Scientia Horticulturae 219 (2017) 310–318

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Nutritional quality of lettuce and onion as companion plants from organic and conventional production in north Greece

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ARTICLE INFO

Article history:
Received 23 January 2017
Received in revised form 17 March 2017
Accepted 20 March 2017
Available online 27 March 2017

Keywords:
Vegetables
Production system
Growing season
Yield
Mineral content
Phytochemicals
Nitrate

ABSTRACT

The purpose of this study was to examine the effect of production systems – (organic-ORG or conventional-CONV) and growing season (autumn or spring) of cos lettuce (*Lactuca sativa* L. var. *longifoila* cv. 'Parris Island') and green onion (*Allium cepa* cv. 'Sturon') as companion planting (the onions and lettuce were grown in the same plot of land), on the yield and quality parameters (mineral composition, phenolic profiles, antioxidant capacity, nitrate content). Soil and meteorological parameters were measured. Lettuce plant in both production system obtained higher content of K, B, Zn, or Fe compared to onion. The general order of the mineral content in both plants was K > Ca > Mg > Fe > Mn > B > Zn > Cu. Organically grown green onions from both growing seasons had higher contents of all macro and micro elements (except Cu) compared to the conventionally grown onions. Lettuce from CONV systems contained more Ca, Mg, Mn, Fe, Cu than that from ORG production. However, no significant difference in total phenols content (TPC) was observed between production system and growing season in lettuce. TPC in green onion was higher compared to lettuce. A similar trend was observed for total antioxidant capacity. The nitrate concentration was significantly higher in lettuce than in onion. Lettuce and onions grown in the fall-winter period contained higher nitrate levels compared to lettuce and onions grown in spring-summer. In conclusion, companion planting can result in an increase in productivity of vegetables per unit area, and can improve net income. At present however, we cannot conclusively demonstrate a higher health-promoting value of ORG lettuce and onion in comparison to lettuce and onion grown by CONV farming methods.

1. Introduction

The organic production area (total arable land) in Greece reached 98,030 ha by latest estimates and represents 3.5% of the total cultivated area. However, only 1.8% of the total arable organic area is used for vegetable production (Eurostat, 2015). Greenhouse production is assessed to be very intensive, with cash crops rotation during the whole year (Tringovska et al., 2015). Companion planting is an intercropping practice often associated with organic agriculture.

Short-duration vegetables like lettuce and green onion can be harvested at the same time to make room for the main crop (tomato, eggplant, or pepper). In organic production, which is traditionally performed on small family farms, the production of lettuce is of great economic and social importance (Čabilovski et al., 2008; Porto et al., 2008), strengthening their self-confidence and improving their livelihood (Nandi et al., 2015). Production of organic lettuce can be organized on different plot sizes since it has a short vegetation period (Čabilovski et al., 2011). This information will allow small, resource-poor farms to use their labour and inputs more efficiently (Yildirim and Guvenc, 2005). Lettuce is used almost throughout the year since there are a number of varieties that are cultivated successfully in early spring, during the summer and winter (Zdravković et al., 2014).

Romaine lettuce (*Lactuca sativa* L. var. *longifoila*) (also known as cos) as a leafy cool-season vegetable is a popular cultivation across Mediterranean countries (Romero-Gamez et al., 2014), such as Greece. It is usually consumed as raw in salads together with green onion and represents a good source of minerals (Caliskan et al., 2014). In every day nutrition, lettuce is of great significance primarily for its content of biologically active substances, especially phenolic compounds, ascorbic acid, vitamins A and

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http://dx.doi.org/10.1016/j.scienta.2017.03.027
0304-4238/

Table 1
Mean air temperature and total precipitation during the vegetation of lettuce and green onion (January to December 2015–2016 from Sapes meteorological stations).

Month	Mean monthly air temperature (°C)		Mean daily temperature maximum for the month (°C)		Mean daily temperature minimum for the month (°C)		Precipitation amount (mm)	
	Year							
	2015	2016	2015	2016	2015	2016	2015	2016
January	5.5	5.0	10.1	9.9	1.8	1.0	140.4	97.6
February	6.3	10.4	10.7	15.3	2.5	6.7	35.8	57.8
March	7.9	10.1	12.3	15.3	4.1	5.7	176.4	34.8
April	11.6	15.9	18.1	23.9	6.2	9.6	62.2	7.8
May	19.5	17.1	26.6	23.5	13.3	11.6	21.8	91.2
June	21.4	23.7	27.7	31.1	15.8	17.5	35.6	8.0
July	26.0	26.4	34.1	33.8	18.2	19.0	43.4	5.0
August	26.6	26.6	34.1	34.3	19.5	19.4	3.4	0.0
September	22.7	21.5	29.9	29.2	16.9	15.3	92.4	0.0
October	14.5	15.0	19.9	21.9	10.5	9.5	55.0	0.0
November	12.5	10.3	19.0	15.4	8.0	6.0	90.0	33.2
December	6.2	2.8	12.6	8.5	2.4	−1.6	2.0	2.4

