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Effects of Irrigation-Fertilization and Irrigation-Mycorrhization on the Alimentary and Nutraceutical Properties of Tomatoes

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1. Introduction

Tomato, a key vegetable in the Italian Mediterranean diet, has recently gaining been attention in relation to the prevention of some human diseases. This interest is due to the presence of carotenoids and particularly lycopene, which is an unsaturated alkylic compound, that appears to be an active compound in the prevention of cancer, cardiovascular risk and in slowing down cellular aging, owing to its high antioxidant and antiradical power (Gerster 1997; Giovannucci et al. 1995). Lycopene is found in fresh, red-ripe tomatoes as all-trans (79-91 %) and cis- (9-21%) isomers (Boileau et al., 2002; Shi et al., 1999; Stahh & Sies, 1992).

In this paper, lycopene was used as a measure of the nutraceutical quality, while flavour volatiles, soluble sugars, organic acids, dry matter and pH as expression of the nutritional quality.

In red-ripe tomato fruit, many volatile compounds have been identified [2(E)-hexenal, hexanal, 3(Z)-hexen-1-ol, β-ionone, 2(E)4(Z)-decadienal, 2-isobutylthiazole, 3(Z)-hexenol, linalool, methylsalicylate, 2-methoxyphenol, 6-methyl-5-hepten-2-one, 6-methyl-5-hepten-2-ol, 2,3-epoxygeranial, neral, geranial, nerylacetone, β-damascenone, α-terpineol etc.] (Di Cesare et al., 2003).

Hexanal, 2(E)-hexenal, 2-isobutylthiazole, are considered to be responsible for the fresh tomato flavour (Dirinck et al., 1976). Besides, according to other authors (Buttery et al., 1989; Buttery & Ling, 1993) 3(Z)-hexenal, β-ionone, β-damescenone, 1-penten-3-one, 2 and 3-methylbutanols, 2-isobutylcyanide, 2(E)-heptenal, phenylacetaldehyde, 6-methyl-5-hepten-2-one, 3(Z)-hexenol, 2-phenylethanol, methylsalycilate are considered to be important contributors to tomato flavour.

Soluble sugars and organic acids play an important role in the characterization of the tomato taste. Sugars (glucose, fructose and traces of sucrose) and organic acids (citric, malic and oxalic) represent half of the total dry matter of tomato fruit (Silvestri & Siviero, 1991).

The irrigation and the potassium (K) fertilization are two among the agronomical factors that mostly influence the alimentary and nutraceutical quality of tomato. Full irrigation regimes enhance the crop yield, however, cause a reduction of total and soluble solids and less colourful and firmness of fruits (Branthôme et al., 1994; Colla et al., 1999; Colla et al., 2001; Dumas et al., 1994; Favati et al., 2009). Among the several studies, Veit Kohler et al. (1999) reported that the higher levels of sugars, titratable acidity, aroma volatiles, and vitamin C are responsible for the higher tomato fruit quality under conditions of limited water supply. Taking into account the effects of irrigation on agronomic performances, a negative trend in response to increasing soil water deficit was observed for fruit yield and size (Candido et al., 2000; Patanè & Cosentino, 2010). Pernice et al. (2010) have also shown that the effects of irrigation on yield and unitary weight of berries are genotype-dependent. Finally, some studies demonstrated that irrigation generally reduces green fruit yield and blossom-end rot (Candido et al., 2000; Warner et al. (2007).

The nutritional quality of tomatoes may be affected by the amount of water applied, regardless of fertilizer management, and their irrigation system. For example, heavy rainfall may reduce the oxygen concentration in the soil, and indirectly affect the nutritional value of fruit (Dorais et al., 2008). Considering the effect of irrigation on ascorbic acid content of fruit, depending on cultivar, low soil water tension generally could decrease the content of this antioxidant compound (Rudich et al., 1977). Zushi & Matsuzoe (1998) also showed that the effects of soil water deficits on the vitamin C content (fm basis) may be positive or null, depending on the cultivar.

The effects of water availability on the synthesis of carotenoids have been studied, but results are sometimes contradictory, and the data often incomplete.

Dumas et al. (2003) reviewed several studies that looked at agronomic and environmental factors that influenced lycopene concentrations in tomatoes and reported that moisture stress, for example, reduced lycopene content in some tomato varieties but increased it as well as β-carotene content in others. On the other hand, it is reported that the increase of abscisic acid, induced by limited water supply, may affect the ethylene production and then the carotenoids synthesis (Dorais et al., 2008). Serio et al. (2006) confirmed the increase of lycopene (and ascorbate) content at moderate levels of water stress. In recent studies performed on two tomato ecotypes, Pernice et al. (2010) found an higher amount of total carotenoids content of fruits under no irrigation conditions, nevertheless no variation for antioxidant activity of carotenoids extracts were detected. Furthermore, this behaviour was also ascertained after canning process.

In soilless culture, however, higher plant water availability provided by a capillary system did not reduce the lycopene content or the antioxidant activity, compared to tomato plants grown either on rockwool or sawdust and irrigated according to solar radiation (Dorais, 2007). However, Dorais (2007) also found that lycopene content of fruit from plants grown in sawdust andpeat at low levels of moisture stress was less than that of fruit grown on rockwool and irrigated according to solar radiation. No effect of irrigation treatment on antioxidant activity detected.

In general, increasing the water supply increased tomato fruit yield but reduced fruit quality attributes, because of high fruit water content (Dorais et al. 2001). Consequently, on a fresh weight basis, vitamin, mineral and carotenoid contents were generally lower under higher water supply although not all nutraceutical compounds responded to soil moisture variation (Dorais et al., 2008).

Mineral nutrients (nitrogen, phosphorous, potassium and calcium) and their supply through fertilization can affect yield and quality of tomato crops.

K is needed in stomatal movement for water regulation in the plant. It activates enzymes and is required for carbohydrate metabolism and translocation, nitrogen metabolism and protein synthesis, and regulation of cell sap concentration. This essential nutrient helps in vigorous growth of tomato and stimulates in early flowering and setting of fruits, thereby increasing the number and production of tomato berries per plant (Bergmann, 1992; Ruiz & Romero, 2002).

In tomato, as well as in other fruit and vegetables, K improves fruit quality: its levels are positively correlated with a good fruit shape, a reduction in ripening disorders (puffiness, gray-wall, blotchy ripening, green back and yellow shoulder), while it simultaneously plays an important role as a counter-ion to organic acids, maintaing electroneutrality in fruit (Dorais et al., 2001). Several studies have shown that K-fertilization increased several quality parameters in tomato fruit such as marketable yield, total and soluble solids contents (°Brix), sugars, acidity, red colour and leads to a reduction of the sugar/acid ratio (Ghebbi Si-smail et al., 2007; 2005; Oded & Uzi, 2003; Wuzhong, 2002). Wright and Harris (1985) pointed out that flavour scores indicated that increasing N and K fertilization had a detrimental effects on tomato flavour. An increase in titratable acidity and soluble solids was found with increasing fertilization. Concentrations of hexanal, 2-hexanone, benzaldehyde, phenylacetaldehyde, β-ionone and 6-methyl-5-hepten-2-one increased with increasing N+K levels.

