (Behera *et al*., 2015). The land configuration and irrigation requirement of mint differs from location to location, depending on soil type, soil-fertility status and climatic conditions. However, the scientific information on the performance of land

Based on a part of M.Sc. Thesis of the first author submitted to the NDUAT, Kumarganj Faizabad in 2017 (unpublished)

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configuration on Japanese mint is meagre under saline soils of northern India, especially Uttar Pradesh. The interaction effects of land configuration, irrigation and nitrogen requirement on crop performance is also lacking for Uttar Pradesh conditions. Considering these points, objective was set to find out suitable land configuration, irrigation regime and rate of nitrogen application in relation to growth, yield and quality of the Japanese mint.

A field experiment was conducted during the summer (*zaid*) seasons of 2016 -17 at Kumarganj, Faizabad, Uttar Pradesh. The soil was silt clay loam, and saline (pH 8.2). It was low in organic carbon (0.32%) and available nitrogen (0.137 t/ha), medium in available phosphorus (0.022 t/ha) and potassium (0.249 t/ha). Rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) rotation was followed in the field for last many years. The treatments consisted of 3 land configuration (flat-bed planting, ridge-planting and raised-bed planting), 3 irrigation regimes [0.8 irrigation water: cumulative pan evaporation (IW: CPE), 1.0 IW: CPE and 1.2 IW: CPE ratio) taken in main plot and 3 nitrogen levels [recommended dose of nitrogen (RDN) 160 kg N/ha, 75% RDN (120 kg N/ha) and 125% RDN (200 kg N/ha)] in subplot in split-plot design with 3 replications. The suckers of variety 'Kashi' were transplanted at spacing of 45 cm×20 cm on 22 March, 2017 as per land-configuration treatments. As per treatment, differential amount of water was applied on the basis of IW: CPE through meteorological approach. Cumulative pan evaporation for different treatments was computed using data from a standard US Weather Bureau Class-A open pan evaporimeter. The depth of irrigation water was 6 cm applied through a Parshall Flume. First irrigation was given 1 day prior to planting. Subsequent irrigations were given as per treatment. If rainfall event occurred between irrigation cycles, then the effective rainfall amount was taken into consideration while applying irrigation. Half amount of nitrogen (through urea) as per treatment, and full dose of phosphorus (0.06 t/ha through single super phosphate) and potassium (0.06 t/ha, through muriate of potash) were applied basal at the time of planting. It was placed in open furrows about 2.5 cm below the suckers and mixed well with the soil by a small stick. Remaining nitrogen was given in 2 equal splits, at 25 and 40 days after planting (DAP). Crop-growth data were recorded periodically up to the harvesting. The chlorophyll and carotenoid content were calculated using the formula given by Lichtenthaler and Buschmann (2001). The crop was single harvested at 100 days after planting. It was done in bright sunny weather with the help of a sickle from 2 to 3 cm above the ground level when the lower leaves start yellowing. The herbage was dried for 2 days. The essential oil was extracted from the fresh herbage through steam distillation method as suggested by Zheljazkov *et al.* (2010). The volume of oil was recorded and oil per cent was computed by the following formula.

Oil content (w/w %) on fresh-weight basis = Weight of oil/ Weight of fresh herb× 100

The oil percent was multiplied with corresponding fresh herbage yield of each treatment to get the oil yield. The oil was analysed at the CIMAP, Lucknow, Uttar Pradesh by gas liquid chromatography (Hewlett Packard 5890, column AT 1000, temperature from 1000 °C to 1700 °C raised to 50 per minute, carrier gas-nitrogen @ 1 ml/min) for principal chemical constituents such as menthone and menthol and expressed in percentage (%). The data were statistically analysed.

During the crop season, total rainfall of 120.4 mm occurred during April - June. In general, there was a gradual increase in temperature from March to June which favoured the growth and development of crop. Maximum and minimum temperature was also favourable for the growth and development of crop. The relative humidity although optimum in the beginning showed an increase as the crop advanced in age from March to June. There was a gradual drop in relative humidity from April to June due to rise in maximum temperature. Period of bright sunshine hours during investigation was normal with slight fluctuation due to cloudy weather or rainfall occurrence.

