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# Row Spacing and Harvesting Age Affect Agronomic Characteristics and Essential Oil Yield of Japanese Mint (*Mentha arvensis* L.)

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## ABSTRACT

A field experiment was conducted to evaluate the influence of row spacing and harvesting age on herb and essential oil yield of Japanese mint (*Mentha arvensis* L.) at Wondo Genet Agricultural Research Center, EIAR, Southern Ethiopia. The treatments were combinations of four levels of row spacing (30, 40, 50 and 60 cm) and three levels of harvesting age (60, 90 and 120 days after planting). A split plot design with three replications, row spacing as main plot and harvesting age as sub plot was used. Fresh leaf weight, leaf/stem ratio, dry leaf weight, moisture content, fresh biomass weight, essential oil content and yield were recorded. Maximum values for fresh leaf weight, leaf/stem ratio and moisture content were recorded when harvesting was made at 60 days after planting. There was a statistically sharp ($P < 0.01$) increase in essential oil content from 0.5 to 1.4 and to 2% (w/w) with delayed harvesting from 60 to 90 and to 120 days after planting, respectively. A highly significant ($P < 0.01$) fresh biomass weight reduction was observed when row spacing was widened from 30 to 40 cm by 29.4% from 11,325 kg/ha. The maximum essential oil yield (39.7 kg/ha) was obtained when harvesting was made 120 days after planting at a 30-cm row spacing.

**Keywords:** essential oil fresh leaf weight, fresh biomass weight, leaf/stem ratio

## INTRODUCTION

*Mentha* is a genus of about 25 species of flowering plants (Abbaszadeh *et al.* 2009). Japanese mint (*Mentha arvensis* L.) is one of the most important species of the family Labiatae and the genus *Mentha* (Shormin *et al.* 2009). The essential oil obtained from fresh shoot of Japanese mint is rich in menthol (62–78%), menthone (3.6–19.32%), iso menthone (2.65–3.56%) and limonene (0.98–4.47%) (Verma *et al.* 2010). It is commercially grown for its essential oil content and herbage yields (Zeinali *et al.* 2004). Japanese mint is used in prescriptions for cold remedies, cough drops, dentifrices, mouth washes; in scenting cigarettes; flavouring tobacco, chewing pan, bakery products and in cosmetic products (Kukreja *et al.* 1991; Rao 2002; Anwar *et al.* 2010; Verma *et al.* 2010). In aromatherapy, essential oil of Japanese mint is prized for its cooling effect on the skin; for pain relieving properties; for treating digestive problems, migraine, heartburn, aching feet, travel sickness, sinus and catarrh problems (Rao 2002). The herb yields and essential oil biosynthesis in Japanese mint is strongly influenced by several intrinsic and extrinsic factors including genotype (Zeinali *et al.* 2004), harvesting age (Verma 2010), drying before essential oil extraction (Zheljazkov *et al.* 2010) and row spacing (Chand *et al.* 2004; Aflatuni 2005). Despite these factors are reported to be important yield limiting factors, there is no available information in Ethiopia about the agronomic performance of Japanese mint.

This field experiment was, therefore, conducted to investigate the influence of row spacing and harvesting age on different agronomic parameters and essential oil yield of Japanese mint under Wondo Genet area.

## MATERIALS AND METHODS

A field experiment was conducted during 2009-2010 at the Wondo Genet Agricultural Research Center, Southern Ethiopia situated at $38^0 38'$ E longitude, $7^0 19'$ N latitude and 1767 m above mean sea level. The treatments were consisted of four row spacing, viz. 30, 40, 50 and 60 cm and three harvesting age vis. 60, 90 and 120 days after planting (DAP). All treatments were replicated three times in a split plot design, where row spacing and harvesting age were allocated on main and sub-plots, respectively.

One-year-old stolons of Japanese mint were collected from the experimental station of Wondo Genet Agricultural Research Center and were planted end to end as per treatments. A uniform dose of 20 Kg N/ha in the form of urea was applied in experimental plots before planting and 60 cm irrigation was given immediately after planting. All cultural practices were applied as and when necessary depending upon the weather conditions. The plot size was 6 × 3.6 m. Data on fresh leaf weight, dry leaf weight, moisture content, leaf/stem ratio, fresh biomass weight, essential oil content and yield were collected. Essential oils were extracted from air dried leaf samples for 2:30 hrs distillation time by hydro-distillation in a Clevenger apparatus. Japanese mint essential oil from each treatment was weighed, and the oil content was calculated as the weight (g) of oil per weight (g) of dry spearmint leaf as was described by Zheljazkov *et al*. (2009). Essential oil yield was determined as the product of essential oil content and dry leaf weight (Abbaszadeh *et al.* 2009).