Trudel and Ozbun (1970; 1971) reported that K enhanced the colour of the fruit, increasing the lycopene content and reducing that of β-carotene. The positive effect of K fertilization on lycopene content, has been confirmed more recently by other authors (Oded & Uzi, 2003; Serio et al., 2007), as it is shown that K deficiency can lead to a reduction in the synthesis of carotenoids, particularly lycopene (Dumas et al., 2003). With regard to accumulation of this antioxidant compound in tomato fruits, Taber et al. (2008) have found that the response to high fertilizer dose of K is cultivar-dependent.

The vesicular-arbuscular mychorrhizae (VAM) are most common in nature but also more interesting for application in agriculture, as they can colonize most cultivated plants.

In addition to improving plant mineral nutrition (mainly phosphate) (Elia et al., 2006; Conversa et al., 2007), VAM fungi can promote photosynthetic activity, improve resistance to root pathogens and drought stress-saline and soil properties too (Turk et al., 2006). Besides, VAM are largely beneficial to crops, since they increase absorption of micro elements (van der Heijden et al., 2006) and water use efficiency (Davies et al., 2002) in the plant.

The importance of mycorrhizal symbiosis for plant growth and health is raising a growing interest in the use of these fungi as bio-fertilizers, bio-regulators and bio-protectors (Akhtar et al., 2008), thus reducing the input of fertilizers and pesticides (Gianinazzi et al., 2003).

Many studies conducted to evaluate the use of VAM fungi in vegetable crops have provided for the distribution fungal inoculum at transplantation time near plant roots; the need to produce the fungal inoculation of host plants through breeding, is still an obstacle for wider application in the field.

The most promising method of VAM application in vegetable crops is represented by inoculation of seedlings (pre-inoculation) during their nursery growth in containers (Azcona-Aguilar & Barea, 1997). The pre-inoculation of VAM fungi reduced the mortality of seedlings, resulted in greater uniformity of crop growth (Waterer & Coltman, 1988) and increased yields too (Sorensen *et al*., 2008).

Although most vegetables (except *Brassicaeae* and *Chenopodiaceae*) are colonized by VAM fungi, it is known that the effectiveness of mycorrhization much depends on the specificity of fungus-host plant (species and/or cultivars) (Sensoy et al., 2007); sometimes VAM colonization does not improve growth and nutritional status of the plant but also a negative effect of the symbiosis may occur (Gosling et al., 2006).

Some studies have also found that VAM influence positively some quality yield parameters, such as essential oils in aromatic plants (Copetta et al., 2006).

VAM fungi colonize the same area of root tissue and therefore often occur together in the rhizosphere and roots of plants. This contemporary occurrence raises a number of reciprocal interactions between these two groups of organisms, among which also a VAM suppressiveness against phytoparasitic nematodes populations (Gera & Cook, 2005). Competition for nutrients or induction of morphological changes or systemic resistance in root tissues were suggested as mechanisms for the nematicidal effect of VAM (De la Peña et al., 2006; Elsen et al., 2008).

Identification of VAM species is difficult because they do not possess a sexual stage and do not grow in host absence. The identification is generally based on morphological characters, in particular, those of spores (Morton & Bentivenga, 1994) which are, however, very similar and result not useful for reliable identification to species level (Jacquot et al., 2000). Molecular techniques (PCR, Nested-PCR analysis of nucleotide sequences, RFLP, RAPD) were used to identify and groped distinguish different species of mycorrhizal fungi in planta and in soil (van Tuinen et al., 1998). These methods have proved much more rapid and sensitive in identifying the species with respect to classical techniques.

2. Materials and methods

2.1 Irrigation

K-fertilization trials

The experimental trial was carried out using a split-plot scheme with 3 replicates, in the plain of Battipaglia (Salerno, South Italy, 40° 58 ′ 45″ 61′′′ Lat. N, 14° 98′ 32″ 27′′′ Long. E, 12 m a.s.l.), during spring-summer of 2009, aimed to compare two irrigation regimes in combination with two levels of K-fertilization on two tomato ecotypes (Corbarino and Vesuviano).

The soil of the experimental plots was clay loam (43.8% sand, 27.8% silt, 28.3% clay), with poor organic matter content (1.4%) and very low salt concentration. Cationic exchange capacity was high (C.E.C. of 20,5 meq/100 g of soil). With regard to K, exchangeable and available fractions were very high (345 ppm and 0.72 meq/100 g of soil) too.

The two tomatoes studied, Corbarino (C) and Vesuviano (V), were ecotypes originating from Campania region (Italy), respectively from plain of Corbara (Agro Sarnese-Nocerino area) and slopes of Vesuvius Volcano. They were different in many morphological: the first one showed oval fruits tending to an extended shape (ratio between two diameters of 1.52) with unitary weight of approximately 13-18 g.; the latter, instead, was characterised by elongated, pear-shaped fruits (ratio between two diameters of 1.85) with a clearly pronounced mucro (pointed shape at blossom end) and a weight of about 20-25 g (Parisi et al., 2006).

Transplant was performed, on May 16th , in single rows with a density of 4.0 plants/m^2. Microirrigation was started from fruit-setting (40 days after transplanting) adopting two different water regimes: "reduced" irrigation (I_1) (total irrigation volume 300 m^3/ha) and "normal irrigation" (I_2) (total irrigation volume 1500 m^3/ha). These established water regimes were applied in quantities of 50 m^3/ha for I_1 level or 250 m^3/ha for I_2 level, once a week for six weeks.

Regard to K-fertilization, to the natural endowment of land (K_0) was compared K_1 level (200 kg/ha of K_2O, added to soil before transplant).

Each parcel was made up of 5 rows having an extension of 7 m. The main morpho-physiological surveys were conducted for the plants of all the parcels; while, at harvesting, the main productive and qualitative aspects of the berries were estimated on the plants of the central row (Giordano et al., 2000).

Fruit harvest was performed at full ripening on August 20th and September 24th; productive data were submitted to analysis of the variance with the program Mstat-C using the scheme "Randomized Complete Block Design for Factor A (watering regime), with Factor B (ecotype) as a Split Plot on A and Factor C (K-fertilization) as a Split Plot on B". Means were evaluated with Duncan's test.

