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Effects of Azocompost and urea on the herbage yield and contents and compositions of essential oils from two genotypes of dragonhead (*Dracocephalum moldavica* L.) in two regions of Iran

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ABSTRACT

Dragonhead is an annual, herbaceous, balm-scented and spicy aromatic member of the family Lamiaceae. We examined effects of different sources of nitrogen on the content and composition of essential oils in two genotypes of dragonhead in two regions of Iran. The sources of nitrogen used were 100% urea (70 kg N ha^{-1}), 75% urea (52.5 kg N ha^{-1}) + 25% Azocompost (3.85 ton ha^{-1}), 50% urea (35 kg N ha^{-1}) + 50% Azocompost (7.77 ton ha^{-1}), 25% urea (17.5 kg N ha^{-1}) + 75% Azocompost (11.55 ton ha^{-1}), and 100% Azocompost (15.55 ton ha^{-1}). Optimal yield and content of essential oil at both locations for both genotypes were obtained by applying 50% urea + 50% Azocompost. Geraniol, geranial, and geranyl acetate were the most abundant compounds. For both genotypes and both locations, application of 50% urea + 50% Azocompost increased levels of geraniol and geranial, and application of Azocompost alone increased levels of geranyl acetate. Overall, we conclude that the application of 50% urea with 50% Azocompost is recommended for optimising the content and composition of essential oils in dragonhead.

1. Introduction

Dragonhead (*Dracocephalum moldavica* L.), which is known as “baderashbo” in Persian, is an annual, herbaceous, balm-scented and spicy aromatic member of the family Lamiaceae (Hussein, El-Sherbeny, Khalil, Naguib, & Aly, 2006; Nikitina, Popova, Ushakova, Chumakova, & Ivanova, 2008). Although native to central Asia, it has been naturalized in Eastern and Central Europe (Dastmalchi, Damien Dorman, Laakso, & Hiltunen, 2007). In Iran, it is distributed in the north and northwestern parts of the country, especially in the western parts of Azerbaijan province, and in the Albourz Mountains (Dastmalchi et al., 2007; Dmitruk & Weryszko-Chmielewska, 2010). Extracts and oil from dragonhead are used widely in the pharmaceutical, cosmetic, food and flavouring industries. In some parts of Iran, distilled aqueous extracts from *D. moldavica* are used as a beverage (Dmitruk & Weryszko-Chmielewska, 2010; Rechinger, 1986). In traditional medicine, aerial parts of dragonhead are used widely in tonics and herbal teas for their analgesic, anti-inflammatory, anticonvulsive, wound-healing, and sedative properties (Boiko & Omel’nitskii, 1994; Rechinger, 1986). Extracts of the plant are also used for their antitumor properties (Chachoyan & Oganesyan, 1996). Essential oil extracts from dragonhead have been reported to possess antibacterial, antimicrobial, and antioxidant activities (Dastmalchi et al., 2007).

The indiscriminate use of nitrogen fertilizer in intensive agriculture has increased crop performance, but has also harmed ecosystems. Integrated nutrient management approaches advocate the controlled use of nitrogen fertilizer. Integrated nutrient supply involves the application of mineral fertilizers, bio-fertilizers such as those derived from *Azolla* spp., green manure crops, and bacterial inoculations. In addition to positive effects on crop production, the application of organic compost has many advantages, which include preventing soil erosion, increasing beneficial soil organisms, reducing the need for fertilizers and pesticides, and improving the physical and biological properties of soil (Epstein, 1997).

Members of the floating fern genus *Azolla* belong to the family Azollaceae. They host a symbiotic blue green algae (*Anabaena azollae*), which can fix and assimilate atmospheric nitrogen. In Asia, *Azolla* spp. are used primarily to provide nitrogen nutrition to crops, such

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as rice. However, *Azolla* spp. can also accumulate other mineral nutrients, such as phosphorus and potassium, which become available to other plants when *Azolla* decomposes. Moreover, *Azolla* spp. are used as green manure, a water purifier, a biological herbicide, and as animal feed (Arora & Singh, 2003).

Several studies have shown that the application of nitrogen, as compost and/or the integrated use of mineral fertilizer and compost, can influence the content and composition of essential oils in medicinal and aromatic plants such as dragonhead, marjoram, *Acorus calamus* L., amaryllis, peppermint, *Tagetes erecta* L., and basil (Gharib, Moussa, & Massoud, 2008; Hussein et al., 2006; Kandeel, Naglaa, & Sadek, 2002). Geraniol is a commercially important terpene alcohol that is found in the essential oils of several medicinal and aromatic plants. It is one of the most important molecules in the flavour and fragrance industries and is a common ingredient in the consumer products that are generated by these industries (Chen & Viljoen, 2010). Researchers have also demonstrated that geraniol has antifungal, antioxidant, insecticidal, anti-helminthic, anti-inflammatory, and anticancer properties (Abe et al., 2003; Choi, Song, Ukeda, & Sawamura, 2000; Navarro et al., 2008; Polo & De Bravo, 2006; Zhang, Li, Qi, & Wan, 2006).

However, little information is available about the effects of combined application of Azocompost and nitrogen fertilizer on the quality and quantity of essential oils in dragonhead plants. Thus, the objective of the study described herein was to determine the effects of different sources of nitrogen on the content and composition of essential oils in two genotypes of dragonhead in two regions of Iran.