All statistical analysis was performed using Statistical Analysis Software following the procedure of General Linear Model as described by SAS (1998). Mean separation was made using LSD.

## RESULTS AND DISCUSSION

Results indicated that Japanese mint exhibited differential performance for most of characters under different harvesting age and spacing (**Tables 1, 2**). Such variation was also reported by Verma *et al*. (2010). Maximum values for fresh leaf weight (5,778.6 kg/ha), leaf/stem ratio (1.8) and moisture content (79.6%) were recorded when harvesting was made at 60 DAP. There was no significant difference between 90 and 120 DAP with respect to fresh leaf weight,

Received: 7 December, 2010. Accepted: 10 December, 2010.

**Table 1** Analysis of variance for Japanese mint spacing and harvesting age.

| Source of variation | Degree of freedom | Leaf: stem ratio | Fresh leaf weight | Dry leaf weight | Moisture content | Fresh biomass weight | Essential oil content | Essential oil yield |
|---|---|---|---|---|---|---|---|---|
| Rep | 2 | 0.9 | 1414460.9 | 559215.2 | 46.6 | 21512669.9 | 0.5 | 15.8 |
| Sp | 3 | 0.4ns | 26052166.9** | 1528347.9** | 16.9ns | 71062642.5** | 0.2ns | 234.6** |
| Error a | 6 | 0.6 | 2543074.7 | 96030.9 | 45.5 | 1752332.6 | 0.3 | 13. 7 |
| H | 2 | 2.0** | 15087492.9** | 180510.7 ns | 465.0** | 7401814.7 ns | 6.7 ** | 1136.3** |
| Rep * H | 4 | 0.6 | 4056512.4 | 164818.6 | 12.0 | 759696.8 | 0.2 | 70.4 |
| Sp * H | 6 | 0.4 ns | 1878314.8 ns | 109507.4ns | 50.6ns | 2087332.2 ns | 0.2 ns | 66.7** |
| Error b | 12 | 0.3 | 1611253.5 | 167006.4 | 40.2 | 3096007.3 | 0.3 | 11.6 |
| CV (%) | | 38 | 28 | 35 | 8.8 | 23 | 42.4 | |

**: Significant at 1% level; ns: non significant at 5%; Sp: row spacing; H: harvesting age

**Table 2** Effect of row spacing and harvesting age on morphology and essential oil yield of Japanese mint.

| Treatments | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | FLW (kg/ha) | DLW (kg/ha) | Leaf to stem ratio | MC (%) | FBW (kg/ha) | EOC (%) | EOY (kg/ha) |
| **Harvesting age** | | | | | | | |
| 60 DAP | 5778.6 | 1092.7 | 1.8 | 79.6 | 7818.4 | 0.5 | 5.4 |
| 90 DAP | 3604.8 | 1123.9 | 1.5 | 68.7 | 6726.8 | 1.4 | 13.7 |
| 120 DAP | 4214.4 | 1319.0 | 1.0 | 68.9 | 8250.7 | 2.0 | 24.8 |
| LSD | 1129.1 | ns | 0.5 | 5.6 | ns | 0.5 | 3.0 |
| **Spacing** | | | | | | | |
| 30 cm | 6533.0 | 1668.2 | 1.4 | 74.2 | 11325.4 | 1.3 | 21.8 |
| 40 cm | 5289.6 | 1352.5 | 1.2 | 71.0 | 7993.2 | 1.1 | 14.3 |
| 50 cm | 3546.4 | 944.8 | 1.7 | 72.2 | 6296.2 | 1.4 | 12.5 |
| 60 cm | 2761.5 | 748.7 | 1.4 | 72.3 | 4779.6 | 1.3 | 9.9 |
| LSD | 1303.8 | 419.74 | ns | ns | 1807.2 | ns | 3.5 |

FLW: fresh leaf weight; DLW: dry leaf weight; MC: moisture content; FBW: fresh biomass weight; EOC: essential oil content; EOY: essential oil yield

**Table 3** Interaction effect of row spacing and harvesting age on essential oil yield (kg/ha) of Japanese mint (*Mentha arvensis* L.).