2.2 Irrigation-Mycorrhization trials

The experimental trial was carried out using a split-plot scheme with 3 replicates, in the plain of Metaponto (Matera, South Italy 40° 24'N; 16° 48'E; 10 m a.s.l.), during spring-summer of 2009, aimed to compare 3 watering regimes in combination with two different mycorrhization systems on Faino (Syngenta) F1 hybrid.

The soil of the experimental plots had a mixed composition, containing 51.3% of silt, 29.0% of sand and 19.7% of clay, with a slight alkaline reaction (pH 7.68), poor in total N (0.8 g /kg), with average organic matter (9.2 g / kg) and well equipped in exchangeable P (21.2 mg / kg) and K (215 mg / kg), in open field conditions.

Transplant was performed on May 28th 2009 in double rows with a density of 4.94 plants/m^2.

"Oval fruit-like" tomatoes were irrigated and mycorrhized as follows:

- V_{100}= full restoration (100%) of Maximum Crop EvapoTranspiration (ETc);
- V_{50}= half restoration (50 %) of ETc;
- V_0= non irrigated control (irrigated only at transplantation);
- M_1 (MICOSAT F)= endomycorrhizal fungi of the genus *Glomus*, rhizosphere bacteria and saprophytic fungi;
- M_2 (VAM)= only endomycorrhizal fungi of the genus *Glomus*.

3. Results and discussion

3.1 Effects of irrigation - K-fertilization interactions

3.1.1 Agronomical and morphological data

The main agronomical and morphological results are reported in Table 1. The lack of natural rainfall during the period from flowering to harvest, together with the adoption of irrigation schemes of medium and small-scale to the needs of the tomato crop have been the main cause of low yields for both ecotypes (26.5 t/ha for Corbarino and 27.3 t/ha for Vesuviano tomato).

	Yield		**Ripe fruits with defects**	**Fruit weight**	**Size homogeneity**	**Fruit firmness**
FACTORS	Total (t/ha)	Waste (%)	(%)	(g)	(1)	(1)
Watering regime (I)						
"normal" (I_1)	32,9 b	9,8 b	15,8 a	12,8 b	3,1 b	3,1 a
"reduced" (I_2)	20,9 a	5,8 a	14,1 a	10,4 a	2,8 a	3,8 b
Signif.	**	**	n.s.	*	*	**
Genotype (G)						
Corbarino	26,5 a	8,2 a	16,8 a	10,5 a	2,9 a	3,1 a
Vesuviano	27,3 a	7,4 a	13,1 b	12,6 b	3,0 a	3,8 b
Signif.	***n.s.***	***n.s.***	**	**	***n.s.***	**
K fertilization (K)						
(K_0)	27,1 a	8,3 a	17,6 a	12,1 a	3,0 a	3,4 a
(K_1)	26,3 a	7,0 a	12,6 b	11,3 a	3,1 a	3,5 a
Signif.	***n.s.***	***n.s.***	*	***n.s.***	***n.s.***	***n.s.***
Interactions						
(I) x (G)	*n.s.*	*n.s.*	**	*n.s.*	*n.s.*	**
(I) x (K)	*n.s.*	**	*	*n.s.*	*n.s.*	*n.s.*
(G) x (K)	*n.s.*	*n.s.*	n.s.	*n.s.*	*n.s.*	*n.s.*
(I) x (G) x (K)	*	*n.s.*	n.s.	*n.s.*	*n.s.*	*n.s.*

(1) value from 1 (worst) to 5 (best). ** P=0.01; *P=0.05; n.s.= not significant

Table 1. Effects of irrigation/K-fertilization on agromical and qualitative traits of Corbarino and Vesuviano tomato.

Indeed a previous research in the same area indicated better agronomic performance for these local varieties (Parisi et al., 2006).

In this research, yields were highly influenced by the water regime; in particular moving from no irrigation to normal irrigation condition, increases in total production of 41.5% for Corbarino and 64.4% for Vesuviano tomato were found. For the first local variety the results were in agreement with those of Pernice et al. (2010).

No significant effects of ecotype and K-fertilization on total yield were recorded; instead, the interactions genotype x irrigation x K-fertilization and that between water regime x K-fertilization were significant for total yield and waste percent, respectively. The incidence of ripe fruit with defects (such as cracking, virus infections and damage by other biotic agents) seemed to have decreased with K-fertilization (from 17.6% to 12.6%), moreover the interactions between irrigation ×genotype and between irrigation × K fertilization were significant.

Increasing in water supply resulted in better values of size homogeneity and, according to Pernice et al., 2010, in worsening of fruit firmness.

3.1.2 Alimentary quality

The most of volatiles substances were found in both genotypes, while their concentrations, expressed as μg/100 g d.m., seemed to be influenced by both agronomical treatments (Table 2).

	(μg/100g d.m.)							
	I_1K_0C	I_2K_0C	I_1K_1C	I_2K_1C	I_1K_0V	I_2K_0V	I_1K_1V	I_2K_1V
ALCOHOLS								
1-penten-3-ol	92,93 a A	89,09 a A	102,81 a A	194,58 b B	118,02 b B	37,37 a A	46,49 a A	83,75 b B
2-pentanol	0 a A	0 a A	115,48 b B	0 a A	253,92 b B	74,80 a B	0 a A	0 a A
3-methyl-1-butanol	1187,99 b A	799,73 a A	1245,44 b A	1130,44 a B	1011,95 b B	321,54 a A	289,99 a A	370,37 a A
2-methyl-1-butanol	134,06 a A	139,25 a A	183,98 a A	214,75 b B	148,76 b B	74,17 a A	73,13 a A	78,25 a A
1-pentanol	183,08 a A	172,42 a A	226,92 a A	227,43 a B	206,04 b B	70,16 a A	69,73 a A	81,43 b A
3(Z)-hexen-1-ol	138,895 b B	4,685 a A	16,155 a A	21,955 a A	40,26 b B	9,685 a A	1,045 a A	11,59 b A
1-hexanol	18,125 a B	10,83 a A	0 a A	32,395 b B	20,455 b B	6,51 a A	0,915 a A	7,2 b A
6-methy-5-hepten-2-ol	1,075 a A	9,015 b A	16,355 a B	11,285 a A	26,56 b B	9,53 a A	0,815 a A	9,995 b A
benzyl alcohol	2506,37 b A	1349,205 a B	1329,405 b A	347,055 a A	1114,895 a A	1100,62 a B	2931,885 b B	496,715 a A
phenethyl alcohol	214,73 b A	130,99 a A	369,92 a B	387,255 a B	210,475 a B	208,025 a B	0 a A	62,205 b A
Total Amount	4477,26	2705,22	3604,47	2567,15	3151,34	1912,41	3414,00	1201,51

