

Effects of different nitrogen fertilisers and application rates on the growth and caffeic acid derivative contents of *Echinacea purpurea* (L.) Moench

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Echinacea purpurea (L.) Moench (commonly known as purple coneflower) is a native North American perennial herb that has been used to treat upper respiratory tract infections and some inflammatory conditions for hundreds of years. The main bioactive compounds with pharmacological effects in *E. purpurea* are caffeic acid derivatives (CADs), such as caftaric acid, chlorogenic acid, cichoric acid, cynarin and echinacoside. Few researches have been performed to explore the relationships between fertiliser management and the contents of bioactive constituents in *E. purpurea* under the cultivation conditions in Taiwan. In this study, a pot experiment was conducted in a greenhouse located in northern Taiwan in order to examine this issue. The aims of this study were: (1) to investigate the effects of chemical (Chem) and organic (Org) fertilisers with different nitrogen (N) application rates on the growth and plant nutrition of *E. purpurea*, and (2) to evaluate the contents of phenolics together with CADs in *E. purpurea* at both vegetative (150 days after transplanting, hereafter 150 DAT) and flowering (180 days after transplanting, hereafter 180 DAT) stages of growth. Treatments in this study included four replicates of the following: Control (0 N), Chem 1 (0.4 g N pot⁻¹), Chem 2 (0.8 g N pot⁻¹), Chem 3 (1.2 g N pot⁻¹), Org 1 (0.8 g N pot⁻¹), Org 2 (1.6 g N pot⁻¹) and Org 3 (2.4 g N pot⁻¹). At 150 DAT, biomass was measured and plant samples (roots and shoots) were collected and analysed to determine the concentrations of total N, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and phenolics, and five types of CADs (i.e. caftaric acid, chlorogenic acid, cichoric acid, cynarin and echinacoside). Soil samples were then collected and analysed to determine pH, electrical conductivity (EC), organic matter (OM), total N, inorganic N, Mehlich III extractable P and cations (i.e. K, Ca, Mg, Fe, Mn, Cu and Zn). The same procedure was repeated at 180 DAT. The results showed that soil pH decreased with the increase in application rate of chemical fertiliser throughout the whole

cultivation period. However, soil pH seemed to increase along with time, so all the values of soil pH were between 5.1 and 5.5 at 180 DAT. The concentrations of soil OM, total N, Mehlich III extractable P, Ca, Mg, Fe, Mn and Zn were higher in the Org treatments than in the Chem treatments at 150 DAT. Although a similar phenomenon was found at 180 DAT as well, the differences between Org and Chem treatments became less significant in soil total N, Mehlich III extractable Ca, Mg, Fe and Zn. On the other hand, soil EC and the concentrations of inorganic N and Mehlich III extractable Cu were higher in the Chem treatments than in the Org treatments throughout the whole cultivation period. As per plant growth, although biomass showed no significant differences between treatments at both stages of growth, almost all concentrations of the nutrients in *E. purpurea* were higher in the Org treatments than in the Chem treatments, except for total N of roots and shoots at both stages of growth, and total Ca of shoots at 180 DAT. Because the concentrations of chlorogenic acid, cynarin and echinacoside were trace or undetectable in this study, only the concentration of total CADs was taken into account. The concentrations of secondary metabolites of total phenolics and total CADs in *E. purpurea* were generally higher in the Org treatments, which had levels similar to untreated Control, compared with the Chem treatments. In conclusion, organic fertiliser seemed to be a good source of nutrients, not only of N but also other essential elements, for *E. purpurea* even though there was no significant change in biomass. Moreover, in *E. purpurea* grown with organic fertiliser, the high concentration of total phenolics suggested that there was a good defence system to ensure product quality, while the high concentration of total CADs suggested a remarkable pharmacological effectiveness.