| Harvesting age | Row spacing | | | | Mean |
|---|---|---|---|---|---|
| | 30 cm | 40 cm | 50 cm | 60 cm | |
| 60 DAP | 7.9 fgh | 6.6 gh | 3.6 h | 3.4 h | 5.4 c |
| 90 DAP | 17.7 bcd | 13.4 def | 13.0 def | 10.6 efg | 13.7 b |
| 120 DAP | 39.7 a | 22.9 b | 20.9 bc | 15.5 cde | 24.8 a |
| Mean | 21.8 a | 14.3 b | 12.5 bc | 9.9 v | |

leaf/stem ratio and moisture content. The average reduction of fresh leaf weight, leaf/stem ratio and moisture content from 60 DAP to the average value of 90 and 120 DAP was 32.3%, 30.6% and 13.6% respectively. There was a statistically sharp ($P < 0.01$) increase in essential oil content from 0.5 to 1.4 and to 2% with delayed harvesting from 60 to 90 and to 120 DAP, respectively (**Table 2**). A similar trend of essential oil accumulation was reported by Verma *et al.* (2010). According to Aflatuni (2005); however, the essential oil content of Japanese mint was almost constant at different harvesting age. No statistical difference between dry leaf weight and fresh biomass weight was recorded with variation in harvesting age (**Table 1**).

Fresh and dry leaf weight, fresh biomass weight and essential oil yield has shown a highly significant difference with variation in row spacing (**Table 2**). In all these parameters, there was a similar reduction trend caused due to increase in row spacing. The maximum fresh leaf weight at 30 cm row spacing, which was statistically similar with 40 cm row spacing out yielded the value recorded at 50 and 60 cm by 45.7 and 57.7%, respectively. Dry leaf weight was ranged between 749 and 1668 kg/ha with reduction in row spacing from 60 to 30cm. The respective reduction in dry leaf weight when row spacing was increased from 30 to 40 cm, 40 to 50 cm and 50 to 60 cm was 18.9, 30.1 and 20.8%, respectively. The reason for this could be accommodation of a large number of planting materials per hectare with narrow spacing, as was discussed by Mishra *et al.* (2009). Similar results have been reported by Saini *et al.* (2002) on Japanese mint, Rao (2002) on rose geranium and Aflatuni (2005) on mint species, who stated the significant reduction of agronomic parameters with an increase in row spacing. A highly significant ($P < 0.01$) fresh biomass weight reduction was observed when row spacing was widened from 30 cm to 40 cm by 29.4% from 11,325 kg/ha. The least value of fresh biomass weight (4,780 kg/ha) was recorded with 60 cm row spacing, which was statistically at par with 50 cm row spacing. The essential oil content and leaf/stem ratio were not influenced significantly by row spacing and this was substantiated by the work of Saini *et al.* (2002). In contrast with the present study, Aflatuni (2005) reported a significant negative correlation between leaf/stem ratio and row spacing.

The interaction effect of row spacing and harvesting age has shown a highly significant ($P < 0.01$) effect on essential oil yield of Japanese mint (**Table 1**). The maximum essential oil yield (39.7 kg/ha) was obtained when harvesting was made 120 DAP at 30 cm row spacing treatment (**Table 3**). With respect to the days to harvest, similar finding was reported by Randhawa and Kaur (1996). At this row spacing the least essential oil yield (7.9 kg/ha) was obtained when it was harvested at 60 DAP. When Japanese mint was planted at a row spacing of 40 cm, essential oil yield was increased by 50.7 and 41.5% when harvesting was made delayed to 90 and 120 DAP from 60 DAP, respectively.

At 50 cm row spacing, 37.8% essential oil yield reduction was observed when harvesting was made 90 DAP from 120 DAP. For all harvesting treatments the least essential oil yield was observed at 60 cm inter row spacing with the value of 3.4 kg/ha at 60 DAP, 10.6 kg/ha at 90 DAP and 15.5 kg/ha at 120 DAP (**Table 3**).

## ACKNOWLEDGEMENTS

The authors are grateful to National Aromatic and Medicinal Plants Research Project, WGARC, Ethiopian Institute of Agricultural Research, for providing funds for the experiment. They do acknowledge assistances rendered by Tigist Germen, Tewabech Tilahun and Tsion Tessema during the field layout, experiment management and collection of some field data. The authors are also thankful to Zinash Zewdie and Tesfaye Degefu of Wondo Genet Agricultural Research Center for their help during data recording and organization for statistical analysis.

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