CARBONYL COMPOUNDS								
3-methyl-3-buten-2-one	7,16 b A	2,01 a A	9,97 b B	4,51 a B	16,04 a B	14,74 a A	7,96 a A	15,93 b A
1-penten-3-one	62,49 a B	89,2 a A	48,935 a A	62,90 b A	62,44 b B	13,60 a B	16,78 b A	7,19 a A
pentanal	68,78 a A	63,56 a B	55,64 b A	1,68 a A	89,66 b B	20,73 a B	31,87 b A	0 a A
2(E)-pentenal	73,28 a A	67,83 a A	80,43 a A	92,02 b A	84,69 b B	0 a A	26,42 a A	67,51 b B
hexanal	246,61 a A	272,42 a A	249,08 a A	282,59 a A	362,33 b B	154,54 a A	146,915 a A	129,555 b A
2(E)-hexenal	44,5 a A	62,60 b B	49,51 a A	77,78 b B	176,245 b B	69,3 a A	79,32 b A	50,245 b A
n-heptanal	17,18 a A	17,58 a A	17,815 a A	22,74 a A	35,605 b B	12,11 a A	14,56 a A	12,425 a A
benzaldehyde	40,635 a A	30,58 a A	69,695 a B	49,6 a A	47,49 b A	23,13 a A	38,46 a A	20,535 a A
2(E)-heptenal	60,495 a A	62,3 a A	70,55 a A	52,975 a A	79,2 b B	35,94 a A	27,945 a A	41,17 b A
1-octen-3-one	0 a A	1,65 b A	9,64 a B	9,145 a B	10,775 a B	7,89 a A	0 a A	4,32 b A
6-methyl-5-epten-2-one	462,965 a A	671,315 b A	600,45 a B	667,465 a A	1060,27 b B	590,135 a A	468,485 a A	568,795 b A
2(E),4(E)-eptadienal	11,29 a A	13,585 a A	14,335 a A	16,9 a A	17,96 b B	9,45 a B	1,03 a A	4,15 b A
2(E),4(Z)-eptadienal	0,695 a A	16,69 b A	8,275 a B	19,865 b A	21,075 b A	5,895 a A	1,465 a A	12,065 b B
2(E)-octenal	177,875 a A	226,565 b A	249,415 a B	203,04 a A	309,04 b B	103,905 a A	80,355 a A	140,865 b A
2,6-dimethyl-5-eptenal	2,015 a B	2,775 a A	0 a A	15,395 b B	1,995 a A	29,45 b B	28,26 b B	4,62 a A
2(E)-nonenal	46,9 a A	62,665 a A	62,485 a A	65,795 a A	90,15 a B	61,38 a A	40,22 a A	47,08 a A
6-methyl-3,5-eptadien-2-one	31,66 a A	49,775 a A	49,11 a A	65,81 a A	102,355 b B	53,435 a A	40,295 a A	42,365 a A
2(E),4(E)-decadienal	127,38 a A	121,955 a A	166,6 b A	109,84 a A	158,17 b B	90,825 a A	76,05 a A	62,655 a A
2(E),4(Z)-decadienal	115,605 a A	126,765 a A	176,355 a A	136,97 a A	136,255 a B	83,57 a A	66,605 a A	80,585 a A
Total Amount	1597,52	1961,82	1988,29	1957,02	2861,75	1380,03	1193,00	1312,06
HETEROCYCLIC DERIVATIVE								
2-isobutylthiazole	10,94 aA	265,52 b A	190,13 aB	791,57 b B	828,095 b B	323,195 a B	409,855 b A	37,2 a A
TERPENS								
2,3-epoxigeranial	50,55 a A	100,59 b A	77,7 a A	77,845 a A	163,03 b B	90,71 a A	70,99 a A	71,145 a A

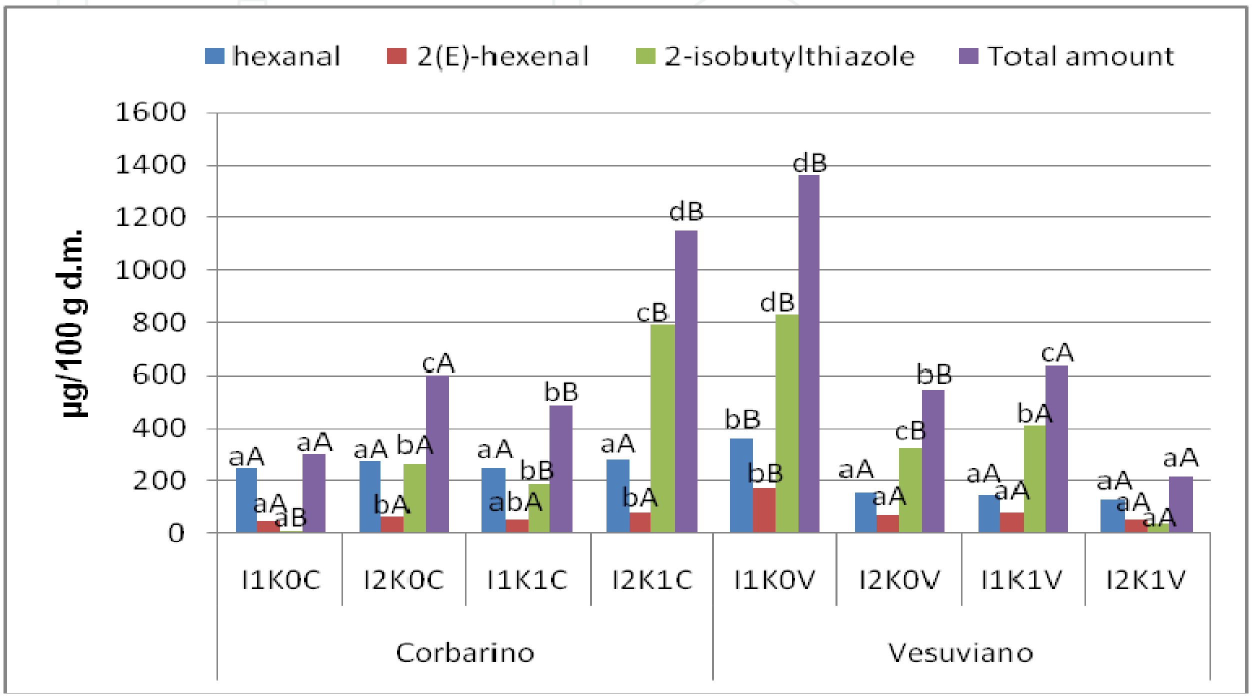
neral	62,075 a A	89,89 a A	87,45 a A	88,755 a A	148,96 b B	80,985 a A	61,04 a A	73,7 a A
geranial	109,105 a A	208,765 b B	177,42 a A	151,89 a A	340,515 b B	194,81 a A	152,62 a A	140,59 a A
β-damascenone	61,66 a A	57,555 a A	80,175 a A	78,315 a A	111,885 a B	73,29 a A	43,3 a A	58,795 a A
neryl acetone	77,93 a A	85,335 a A	100,84 a A	90,43 a A	108,265 a B	82,385 a B	50,6 a A	49,06 a A
β(Z)-ionone	2,015 a A	7,895 b A	14,44 a B	16,485 a B	22,52 b B	9,475 a A	1,605 a A	10,03 b A
β(E)-ionone	36,83 a A	39,605 a A	38,93 a A	38,475 a A	44,79 a B	30,46 a A	21,635 a A	20,905 a A
(E,E)-pseudoionone	34,76 a A	51,73 a A	47,13 a A	55,225 a A	86,845 a A	55,575 a A	207,655 b B	35,395 a A
Total Amount	434,93	641,37	624,09	597,42	1026,81	617,69	548,41	459,62
PHENOLIC DERIVATIVES								
2- methoxyphenol	60,085 a A	113,435 b A	97,48 a A	103,905 a A	121,06 a B	89,41 a A	0,605 a A	60,72 b A
methyl salicylate	202,96 a A	319,375 b A	204,495 a A	248,93 a B	161,73 a A	170,735 a B	207,925 b A	85,78 a A
eugenol	49,32 b A	0 a A	47,96 a A	67,625 a B	54,56 b A	29,15 a B	29,58 b A	0 a A
Total Amount	312,37	432,81	349,94	420,94	337,35	289,30	238,11	146,50