Among land configurations, raised-bed planting significantly increased the growth attributes such as plant height, leaves, fresh weight of plant, leaf: stem ratio and branches of mint crop at 60 days after planting (DAP) as compared to ridge and flat-bed planting (Table 1). The increase in growth parameters might be owing to better soil condition under raised-bed planting ultimately better growth and development of crop. Increasing the level of irrigation from 0.8 IW: CPE to 1.2 IW: CPE significantly enhanced the growth attributes. Irrigating the crop at IW: CPE ratio of 1.2 showed maximum leaves/plant, fresh weight of plant, leaf: stem ratio followed by IW: CPE ratio 1.0 and 0.8, respectively. Frequent irrigations enhanced the growth parameters owing to quick development of extensive root-system, which created a conducive environment to absorb more water and nutrient. It is well known that proper supply of moisture and nutrients helps in maintaining high photosynthetic rate, which increases the cell elongation and its multiplication at a much faster rate. In the present study, all these factors cumulatively affected the plant growth from the initial stage to harvesting under different irrigation regimes. Our results confirm the findings of Behera *et al.* (2015) and Singh *et al.* (2018a). Leaves/plant, fresh weight of plant and leaf: stem ratio were significantly influenced by application of 125% RDN as compared to 75% RDN and it was statistically at par with RDN. This may be attributed to more proliferation of root biomass, resulting in more absorption of nutrients and water from the soil leading to production of higher vegetative biomass. Adequate nutrition plays an important role on plant growth and development. It promotes vegetative growth through cell enlargement, multiplication and increase in the rate of photosynthesis (Behera *et al.*, 2013, Singh *et al.*, 2015; Singh *et al.*, 2018).

Land configuration did not significantly influence the chlorophyll and carotenoid contents, but these were the highest under raised-bed planting. Irrigation at an IW: CPE ratio of 1.2 recorded significantly the highest chlorophyll and carotenoid content as compared to irrigation at IW: CPE ratio of 1.0 and 0.8, respectively. This might be owing to better aeration and adequate supply of moisture under raised-bed planting resulting in proper photosynthetic activity in the plants (Table 1). Chlorophyll and carotenoid contents in leaves differed significantly due to different levels of nitrogen. The application of 125% RDN resulted in higher chlorophyll (2.34 mg/g fresh weight of tissue) and carotenoid (2.60 mg/g fresh weight of tissue) content. While the minimum chlorophyll and carotenoid content was observed in plants supplied with 75% RDN. This might be due to increased nitrogen supply which would retard the leaf senescence and improve photosynthates. The results are in conformity with the results of Mahantesh *et al.* (2018).

No significant difference was noticed in menthol and menthone contents of herb due to land configurations. However, raised-bed planting recorded the highest menthol and menthone contents than ridge and flat-bed planting (Table 1). This was due to better growing environment which was favourable for accumulation of menthol and menthone in the leaves. Irrigation at an IW: CPE ratio of 1.2 significantly increased the menthol and menthone contents. Menthol content was not significantly affected due to nitrogen application. But menthone content was considerably affected due to nitrogen levels, being the highest with 125% RDN which was statistically at par with 100% RDN. The results are in accordance with the findings of Behera *et al*. (2013), Izhar *et al.* (2015) and Mahantesh *et al*. (2017).