K, folates, and carotenoids (Llorach et al., 2008). In Greece, lettuce is cultivated either in greenhouses or in the open field (Foteinis and Chatzisymeon, 2016) in conventional and organic agriculture. Green onions (*Allium cepa.* var. *cepa* L.) are valued highly for their flavour and nutritional value in supplying minor constituents, such as macro and micro minerals (potassium, calcium, magnesium, iron, selenium), and also vitamins (β-carotene, folate, vitamin A, vitamin C) (USDA National Nutrient Database for Standard Reference, 2011) and high level of flavonoids (quercetin, kaempferol, luteolin) (Miean and Mohamed, 2001). Green onions are comprised of roots, a compressed stem (sometimes called stem plate), and leaves, which consist of a lower white leaf sheath and hollow upper green tissues (Viškelis et al., 2012). Growing of two or more plants together usually is a method for disease management in crop production, but it also can alter positively the microclimatic conditions around the canopy (Gómez et al., 2009). Furthermore, resources such as water, light and nutrients are utilized more effectively than in the respective monocropping systems (Wang et al., 2007).

Traditionally farmers are using farmyard manure (FYM) as a source of nutrients for organic lettuce cultivation (Hammad et al., 2011). The treatment with 25 tons cattle manure/ha was the best dose of organic fertilizer for maximizing the production of lettuce (Islam et al., 2012). However, the higher cost and the scarcity of animal manure is forcing farmers to search for alternate nutrient sources for organic lettuce cultivation. Application of vermicompost (5 t ha^{-1}) inoculated with biofertilizer Azophos (Chatterjee, 2015) and the combined use of green manure and FYM or compost and vermicompost teas (Santiago-López et al., 2016) has been used successfully in organic lettuce production (Caliskan et al., 2014). Although a number of studies have shown that amending soils with animal manure results in improvement of soil properties, the application of manure can lead to weed spreading if preparation and maintaining of manure is not adequate (Larney and Blackshaw 2003). In addition, uncontrolled use of manure, as well as other organic fertilizers, can lead to adverse effects such as accumulation of nitrates in plants (Larney et al., 2006). In order to avoid these potentially negative aspects, the Council Regulation EC 1804/1999 and Nitrates Directive (Council Directive 91/676/EEC 1991) limits the maximum annual incorporation of organic fertilizers to the amount equivalent to 170 kg N ha^{-1}.

Several factors influence the accumulation of nitrates in plants, including plant variety, lack of sunlight or water, high levels of fertilizers (Solberg et al., 2015), maturity, nitrate levels in the soil (Manojlović et al., 2010), and quality of irrigation water. The nitrate content has been shown to be dependent on the agricultural production system (Aires et al., 2013). Some studies have confirmed that organic vegetables have lower nitrate contents than vegetables grown conventionally (Gonzalez et al., 2010), whereas other studies show the opposite trend (Guadagnin et al., 2005).

Polat et al. (2008) revealed that the mineral content of organically grown and conventionally grown plants were similar (almost equal), but that the organically grown plants contained higher levels of Fe and Zn. This finding corroborated results from previous studies revealing that organically grown lettuce had higher contents of iron (Fe), magnesium (Mg), and phosphorus (P) than the conventionally grown ones (Caliskan et al., 2014). Plants treated with organic fertilizers had higher levels of vitamin C (Polat et al., 2008) and soluble solids (Magkos et al., 2003) than plants treated with chemical fertilizers. These examples point to the advantages of organic growing. Although a majority of published studies agree on the higher contents of certain vitamins and antioxidants and lower contents of nitrates and pesticide residues in organically grown vegetables, than in conventionally grown vegetables, there are nevertheless reports that present the opposite results (Sobieralski et al., 2013).

We therefore undertook experiments to determine the nutrition properties of lettuce and green onions grown under different production methods (organic and conventional), to assess whether fresh salads could be provided throughout the year and during different growing seasons (autumn and spring).

2. Material and methods

2.1. Experimental site

Cos lettuce (*Lactuca sativa* L. var. *longifoila* cv. 'Parris Island') fast-growing multi-purpose lettuce for baby leaf or full size heads (uniform grey-green heads have nicely savoyed leaves) have been tested in greenhouse production (plastic tunnels 3.5 m high, covered by 3-layer, long-life, thermic, EVA film – Kritifil 180 μ, origin from Plastika Kritis, Greece, with the following optical properties – total light transmission 89%; diffusion 45%; infrared transmission < 17), located in the Sapes, north-Eastern Greece (longitude: 25° 42′ E, latitude 41° 01′N) during 2015–2016, using two different growing systems, organic and conventional. Mild weather conditions, the low-level agrochemical pollution, and small size familly-farms all promote the production of organic lettuce and green onion in Sapes region with good organoleptic properties. Organic production from experimental garden is certified by private bodies approved by the Ministry of Agriculture, under Regulation (EC) No 834/2007 and the Regulation No 889/2008.