Table 2. Quali-quantitative composition of identified volatile components.

Different letters indicate significant difference (ρ≤ 0.05). Small letters concern the statistical analysis within the same genotype, keeping as fixed variable the K-fertilization levels, while the capital letters concern the statistical analysis within the same genotype, keeping as fixed variable the watering regimes.

In order to better estimate the effects of two agronomical methods on the tomato flavour, all the identified volatile compounds were distinguished in the volatile characteristic compounds (hexanal, 2(E)-hexenal and 2-isobutylthiazole), responsible of the tomato impact aroma, and the contributor volatile flavour such as alcohols, carbonyl compounds (aldehydes and chetones), phenolic derivatives and terpens. Fig. 1 showed that this effect was more evident for the volatile characteristic compounds and particularly for 2-isobutylthiazole in the sample treated with the highest watering volumes and K-fertilization. On the contrary, in Vesuviano genotype, the volatile characteristic compounds had the highest concentration in the control. In fact the increasing watering volumes and K-levels caused a decrease of the values of the three compounds respect of the control, especially for 2-isobutylthiazole. The negative effects of the two cultural methods on the characteristic volatile compounds found in Vesuviano tomato were in accord to Veit-Khöler et al. (1999), who noted that an increase of watering regimes caused a decrease of six carbon atoms aldehydes as hexanal, 3(Z)-hexenal and 2(E)-hexenal in tomato samples.

Fig. 2 showed the influence of agronomical treatments on the contributor volatile compounds. In the Corbarino tomato, the increase of watering levels, with or without K-fertilization, caused a decrease of alcohols, an enhancement of carbonyl compounds and terpens; while the content of phenolic derivatives were quite similar in all the samples. In Vesuviano genotype, the unirrigated sample had the highest values of all the classes of contributor substances, especially of the alcohols. Besides, the K-fertilization caused a decrease of contributor compounds and this behaviour was more evident in the sample irrigated with the highest watering regime, except of carbonyl compounds.

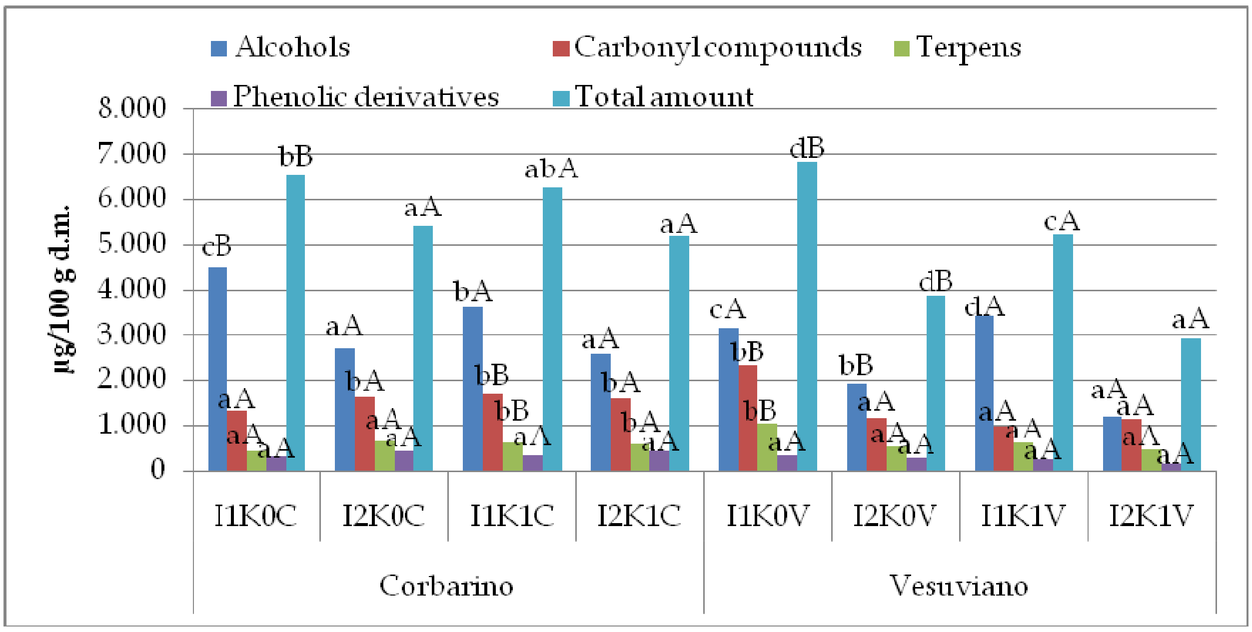


Small letters concern the statistical analysis within the same genotype, keeping as fixed variable the K-fertilization level, while the capital letters concern the statistical analysis within the same genotype, keeping as fixed variable the watering regimes.

Fig. 1. Characteristic volatile compounds in irrigated and K-fertilized "Corbarino" and "Vesuviano" tomato genotypes. Different letters indicate significant difference ($\rho \leq 0.05$).

