**ORIGINAL RESEARCH ARTICLE**

# Ortho Silicic Acid: A novel solution to combat climatic vagaries for production of quality menthol

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## ABSTRACT

*Cultivation of essential oil crops is a lucrative and viable option for sustainable agriculture. These essential oils have immense commercial value in medicine, cosmetic, fragrance and flavor industries. Quality and quantity are the two important traits that primarily ascertain the commercial price tags of these oils. Like all other agricultural crops, the physiological and biochemical processes in aromatic plants are also strongly affected by climate and other environmental stresses which in turns, significantly affect the quality and yield of their essential oils. Silicon, an essential mineral nutrient, is gaining immense importance in agriculture due to its manifold beneficial impacts on crops productivity under abiotic and biotic stresses. Ortho Silicic Acid (OSA) is the assimiable form of silicon but the highly reactive nature of OSA often limits its wide applicability. Present study is aimed to assess the impact of stabilized OSA, applied in the form of a proprietary formulation by the name "Silixol", on quality and quantity of menthol oil under fluctuating climatic conditions. Experiments were conducted on Mentha arvensis grown at farmer's field at Hapur and Barabanki regions of Uttar Pradesh during March to June for two consecutive years 2017-2019. The formulation was applied twice (35 DAT and 55 DAT) during the crop cycle as a foliar spray @ 2ml per liter of water. Foliar spray of OSA imparted visible morphological changes in crop vigor and canopy cover. The leaf area increased by 15% while branching increased by 19%. The increased canopy had further resulted in significant increment in oil yield (18%) and 11% increment in menthol content in the oil. These observations are very significant and offer a sustainable solution to commercial mentha growers to combat climatic stresses.*



## INTRODUCTION

Common mint or field mint (*Mentha arvensis* L.), also popularly known as menthol mint, is the source of natural menthol that finds wide application in the pharmaceutical and flavor industry (Rajeshwara et al., 1988). It is extensively cultivated in temperate regions of Europe and Western and Central Asian countries. In India, it is commercially

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cultivated in Himachal Pradesh, Haryana, Punjab, Bihar, tarai region of Himalayan foot hills of UP and Uttrakhand (Nainital, Badaun, Bilaspur, Rampur, Moradabad and Bareilly), extending to a larger parts of Indo-Gangetic plains (Barabanki and Lucknow). It is an erect, profusely branched, herbaceous, perennial plant of the family *Lamiaceae*, cultivated for its leaves that store 40-50% menthol. Under sub-tropical conditions of India, the menthol content in the oil declines if the crop is cultivated for extended period. The oil extracted from *M.arvensis* is a mixture of several terpenes such as α-menthol, neo menthol, isomenthol, carvomenthone, cinenol, α-pinene (Verma et al., 2010). The relative proportion of these constituents in the oil is influenced by genotypes, season, climate, cultural practices as well as post-harvest processing of the herbage.

Abiotic stresses also play a crucial role in governing the quality and yield of secondary metabolites including the essential oils. Crops often experience water stress due to erratic and unpredictable climate. Water stress has been identified as one of the most common limiting factor that affects production dynamics and quality of essential oils of several aromatic crops,including *M.arvensis* L. (Cakmackci et al., 2005). Stress induces physiological and biochemical changes in plants that impair their developmental processes and result in less branched crop with narrow leaves. Impact of water stress on quality and yield of essential oil has been frequently reported in *Calendula officinalis* (Hosseinzadah et al., 2011), *Melissa officinalis* (Babalola, 2010), peppermint (Mahaian and Tuteja, 2005), and menthol mint (Aliabadi et al., 2009). Kara and Baydar (2013) had observed that composition of rosemary oil was altered under stress conditions due to changes in plant's respiratory metabolism and phosphate – pentose pathways that regulates the expression of several enzymes that are associated with essential oil synthesis.

Foliar applications of stabilized ortho silicic acid has been found to improve the quality and yield, of several horticultural crops and vegetables (Da Silva et al., 2010; More et al., 201; Ratnakumar et al., 2016). To address the increasing concern of declining quality and yield of menthol mint oil, the present study was initiated to assess the efficacy of the foliar spray of a stabilized Ortho Silicic Acid (OSA) preparation on combating the moisture stress-induced adversaries on productivity parameters of this cash crop.

## MATERIALS AND METHODS

### *Expewrimental layout and treatments*

Field experiments were conducted on *Mentha arvensis* variety Kosi, during two consecutive growing seasons (March-June) in 2017-2019 at farmer's field in Hapur and Barabanki regions of Uttar Pradesh A randomized block design. A commercial formulation of stabilized Ortho Silicic Acid with brand name "Silixol" (2.7% OSA'; M/s Privi Lifesciencs Pvt. Ltd, Mumbai) was used in the study. Crop was grown as per recommended package and practices of fertilizers and pesticides. Foliar sprays of OSA were applied twice (35 DAT and 55 DAT) during the crop growth @ 2ml/ liter of water. The product was sprayed in a tank mix with other pesticides. Crop was harvested 85 days after transplantation. Agronomic parameters were recorded and crop was processed for oil extraction within 4 hours of harvesting.

