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FULL LENGTH ARTICLE

Antioxidant activities of phenolics, flavonoids and vitamin C in two cultivars of fennel (*Foeniculum vulgare* Mill.) in responses to organic and bio-organic fertilizers

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Abstract Field experiment was conducted to study the effect of organic and bio-organic fertilizers on dry weight; yield, total phenolics (TPC), total flavonoids (TFC), vitamin C and on their antioxidant activities of two sweet fennel cultivars *Dolce* and *Zefa fino*. Results strongly showed that there were significant differences between sweet fennel cultivars. Generally the highest values of all parameters were obtained when fennel plants were supplemented with 50% NPK + 50% organic fertilizer and bio fertilizer when compared with control treatment. The highest values of TPC, TFC and Vit. C were recorded by *Zefa fino* cultivar when received 50% NPK + 50% organic treatment. The antioxidant activities of both cultivars were evaluated and *Dolce* cultivar showed the highest DPPH· scavenging activity expressed as IC_{50} compared with *Zefa fino* cultivar. In addition, *Dolce* cultivars exhibited the highest value for Fe^{2+}-chelating activities for organic and bio-organic fertilizers followed by *Zefa fino* when compared to control treatment. *Dolce* cultivar generally showed superiority than *Zefa fino* in all measured parameters.

1. Introduction

Recently, an increasing interest in the cultivation and the production of un-traditional vegetable crops has been noticed in Egypt in order to cover the increasing demand of the local consumption as well as export purposes. Among them sweet fennel (*Foeniculum vulgare* Mill.) is one of the most promising new crops in Egypt. Also, Ehsanipoura et al. (2012) found that nitrogen is one of the most important

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nutrients needed for plant growth and seed yield, essential oil contents of seed and foliage and fiber, protein and ash contents of seeds. It is considered as the most important economic medicinal and aromatic plant grown within the Mediterranean region (Kandil, 2002). The cultivated area in Egypt is about 2000–3000 fed and its export value amounts to 10 million US $ according to the Ministry of Agriculture Statistics.

Fennel is a member of the family *Apiaceae*. It is classified into two sub species *vulgare* and *piperitum*. The most important cultivated fennel cultivars belong to subspecies *vulgare*. Sweet fennel is a variety group with inflated leaf bases which form an edible bulb-like structure (swollen base). Due to medicinal and aromatic compound's content of fennel, it is widely used in culinary preparation as a flavoring agent, food and beverages and perfumery industries, scenting soaps and cosmetics industries as well as in confectionery. Also in phototherapy and pharmaceutical purposes (Blumenthal et al., 2000). It is also considered as a spice due to terpenic compounds isolated from its fruit volatile oil (Abdallah et al., 1978) .Vegetative growth, edible bulb yield and quality of sweet fennel plants were strongly affected by cultivars as reported by Atta-Aly (2001), Paschalina et al. (2006), Osman (2009), Zaki et al. (2009).

Many investigators proved that phosphorus source even as mineral or organic is urgently needed to enhance plant growth, bulb yield and produce acceptable amounts of essential oils with sufficient quality in sweet fennel plants (Kandil, 2002; Rai et al., 2002; Kapoor et al., 2004; Osman, 2009 and Zaki et al., 2010). Moreover, Abd El-Salam (1999) indicated that increasing phosphorus fertilization rates caused an increase in plant height, number of branches/plant, dry weight of different plant organs in sweet fennel plants. Also, Ehsanipoura et al. (2012) reported that nitrogen is the most important nutrient needed for plant growth, seed yield, essential oil contents of fennel.

Organic fertilization has a stimulatory effect on accumulation of phenolics in fennel. It is well known that, the higher concentrations of phenolics can be explained by the role of organic fertilizers in the biosynthesis which induces the acetate shikimate pathway, resulting in higher production of flavonoids and phenolics (Sousa et al., 2008). Also, because of the higher photo-pathogenic stress in organic farming, which in turn may have abiotic stress, and causes an increase of phenolics and flavonoids and their antioxidant activity grown organically (Young et. al., 2000).

This study was undertaken to study the enhancement of total phenolics (TPC), total flavonoids (TFC), Vit. C and their antioxidant activities in sweet fennel in response to organic and bio-organic fertilizers.

2. Materials and methods

2.1. Chemicals

All chemicals and solvents used were HPLC spectral grade, and obtained from Sigma (St. Louis, USA) from Merck – Shcuchrdt (Munich, Germany).

2.2. Plant materials

Two cultivars of sweet fennel (*Foeniculum vulgar*, Mill.) which belong to family *Apiaceae* (*Umbelliferae*) were *Dulce* and *Zefa fino* which were obtained from Topstar Co., Holland.

2.3. Field experiment

A field experiment was carried out at El-Saff, Hellwan Governorate, Egypt, on newly reclaimed soil. The aim is to study the effect of organic and bio-organic fertilizers on phenolic flavonoids, glucosinolates and Vit. C contents and their antioxidant activities of two cultivars of fennel compared with NPK as control treatment.

2.3.1. Agriculture conditions

Seeds of sweet fennel were sown in foam trays filled with a mixture of peat moss and vermiculite (1:1 volume). Seedlings at 45 days old were transplanted in the open field on the center of raw and spacing of 50 cm between plants. Ditches of 20 cm depth and 40 cm width were prepared in the sites of drip irrigation lines; chicken manure, rocks phosphate, calcium super phosphate and agricultural sulfer were mixed and were added and covered with soil before planting. Plot area was 3.5 lengths and 3.0 widths in three raw which equals to 10.5 m^2.

2.3.2. Fertilizer treatments

2.3.2.1. Mineral NPK fertilizer (control). Basic fertilizers were mixed with the soil in doses of ammonium sulfate (21.5% N) at the rate of 100 N2 kg/fed; calcium super phosphate (15.5% P_2O_5), and rock phosphate (30% P) at the rate of 60 P_2O_5 kg /fed and potassium sulfate (48% K_2O) at the rate of 40 K_2O kg/fed. In addition, agricultural sulfur was used at the rate of 200 kg/fed.

2.3.2.2. Organic fertilizer. Complementary between 50% organic (chicken manure) at the rate of 100 N_2 unit/fed (5.850 m^3/fed) and 50% mineral (NPK) was used. NPK is formed from ammonium sulfate (21.5% N) as a source of nitrogen, at the rate of 100 N_2 kg/fed; calcium super phosphate (15.5% P_2O_5) and rock phosphate (30% P) were used at the rate of 60 P_2O_5 kg/fed; Potassium sulfate (48% K_2O) was used at the rate of 40 K_2O kg/fed. In addition, agricultural sulfur was used at the rate of 200 kg/fed based on the recommended fertilizer requirements according to the Ministry of Agriculture.

Ammonium sulfate and potassium sulfate were splinted into three equal doses and applied as dressing (0, 30 and 60 days after transplanting) beside plants.

2.3.2.3. Bio-organic fertilizer. It contained a mixture of N_2-fixing bacteria *Azotobacter Chrococcum* and phosphate dissolving bacteria Bacillus megaterium (1:1 v/v). Bio-organic fertilizer was applied to the plant once after 2, 5 and 8 weeks of transplanting at the level of 10 ml/plant at concentration of 10^9 cell/ml. The mixture was injected near the root of the plants. The bio-organic fertilizer was kindly supported by the Agriculture Microbiology Department, National Research Centre.

In all treatments, Drip irrigation line was spread over the ditches and soil was irrigated continuously 3 days before transplanting.