In Table 3 the other parameters of alimentary quality of two genotypes were reported. Dry matter was always similar in all the samples of Corbarino genotype, but it decreased in the Vesuviano samples irrigated with the highest water levels, according to Fontes et al (2000) and Helyes et al. (2009), who observed a positive effect of K-fertilization at different watering regimes. The pH of both genotypes was not modified by different watering regimes and K-fertilization, according to Ghebbi Si-smail et al. (2007), even if Fontes et al. (2000) reported a decrease of pH with increasing K-levels. As concern the soluble sugars, glucose decreased in the samples irrigated with the highest levels only in Vesuviano genotype, according to Parisi et al. (2006) and Mitchell et al. (1991). On the contrary fructose was not affected by the two cultural methods in both genotypes.

As regards the organic acids, oxalic acid was not influenced by the cultural techniques in both genotypes, citric acid did not show any variation in all the Corbarino samples, while it was positively influenced by fertilization in Vesuviano genotype, according to Mitchell et al. (1991). Malic acid was negatively affected only by watering irrigation.



Small letters concern the statistical analysis within the same genotype, keeping as fixed variable the K-fertilization level, while the capital letters concern the statistical analysis within the same genotype, keeping as fixed variable the watering regimes.

Fig. 2. Contributor volatile compounds in irrigated and K-fertilized Corbarino and Vesuviano tomato genotypes. Different letters indicate significant difference (ρ≤ 0.05).

			SOLUBLE SUGARS (g/100g p.f.)		ORGANIC ACIDS (mg/100g p.f.)		
	d.m.%	pH	Glucose	Fructose	Oxalic	Citric	Malic
I_1K_0C	10.92 aA	3.92 aA	3.17 aA	2.67 aA	2.06 aB	477.95 aA	154.66 bB
I_2K_0C	10.12 aA	4.10 aA	3.15 aA	2.73 aA	2.02 aB	474.22 aA	123.84 aA
I_1K_1C	10.88 aA	4.24 aA	2.92 aA	2.66 aA	2.08 aB	487.13 aA	138.76 bB
I_2K_1C	10.49 aA	4.31 aA	3.18 aA	2.88 aA	2.01 aB	495.12 aA	118.17 aA
I_1K_0V	11.05 bB	3.93 aA	3.23 bB	2.87 aA	1.71 aA	457.92 aA	162.46 bB
I_2K_0V	10.00 aA	3.97 aA	2.79 aA	2.65 aA	1.73 aA	467.83 aA	136.45 aB
I_1K_1V	11.38 bB	3.82 aA	3.08 bB	2.77 aA	1.74 aA	582.81 bB	178.07 bB
I_2K_1V	10.56 aA	4.11 aA	2.78 aA	2.54 aA	1.74 aA	553.84 aB	155.70 aB

Different letters indicate significant difference (ρ≤ 0.05). Small letters concern the statistical analysis within the same genotype, keeping as fixed variable the K-fertilization level, while the capital letters concern the statistical analysis within the same genotype, keeping as fixed variable the watering regimes.

Table 3. Effects of irrigation and K- fertilization on chemical-physical parameters of two tomato genotypes.

3.1.3 Nutraceutical quality

Fig. 3 showed the content of total lycopene in two treated genotypes. In both Corbarino and Vesuviano tomato, the lycopene content increased in samples treated with the highest watering regimes, with or without K-fertilization. So the lycopene content in both genotypes seemed to be mainly influenced by watering regimes than fertilization. In literature, contrasting results about total lycopene in relation with irrigation regimes and K-fertilization are reported.

Achilea & Kafkafi (2003) evaluated, in a series of experiments performed in different countries, the specific contribution of potassium nitrate to yields and quality parameters of processing tomatoes. They noted that potassium nitrate was found to be the best form for maximum lycopene concentration in the fresh fruit.

In another experiment, Fontes et al. (2000) studied the effect of K-fertilizers rates on the fruit size, mineral composition and quality of the trickle-irrigated tomatoes. Lycopene and other analytical parameters in the fruits were not affected by K-rates.

On the contrary, Serio et al. (2007) determined the influence of K-levels in the nutrient solution on lycopene content of tomato plants grown in a soil-less system using rockwool slabs as substrate. Two growing seasons were studied with the aim of comparing three K-levels: low, medium and high (corresponding to 150, 300 and 450 mg K t^{-1} in the nutrient solution). The lycopene content increased linearly with increasing K-level in the nutrient solution.

