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ORIGINAL ARTICLE

Productivity of pepper crop (*Capsicum annuum* L.) as affected by organic fertilizer, soil solarization, and endomycorrhizae

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Fruit yield

Abstract Two protected experiments were designed to study the effect of organic fertilizer, soil solarization, and endomycorrhizae on yield and fruit quality of sweet pepper. A split–split plot design was used with four replicates for each treatment. The organic fertilizer treatments were randomly distributed among the main plots, soil solarization treatments arranged among the sub plots, while mycorrhizal treatments were allocated as sub–sub plots.

The combined interaction of organic fertilizer, soil solarization, and endomycorrhizae gave the highest increase roots infection percentages when compared to other treatments, being 78% and 87% in the first and second seasons in respective order. Organic fertilizer, soil solarization and mycorrhizal inoculation, either separately or in different interactions resulted in significant increases in pepper's early yield, total yield, total number of fruits per plot, and fruit length and diameter. The combined interaction between organic fertilizer, soil solarization, and VAM gave the highest significant increase in early and total yields (kg/plot) and total number of fruits/plot being 9.251 and 75.645 kg/plot and 529.3 fruits/plot, respectively.

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Introduction

Pepper, *Capsicum sp.* is a member of the Solanaceous family and commonly divided into two groups, pungent and non-pungent, which also called hot and sweet pepper. Sweet pepper includes different cultivars and the most commonly used ones, in greenhouse production, are hybrids that have bell-shaped (*Capsicum annum* L.).

Worldwide, there is an increasing interest to use organic manures as a trail to compensate the decrease in soil fertility.

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The need to reduce costs of fertilizing crops has revived the use of organic fertilizers (Delate and Camberdella, 2004; Farhad et al., 2009).

Organic fertilizers are essential for the proper development of plants, vegetables, flowers and fruits, as they offer rapid growth with superior quality to all species. They have the nutrients necessary for better development. In addition, the organic matter serves as nutrients and energy sources for soil microorganisms (Silva et al., 2012). The suitability and usefulness of organic fertilizers has been attributed to high availability of NPK content (Waddington, 1998), which capable to enhance soil fertility (Thomas, 1997). They also act as a substrate for soil microorganisms which lead to increase microbial activity, whereof increasing the rat of organic material decomposing and releasing nutrient for plant uptake. They improve the physical properties of the soil as well (Nasef et al., 2004; Palada et al., 2004; Khalid and Shafei, 2005).

Bhata and Shukla (1982) reported that organic fertilizer (farm yard manure) resulted in significant increase in soil carbon, nitrogen, pH, cation exchange capacity, and exchangeable Ca, Mg, and K which invariably enhance crop yield and productivity.

Soil solarization is a technique used by covering soil with clear polyethylene sheets, during summer months, to trap the solar radiation to heat soil (Horouwitz et al., 1983; Abdallah, 1991). The improvement of plant growth, using solarized soil technique, was reported by Abdallah (2000) and Soil solarization also provides excellent control of soil-borne pathogens with resultant increase in growth, yield, and quality of pepper and other crop plants (Kurt and Emir, 2004; Cimen et al., 2010).

Vesicular arbuscular mycorrhizal fungi (VAM) are widespread group of soil fungi that can enhance yield of several agricultural crops (Thanuja, 2002; Durgapal et al., 2002; Smith and Read, 1997). They are important in ecological agriculture because of the benefits they provide to the majority of cultivars and the conservation of the environment by acting as biofertilizers, biological protectors, and biological control agents (Azcón-Aguilar et al., 2002). VAM has distinguishing importance due to improving soil structure (Miller and Jastrow, 2000) and great capability to increase plant growth and yield of pepper under different conditions (Smith and Read, 1997; Thanuja, 2002; Durgapal et al., 2002). This increments was reported due to various mechanisms such as increased nutrients uptake especially P content, which has special effect on physiological parameters in plants (Paradi et al., 2003; Turk et al., 2006; Mehrvarz et al., 2008; Soleimanzadeh, 2010), water exploitation (Varma and Schuepp, 1996; Augé, 2001), and production of plant growth promoting substances (Lambais, 2000). The increments in cytokines could elevate photosynthetic rates by regulating chlorophyll levels (Allen et al., 1980; Allen et al., 1982). VAM also increased the absorptive area of roots by the formation of an extensive extraradical hyphae network that enhances the efficiency of water and nutrients absorption. VAM enable the plants to cope with both biotic and abiotic stresses (Garmendia et al., 2004).

Several investigators indicated that there is a beneficial effect of VAM fungi on nutrient uptake and plant growth especially in solarized soils (Menge, 1983; Powell, 1984). Studies have indicated that inoculation of pepper with VAM significantly increased plant growth and yield compared to un-inoculated control (Thanuja, 2002; Durgapal et al., 2002; Demir, 2004; Garmendia et al., 2004; Turkmen et al., 2005).

This investigation was designed to determine the effect of organic fertilizer, soil solarization, and vesicular arbuscular mycorrhizae (VAM) on pepper yield and quality of fruits.

Materials and methods

This work was carried out during two successive seasons of 2008/2009 and 2009/2010, at the greenhouse of Experimental Farm of Protected Cultivation, El-Bousaily site, Rosetta city, Al-Behaira Governorate, Egypt, belonging to Central Laboratory of Agricultural Climate (CLAC). The experiment was conducted in plastic greenhouse with an area of 9 $m^2 \times 70$ m^2 and height of 3.30 m.

Experimental design

The split–split plot design was used in this study with four replicates for each treatment, where the organic fertilizer treatments were randomly distributed among the main plots; soil solarization treatments were randomly arranged among the sub plots, while mycorrhizal treatments were carried out with sub–sub plots.

The greenhouse soil was cleaned, ploughed, leveled, and divided into plots (1×8) meters bed. Each season experiment included eight treatments.

Soil analysis

Soil samples were collected from two sites of each plot, mixed, and passed through a 2 mm sieve in order to give uniform sample. Samples were analyzed at the standard soil-testing laboratory of Central Laboratory of Agricultural Climate (CLAC). The chemical analysis was carried out according to the procedures outlined by Richards (1954), while mechanical and physical analysis was carried out according to Jackson (1958). The chemical, mechanical, and physical properties of the collected soils are given in Table 1.

Chemical analysis of irrigation water

Irrigation water was analyzed at the standard soil-testing laboratory of Central Laboratory of Agricultural Climate (CLAC) according to Landon (1984). The chemical analyses of the irrigation water are presented in Table 2.

Plant material

Seeds of sweet pepper (*Capsicum annum* L. cv. Reda F1 hybrid) were sown on mid-June at each of the seasons 2008 and 2009. Pepper seedlings were transplanted to experimental area using after being developed.

Organic fertilizer

Organic fertilizer (chicken manure, obtained from privet farm) was applied at the rate of 2.5 m^3. Chemical analyses of chicken manure were carried out at the standard soil-testing laboratory of Central Laboratory of Agricultural Climate (CLAC) according to the procedures outlined by Richards (1954). The chemical analyses are presented in Table 3.

The recommended inorganic chemical fertilizers were added to all the treatments (plots) through drip Irrigation (g/m^3 water/greenhouse), every week during the two seasons, as follows:

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