Table 1. Effect of land configuration, irrigation regimes and nitrogen level on crop growth and yield attributes at harvest

Treatment	Leaves/ plant	Plant fresh weight (g/m^2)	Leaf: steam ratio	Chlorophyll content at 60 DAS (mg/g fresh weight)	Carotenoid content (mg/g fresh weight)	Herbage yield (t/ha)	Menthone content (%)	Menthol content (%)	Oil content (%)	Oil yield (lit./ha)
Land configuration										
Flat-bed planting	173.9	1662	1.62	2.28	2.52	1.53	6.13	70.4	0.73	111.4
Ridge planting	181.0	1711	1.74	2.30	2.54	1.59	6.14	71.6	0.75	119.2
Raised-bed planting	188.8	1868	1.84	2.32	2.58	1.80	6.20	72.0	0.76	136.5
SEm±	2.1	18.0	0.03	0.03	0.05	0.32	0.04	1.2	0.02	2.5
CD (P=0.05)	6.3	53.6	0.09	NS	NS	0.96	NS	NS	NS	7.49
Irrigation regimes										
0.8 IW/CPE	170.0	1719	1.62	2.25	2.48	1.54	6.12	69.9	0.74	113.6
1.0 IW/CPE	184.2	1753	1.76	2.30	2.58	1.66	6.14	71.4	0.74	123.1
1.2 IW/CPE	189.5	1769	1.82	2.34	2.60	1.71	6.22	72.7	0.76	130.1
SEm±	1.9	9.2	0.03	0.03	0.03	0.21	0.03	1.1	0.02	2.2
CD (P=0.05)	5.9	27.7	0.08	0.08	0.11	0.62	0.09	NS	NS	6.52
Nitrogen levels										
RDN (160 kg N/ha)	184.6	1759	1.75	2.32	2.60	1.66	6.18	71.6	0.76	126.4
75% RDN (120 kg N/ha)	169.2	1698	1.62	2.19	2.39	1.54	6.08	70.3	0.72	110.6
125% RDN (200 kg N/ha)	189.8	1784	1.77	2.38	2.66	1.71	6.23	72.0	0.77	131.9
SEm±	1.8	9.0	0.02	0.02	0.03	0.16	0.02	0.9	0.02	1.9
CD (P=0.05)	5.6	26.0	0.07	0.06	0.08	0.49	0.06	NS	0.05	5.59

IW: CPE, Irrigation water: cumulative pan evaporation; recommended dose of nitrogen (RDN); DAS- days after sowing

Herbage yield was significantly affected by the land configuration. It was 15.0 and 11.5% higher under raised-bed planting than ridge and flat-bed planting respectively. The raised-bed planting provides better soil condition for crop growth, resulting in maximum herbage yield. The maximum herbage (1.71 t/ha) yield was recorded with IW: CPE ratio of 1.2, which was 10.3 and 2.8% more than that of IW: CPE ratio of 1.0 and 0.8 respectively (Table 1). The favourable effect of irrigation in enhancing herb yield of mint species was also reported by Behera *et al*. (2013) and Lakra and Verma (2021). Application of 125% RDN resulted in significantly maximum herb (10.4%) and oil yield than 75% RDN and it was at par with RDN. Adequate supply of nutrients increased herbage yield owing to production of taller plants, more branches and leaves/plant, superior leaf: stem ratio and increased dry-matter accumulation. An increase in leaf number increased the photosynthetic area. It facilitated the crop for more vegetative growth and accumulation of secondary metabolites to develop more oil (Behera *et al*., 2015).

Land configuration significantly increased the oil yield. It was 18.4 and 112.7% higher under raised-bed planting than ridge and flat-bed planting respectively. Significantly maximum oil yield was recorded with irrigation at IW: CPE ratio of 1.2, which was 12.7 and 5.4% more than that of irrigation at IW: CPE ratio of 0.8 and 1.0 respectively (Table 1). Among nitrogen levels, application of 150% recommended dose of nitrogen resulted in 15.5 and 4.2% more oil yield than 75% RDN and RDN respectively. Izhar *et al*. (2015), also reported higher yield of menthol mint with higher rate of N application.

It can be concluded that, planting of Japanese mint on raised bed, irrigation at 1.2 IW: CPE and the application of 125% RDN (200 kg N/ha) resulted in significantly in better growth, maximum herbage and oil yield during summer season at Kumarganj, Faizabad, Uttar Pradesh.

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