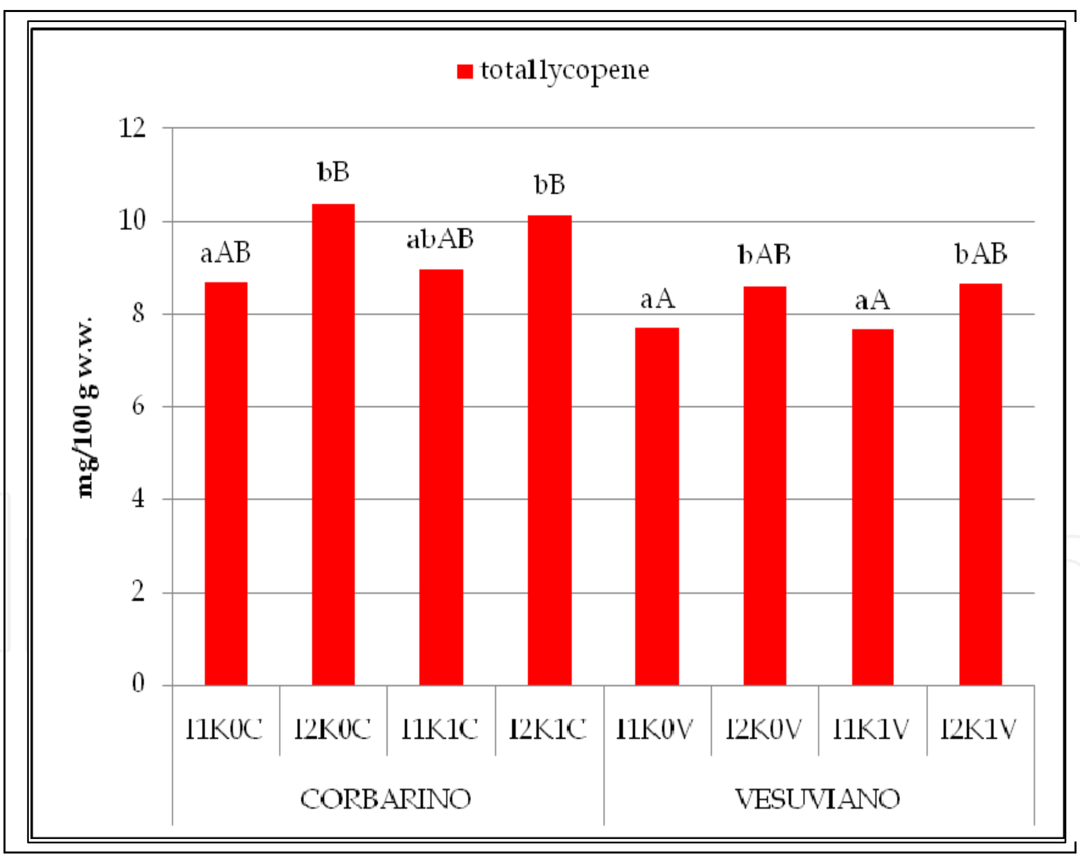


Fig. 3. Total lycopene in irrigated and K-fertilized Corbarino and Vesuviano tomato genotypes. Different letters indicate significant difference ($\rho \leq 0.05$). Small letters concern the statistical analysis within the same genotype, keeping as fixed variable the K-fertilization level, while the capital letters concern the statistical analysis within the same genotype, keeping as fixed variable the watering regimes.

Ghebbi Si-smail. et al. (2007) studied the effect of three levels of K-supply on the total lycopene content of two tomato cultivars, during two seasons in open field. The plants were grown in loamy soil poor in organic matter (1.18%) and in K (75 ppm K_2O). Results about lycopene concentration seemed to be negatively affected by K-fertilization.

Zdravković et al. (2007), in order to research whether lycopene production depended upon mineral macro-nutrient, used industrial tomato cv. Narvik SPF as a material. The content of lycopene regarding the fertilizer formulation was from 33.69 mg/kg in control to 56.92 mg/kg in plants treated with increased content of potassium.

Taber et al. (2008), studying the response of tomato cultivars with fruit of average and high lycopene to increased K-fertilization, demonstrated that K-fertilization could affect carotenoids biosynthesis, and the response of tomato to an high K-rate was genotype dependent.

Finally, Helyes et al. (2009) in an open field experiment, studied the effects of irrigation (regularly irrigated, irrigation cut-off 30 days before harvest, and unirrigated) and two K-supplementation (454 and 555 kg ha^{-1} respectively) on lycopene and other analytical parameters of tomato fruit. The high K-rate increased the lycopene content of tomato in the irrigation cut-off and unirrigated treatments.

In our research, the scarce influence of K-fertilization on the lycopene biosynthesis, in contrast with other authors (Achilea & Kafkafi, 2003; Helyes et al., 2009; Serio et al., 2007; Zdravkovic et al., 2007;), could be explained with the high natural content of K in the soil, where the tested tomatoes were grown, as reported in materials and methods. On the other hand, this behaviour is in accordance with other authors (Dumas et al., 2003; Panagiotopoulos & Fordham, 1995;), who found a positive response of the lycopene content to fertilization levels only in tomato grown in soil treated with excessively high dose of fertilizers, in contrast to the modern cultural management, whose target is the reduction of the crops chemical input.

Besides, our researches showed that the lycopene content seemed not to be genotype-dependent because Corbarino and Vesuviano showed the same trend in relation with K-fertilization, in contrast with Taber et al. (2008).

The effect of watering supply on lycopene content of tomato was investigated by other authors. Brandt et al. (2003) found that the lycopene content of tomato harvested in greenhouse, supplied with 50% of optimal water intake, was higher than that of fruits supplied with 100% of optimal intake. Riggi et al. (2008) studied the influence of two watering regimes (a fully irrigated treatment receiving 100% of evapotranspiration for the whole growing season and an unirrigated control watered up to plant establishment only) on lycopene and β-carotene accumulation during fruit ripening in a field-grown processing tomato. Higher amounts of lycopene were measured in the well watered treatment. On the contrary, Favati et al. (2009) in a two-years research found an higher fruit content of carotenoids (lycopene and β-carotene) under water deficit irrigation respect to well irrigated processing tomatoes. In other studies, on the effects of four irrigation regimes (40, 50, 60 and 70% depletion of the available soil moisture) on three tomato cvs, Naphade (1993) ascertained that the lycopene content decreased in response to moisture stress, whereas Matsuzoe et al. (1998) in red and pink cherry tomato cvs found that lycopene increased when there were soil water deficits. In red and pink large-fruited tomatoes, soil water deficits also tended to increase the amount of lycopene in the region of the outer pericarp (Zushi and Matsuzoe, 1998). However, the effects of water availability seemed to need further studies, particularly in relation with the fruit environmental conditions (Dumas et al., 2003).

3.2 Effects of Irrigation – Mycorrhization Interactions

3.2.1 Agronomical and morphological data

Table 4 showed that the watering regimes had positively influenced the commercial yields. In fact, the total yield had highlighted an increase of 36.1 t/ha and 59.6 t/ha respectively for V_{50} and V_{100}. The higher productivity levels of the watered thesis were also accompanied by a significant increase in weight of the berries. Besides, the increase of water volumes caused an increase of waste berries, from 12.6% of the control (V_0) to 15.1% and 16.7% respectively in V_{50} and V_{100}.

	Yield		**Fruit weight**	**Fruit firmness**
FACTORS	Total (t/ha)	Waste (%)	(g)	(Kg/cm²)
Watering regime (IR)				
V_0	47,6 a	12,6 a	65,6 a	1,0 a
V_{50}	83,7 b	15,1 b	93,2 b	1,0 a
V_{100}	107,2 c	16,7 c	104,6 c	0,9 a
Signif.	**	**	**	***n.s.***
Mycorrhization (M)				
M_1	82,5 a	14,3 a	90,4 a	1,01 a
M_2	81,7 a	14,5 a	88,5 c	0,95 a
Signif.	***n.s.***	***n.s.***	***n.s.***	***n.s.***
Interactions				
(IR) x (M)	***n.s.***	***n.s.***	***n.s.***	***n.s.***

** P=0.01; *P=0.05; n.s.= not significant.

Table 4. Effects of irrigation/Mycorrhization on agronomical traits of Faino F_1 cultivar.

The yields of the mycorrhized thesis with Micosat F and VAM did not show significant differences and the yields of the two mycorrhizae had similar values in comparison with unmycorrhized and irrigated samples (V_{50}).

Take into account the interaction between irrigation × mycorrhization, the agronomical parameters had not statistically significant differences. As concern firmness, the reported values were similar among all the studied theses, irrigated, mycorrhized and irrigated/mycorrhized samples.

3.2.2 Alimentary quality

Table 5 showed the composition and the values (µg/100 g d.m.) of tomato aromatic profiles treated with different watering regimes and mycorrhizae. The single volatile compounds were identified in all the analyzed thesis and the influence of the agronomical treatments were only ascertained for their content. Even in this section, as for the irrigation/K fertilization one, the volatile compounds were subdivided in characteristic and contributor volatile compounds of the tomato aroma.