### *Estimation of impact of OSA on quality of menthol oil*

Freshly harvested crop (shoots + leaves) was used for oil extraction. Oil was extracted through steam distillation at farmer's field. Extraction process was completed within 4 hours. The extracted oil was stored in the jars at cool place, till further usage.

### *Gas chromatographic/mass spectrometric analysis*

Qualitative GC/MS analysis of oil was performed on GC/ MS (GC Agilent 6890N; MS: Agilent 5973; Agilent Technologies, CA, USA) with an HP5-MS column (30 m× 0.25 mm fused silica capillary column, film thickness 0.25 ìm). The temperature program ranged from 50 °C (5 min) – 230°C (2 min) with at an increase rate of 5 °C/min (injection temperature 260 °C, carrier gas: helium). The flow rate was 0.6 ml/min. The detector temperature was 250 °C with the ionization energy of 70 eV, the mass range was10–300 amu, and the scan time was 1s (Adams, 1995). The constituents were identified by comparing their MS spectra with the use of information available in the library of the device as per standard protocol.

## RESULTS AND DISCUSSION

### *Impact of OSA on growth parameters of Mentha*

Foliar application of stabilized OSA significantly improved the crop vigour and canopy cover under prevailing growing conditions of an average temperature of 40 °C with scattered rainfall over the entire cropping season. Significant increases in growth traits like number of branches (19%), plant height (10%) and leaf area (15%) were recorded in the treated plants. Increase in these parameters culminated in 16% and 19% increase in fresh and dry biomass of plants, respectively (Table 1). Results are in accordance with a previous report where beneficial impacts of OSA on crop vegetative growth were documented under drought stress (Ratnakumar et al., 2016). OSA application has also been shown to improve the crop nutritional status attributing to increased yields in mango (More et al., 2014), apple (Javaid and Misgar, 2017), soybean, bean and peanut (Crusciol et al., 2013), and potato (Da Silva et al., 2010).

**Table 2: Major constituents of the essential oil extracted from control and sprayed plants of *Mentha arvensis***

| Constitutents | Control (%) | Treated (%) |
|---|---|---|
| Low Boilers | 0.07 | 0.03 |
| α-Pinene | 1.39 | 0.68 |
| β-Pinene | 0.00 | 0.73 |
| Sabinene | 0.48 | 0.27 |
| Bicycloheptane | 1.37 | 0.00 |
| β-myrcene | 1.05 | 0.47 |
| D-Limonene | 4.83 | 2.49 |
| p-Menthanone | 7.63 | 7.03 |
| p-Menthone | 4.35 | 3.95 |
| Menthol Acetate | 2.64 | 1.60 |
| Isopulegol | 1.00 | 0.90 |
| Caryophyllene | 0.32 | 0.26 |
| Neomenthol | 2.22 | 1.89 |
| Neo-isomenthol | 0.00 | 0.23 |
| Menthol | 68.09 | 75.64 |
| α-Terpineol | 0.48 | 0.20 |
| Others | 3.44 | 2.58 |
| Total | 100.00 | 100.00 |
| Total Menthol | 70.31 | 77.76 |

**Table 1: Impact of foliar applications of stabilized OSA on mean growth parameters of *Mentha arvensis***

| Treatment | Plant height (cm) | Number of branches per plant | Leaf area (sq cm) | Fresh weight (g) | Biomass (g) |
|---|---|---|---|---|---|
| **Control** | 63.7 | 17.2 | 82.9 | 30.6 | 17.5 |
| **Treated** | 70.2* | 20.4* | 95.3* | 35.6 | 20.8* |

*indicates significant difference between the numbers by LSD test at 1% level

### *Effect of OSA on yield and quality of Mentha oil*

OSA application also improved the yield (19%) of oil, from 50 kg /acre in control to 59.3 kg/acre of treated crop, respectively. GC/MS analysis carried out to ascertain the compositional changes of the oil showed that total menthol content in the oil increased by 11% following application of OSA compared to that of unsprayed plants (Table 2). Change in composition of essential oils under different cultivation conditions have also been reported earlier for peppermint (Tsai et al., 2013), and rosemary (Bidgoli, 2018). Increase in secondary metabolites upon application of OSA has also been recorded in several vegetable and fruit crop (More et al., 2014; Javaid and Misgar 2017).

## CONCLUSION

Recent past had witnessed a phenomenal increase in demand of natural essential oils in pharmaceuticals, fragrance and flavor industry. Quality and yield of these oils are dependent not only on crop physiological and nutritional status but also on climatic conditions. Unpredictable climate change and erratic weather conditions are posing significant economic losses to growers of aromatic crops. Various lesser known agri-chemicals are now being tested upon to address such problems.

Ortho Silicic Acid (OSA), a bio-available form of silicon, is one such chemical that is emerging as a potent stress alleviator for several agricultural crops. The beneficial impact of OSA application on menthol mint productivity traits have been assessed in the present study and our results concurred with earlier documented reports on vegetable and horticultural crops. Results described in the study on yield and qualities of menthol mint are very promising and have great potential in ensuring sustainable cultivation of menthol mint under the threats of intense climate change, leading to moisture stress.

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