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Short communication

Alteration in yield and chemical composition of essential oil of *Mentha piperita* L. plant: Effect of fly ash amendments and organic wastes

Kalpna V. Kumar*, D.D. Patra

Department of Agronomy and Soil Sciences, Central Institute of Medicinal and Aromatic Plants (CSIR), Lucknow 226015, India

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ABSTRACT

Fly ash (FA), containing considerable amounts of K, Ca, Mg and S can be potentially used as a soil amendment. Experiments were conducted to evaluate the effect of various concentrations of FA (0%, 25%, 50%, 75% and 100%) along with Garden soil (GS) and organic wastes in the form of oil cakes (*Jatropha* and mustard) on growth responses, element accumulation, yield and composition of volatile oil of *Mentha piperita* plant (essential oil bearing crop). Application of FA at >50% reduced plant growth, oil yield and its composition, whereas addition of FA at level of ≤50% exhibited positive results. Supplementation of *Jatropha* oil cake (OC1) along with FA had better response compared to other treatments. Treatment of FA (50% FA + 50% GS) along with OC1 was the best ameliorant to support growth and essential oil yield of *M. piperita*. It is recommended that *M. piperita* may be grown in a region where fly ash is used for amendment of agricultural soil.

1. Introduction

Combustion of bituminous, sub-bituminous, anthracite and lignite coal for generation of electricity in thermal power plants produces coal combustion residues i.e., fly ash (FA). In India, National Thermal Power Corporation (NTPC) runs more than 70 thermal power plants generating about 110 million tons (Mt) of FA which is likely to exceed 140 million ton per annum by 2020 (Pandey et al., 2009). Disposal of such a huge amount of FA as a landfill is unsustainable because of environmental concerns. In recent years many applications of FA have been suggested. Major areas of application include use in cement and bricks industries, land reclamation and as a soil amendment in agriculture (Kriesel et al., 1994). Elementally, FA contains both toxic and nutrient compounds. Application of lower doses of FA in soil causes enhancement of growth and yield of crop; however, at high concentrations adverse effects are observed (Pandey et al., 2009). Page et al. (1979) also suggested the restricted use of FA as commercial fertilizer due to its potentially toxic elements like B, Se, Mo, Ni and Cd), high salinity and reduced solubility of nutrients due to high pH (Page et al., 1979). As FA contains essential macronutrients like K, Ca, Mg and S and micronutrients including Fe, Mn, Zn, Cu, Co and Mo agricultural utilization of FA has been proposed by several workers (Jala and Goyal, 2006; Pandey and Singh, 2010). Sikka and Kansal (1994) conducted green house experiment and showed that application of 2–4% fly ash significantly increased N, S, Ca, Na and Fe content of rice (*Oryza sativa*) plants.

Mentha piperita (pepper mint) is an important crop which produces essential oil having menthol, menthofuran, menthone, 1,8 cineole and isomenthone, etc. These are extensively used in pharmaceutical and nutraceutical products and therefore the oil has high demand both in domestic as well as in international markets. Among the non-food crops, essential oil crops are widely grown in India. These oil bearing crops could be grown on severely polluted sites and air pollution provided that the pollutants did not significantly decrease yield. Essential oils are extracted from plants using different methods, but all of them seem to prevent heavy metal transition from the herbage into oil (Zheljazkov et al., 2006). The present study was designed to evaluate the influence of organic wastes (*Jatropha curcas* and mustard oil cake) on growth, yield and quality of *M. piperita* grown in FA amended soil.

2. Material and methods

2.1. Fly-ash, ameliorants, plant material and experimental setup

Fly ash used in this study was collected from the landfill area of National Thermal Power Corporation (NTPC), Unchahar, Rai Bareli (U.P.), India. The soil (to be used as control) was collected from the local premises of Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow (U.P.), India, and the oil cakes were procured from the local market, Lucknow (U.P.), India. Free suckers of

* Corresponding author. Tel.: +91 522 2359624.
E-mail address: kalpna529@gmail.com (K.V. Kumar).