2. Materials and methods

2.1. Field experiments

Field experiments were carried out in 2009 growing season at the field research station of the Faculty of Agriculture of Tarbiat Modares University (location 1; 35°70′N, 51°40′E and 1200 m above sea level), and at the Khoy Agricultural Research Center in West Azerbaijan Province (location 2; 38°35′N, 44°52′E and 1040 m above sea level). Monthly weather data were obtained from the Chitgar (51°10′E, 35°44′N, 1305.2 m above sea level) and Khoy (38°33′N, 44°59′E) weather station, which are 1 and 4 km from the experimental locations, respectively. Climate data for the growing seasons at both sites are provided in Table 1.

The climate in location 1 is semi-arid, with an average annual precipitation (measured over 30 years) of 246 mm and a mean annual temperature of 17.69 °C. The soil is classified as Entisols with a sandy loam texture (16% clay, 24% silt, and 60% sand).

The climate in location 2 is semi-arid, with warm and dry summers, a mean annual rainfall of 286.6 mm and a mean annual temperature of 12 °C. The soil is classified as Inceptisol with a clay loam texture (38% clay, 22% silt, and 40% sand). For both sites, composite soil samples were collected two weeks before planting, at a depth of 0–30 cm. The soil was air-dried and crushed before its pH, electrical conductivity (EC), and saturation percentage were evaluated. Next we determined total organic carbon (using the Walkley and Black method, which involves sulphuric acid), total nitrogen (using the Kjeldahl method), available phosphorus (using the Olsen procedure), available potassium after extraction with ammonium acetate, and levels of the micronutrients iron, zinc, copper, and manganese after extraction with diethylene triamine pentaacetic acid (Tandon, 1995). Details of the properties of soil collected at the two locations are shown in Table 2.

The experiment was laid out as factorial in a randomized complete block design with three replications. They comprised a factorial combination of two genotypes (G1, the landrace genotype Urmia, and G2, the modern cultivar SZK-1), and five fertilisation regimes: F1, 100% urea (70 kg N ha^{-1}); F2, 75% urea (52.5 kg N ha^{-1}) + 25% Azocompost (3.85 ton ha^{-1}); F3, 50% urea (35 kg N ha^{-1}) + 50% Azocompost (7.77 ton ha^{-1}); F4, 25% urea (17.5 kg N ha^{-1}) + 75% Azocompost (11.55 ton ha^{-1}), and F5, 100% Azocompost (15.55 ton ha^{-1}).

Azocompost was provided from Salem Saze Mohite Gil Research Production Company, (Gilan, Iran). The physicochemical properties of Azocompost are shown in Table 3. The compost manure and half of the total urea applied were broadcast by hand and incorporated immediately into the soil using a rototiller three days before planting. The remaining half of the urea was applied as top dressing when the dragonhead seedlings were at the six-leaf stage. Plots were 3 m long and consisted of six rows, which were spaced 0.375 m apart. A 2-m alley was maintained between all plots to eliminate any influence of lateral water movement.

Seeds of SZK-1 (originally from Hungary) and Urmia were obtained from the Zardband company, Iran and the West Azerbaijan Agriculture and Natural Resource Research Center, respectively. Seeds were planted by hand on 9 April 2009 in location 1 and 10 May 2009 in location 2 at a rate of 1 g seeds/m of row, and then were thinned at the four-leaf stage to achieve a density of approximately 133,333 seeds ha^{-1} in both locations. Weeds were controlled by hand weeding using a hoe and/or a rototiller whenever necessary. Water was applied through furrow and sprinkler methods of irrigation in location 1 and 2, respectively. The plots were irrigated to 70% of field capacity. A water counter was used to record the volume of water applied. Water use at each irrigation interval (V_w in m^3) was determined based on pre-irrigation soil moisture (θ_i) using a TRIME-FM TDR (Time Domain Reflectometry, IMKO Micromodultechnik, Ettlingen, Germany) and the vertical depth of root expansion (D, 0.3 m here) according to the following equation (Cuenca, 1989):

$$V_w = (\theta_{fc} - \theta_i) \times D \times A$$

where θ_{fc} represents the volume of soil moisture at field capacity, and A represents the irrigation area (m). In location 1, 5600 m^3 water ha^{-1} and in location 2, 4820 m^3 water ha^{-1} was delivered. The plants were harvested once flowering was complete (Hussein et al., 2006), which was on 10 July 2009 in location 1, and on 10 August 2009 in location 2.

Table 1
Monthly temperature and precipitation during the growing season in 2009.

Month	Average temperature (°C)						Total precipitation (mm)	
	Minimum		Maximum		Mean			
	Location 1	Location 2	Location 1	Location 2	Location 1	Location 2	Location 1	Location 2
April	0.0	3.58	21.8	15.25	11.8	9.41	41.7	34.63
May	5.2	8.32	29.8	23.16	18.4	15.74	31.9	9.55
June	13	12.93	33.6	27.35	24.8	20.14	2.8	52.93
July	18	17.12	41	33.58	29.8	25.35	0.0	11.01
August	18.2	16.52	38.6	32.31	29.2	24.41	0.0	4.03