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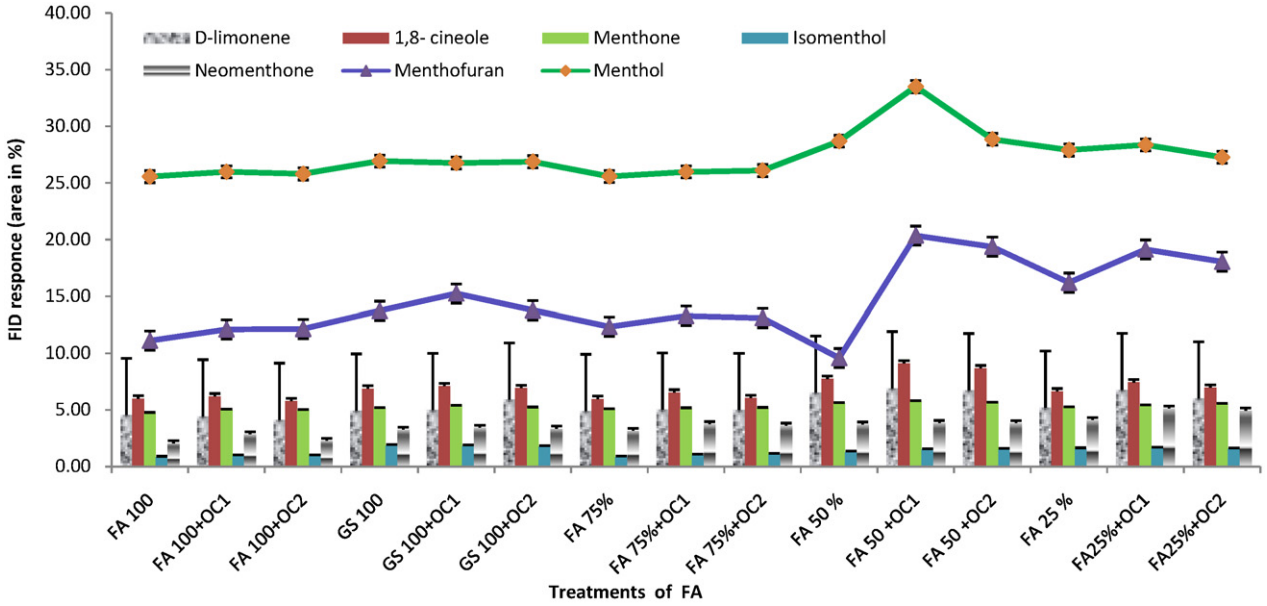

Fig. 1. Effects of fly ash treatments along with oil cakes on the chemical composition of *M. piperita* oil. *Vertical bars* represent SD of the mean value.

the *M. piperita* (cv. CIM-INDUS) were obtained from farm house of CIMAP. Various concentrations of FA: Garden soil (GS) were filled in earthen pots at 6 kg soil pot^{-1}. There were two supplements used viz. *Jatropha* oil cake (OC1) and mustard oil cake (OC2), which were mixed with top 10 cm layer of growth medium @ of 7.5 g pot^{-1}. Moisture content of the pots was maintained for fifteen days and then crop suckers were planted in triplicate. Treatment details are as mentioned below:

Treatment	Description	Supplements		
I	100% GS	WS	OC1	OC2
II	100% FA	WS	OC1	OC2
III	75% FA + 25% GS	WS	OC1	OC2
IV	50% FA + 50% GS	WS	OC1	OC2
V	25% FA + 75% GS	WS	OC1	OC2

WS, without supplement; OC1, *Jatropha* oil cake; OC2, Mustard oil cake.

2.2. Physico-chemical analysis of FA, GS and oil cakes

The FA, GS, oil cakes samples were air-dried and analyzed for pH and electrical conductivity (EC) using a pH meter and a conductivity meter, respectively, by diluting samples with double distilled water (DDW) in 1:2 ratio (Piper, 1966). Total organic carbon was measured using the method of Walkley and Black (1934); total nitrogen by micro Kjeldahl digestion (Nelson and Sommers, 1972) and total phosphorus using the molybdenum blue method (Allen et al., 1974).

For metal analysis FA and GS samples (1 g each) were digested in a tri acid mixture at 150 °C. Digested material was filtered and diluted with DDW and Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn contents were analyzed using inductively coupled plasma optical emissions spectrometry (ICP-MS) (Perkin–Elmer, Optical Emission Spectrometer, Optima 5300 V).

2.3. Plant biomass and essential oil yield

At the end of experimental trial the plants were harvested, weighed, and sampled for mineral element analyses. The plant samples were collected by uprooting carefully to determine root and shoot biomass. The dry weight of roots and shoots was estimated after drying at 60 ± 2 °C to a constant weight. The essential oil content in fresh shoots was determined by hydro-distillation for 2 h in a Clevenger apparatus. The essential oil thus obtained was dried over anhydrous sodium sulfate and were stored at −20 °C prior to determination of chemical components. The GC analyses of essential oil of *M. piperita* were performed using a Perkin–Elmer gas chromatograph model Auto XL, equipped with a flame ionization detector (FID) and capillary column PE-5 (50 m × 0.32 mm, 0.25 μm film thickness). The carrier gas was nitrogen with a flow rate of 1.6 ml/min and the split ratio was 60:1. The analyses were performed using the following temperature program of 100–280 °C at 3 °C/min. Injector and detector temperatures were held, respectively at 220 and 280 °C. Total Chrom software (Clarus) was used for peak percentage calculation. Identification of compounds was based on comparison of their retention indices and mass spectra with those obtained from authentic samples, the NIST version 2.1, and Wiley libraries registry of mass spectral data 7th edition, and the literature (Adams, 1995).

2.4. Heavy metal in plant samples

After recording dry matter yield, the samples were ground for heavy metal estimation. The finely ground plant samples were digested in the mixture of nitric acid and perchloric acid (HNO_3:$HCLO_4$; 10:4, v/v). Digested samples were then filtered and the content of mineral elements, as Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn were determined by inductively coupled plasma optical emissions spectrometry (Perkin–Elmer, Optical Emission Spectrometer, Optima 5300 V).

2.5. Statistical analysis

The data were subjected to two way analysis of variance (ANOVA) test using herb yield, dry matter yield and oil content as source of variables. Computation of linear regression analysis was also applied between different concentrations of FA and heavy metal in roots and shoots of *M. piperita* plants. The statistical analysis was done by the method of Singh and Chaudhary (1979).