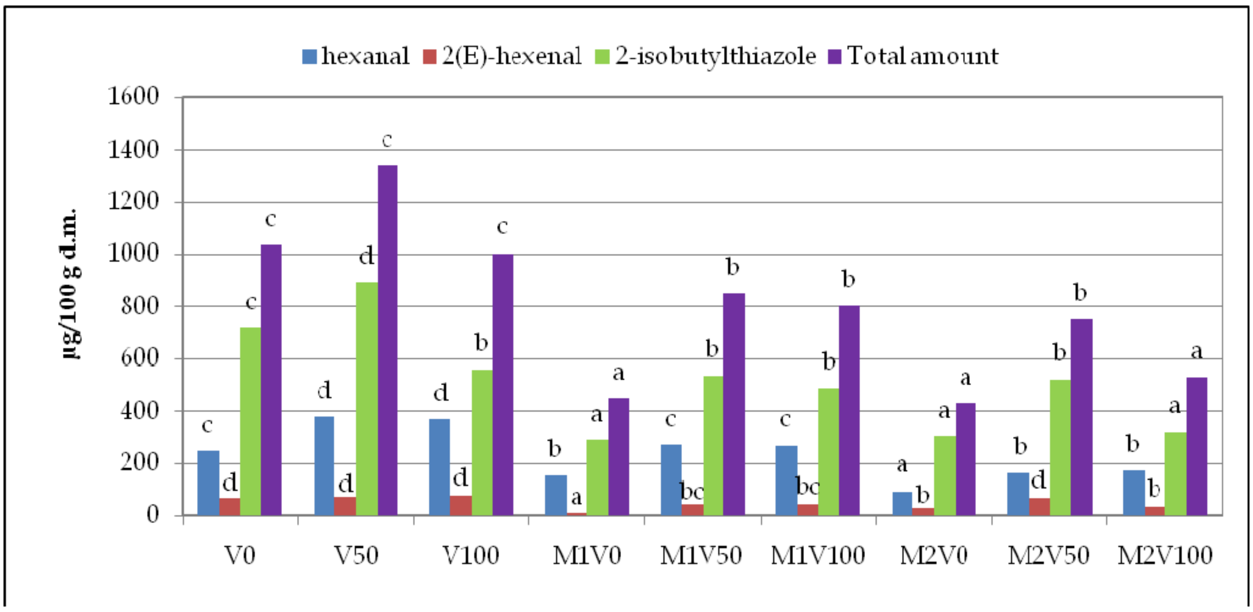
	(µg/100g d.m.)								
	V0	**V50**	**V100**	**M1V0**	**M1V50**	**M1V100**	**M2V0**	**M2V50**	**M2V100**
ALCOHOLS									
1-penten-3-ol	11,99 b	3,08 a	12,54 b	3,06 a	3,14 a	4,05 a	3,14 a	4,87 a	5,09 a
3-methyl-1-butanol	400,27	450,16 bc	592,53 c	248,48 b	363,73 bc	551,36	138,20 a	214,98 b	246,33 b
2-methyl-1-butanol	70,12 ab	150,12 c	28,32 a	84,66 ab	111,66 b	100,24 ab	22,37 a	28,84 a	28,02 a
1-pentanol	24,00 bc	10,65 b	42,96 d	5,58 a	18,96 bc	23,03 bc	4,88 a	7,99 a	10,21 b
3(Z)-hexen-1-ol	n.d.	n.d. a	n.d. a	n.d. a	2,15 a	2,12 b	n.d. a	3,15 bc	5,12 c
1-hexanol	n.d.	n.d.	n.d.	n.d.	3,08 b	n.d.	n.d.	5,03 c	4,15 c
6-methy-5-hepten-2-ol	28,85 c	47,34	34,38 bc	5,12 a	15,14 b	32,23 bc	2,19 a	3,93 a	4,81 a
benzyl alcohol	116,21 b	162,87 c	142,27 c	71,19 a	127,74 d	103,74 d	52,80 a	50,70 a	45,46 a
phenethyl alcohol	105,19 d	173,45 de	217,29 de	127,17 b	135,05 d	148,22 d	76,86 c	43,02 b	13,99 a
Total amount	**756,63 b**	**997,67 c**	**1070,29 c**	**545,26 ab**	**780,65 b**	**964,99 c**	**300,44 a**	**362,51 a**	**363,18 a**
CARBONYL COMPOUNDS									
3-methylbutanal	62,76 bc	71,51 c	83,76 d	71,58 c	64,44 bc	57,74 b	28,13 a	41,62 b	45,15 b
3-methyl-3-buten-2-one	18,95 b	3,15 a	31,25 c	4,38 a	1,13 a	35,54 c	1,15 a	24,40 bc	22,38 b
1-penten-3-one	2,15 a	2,05 a	5,22 c	2,15 a	2,88 ab	3,12 b	2,16 a	3,58 b	3,12 b
pentanal	3,12 a	5,74 b	15,62 c	4,12 ab	2,97 a	5,20 b	3,59 a	3,84 ab	4,87 b
benzaldehyde	13,20 b	21,92 c	12,65 b	8,87 ab	24,49 c	14,88 b	3,16 a	7,59 ab	5,18 a
2(E)-heptenal	40,40 c	35,77 d	33,60 c	19,77 b	38,20 c	25,86 bc	5,12 a	4,37 b	6,15 a
6-methyl-5-epten-2-one	308,56 c	438,03 d	310,46 c	182,92 b	261,43 c	310,69 c	99,84 a	150,42 a	200,59 b
2(E)-octenal	41,29 b	8,62 a	46,81 b	2,46 a	32,20 b	38,00 b	3,88 a	5,26 a	2,88 a
2,6-dimethyl-5-eptenal	22,73 cd	31,60 b	25,51 cd	4,55 b	19,90 cd	5,03 b	2,16 a	2,37 a	4,35 b
6-methyl-3,5-eptadien-2-one	17,14 c	22,48 c	17,32 c	3,75 a	3,71 a	2,75 a	2,09 a	7,14 b	5,04 ab
2(E)-nonenal	78,15 c	131,36 c	97,38 bc	31,74 ab	79,90 b	69,81 b	24,22 a	21,32 a	20,84 a
2(E),4(E)-decadienal	34,25 b	38,15 b	54,94 c	4,12 a	2,87 a	32,75 b	3,12 a	4,72 a	2,18 a

2(E),4(Z)-decadienal	45,51 cd	50,91 cd	64,01 d	21,29 c	35,42 c	38,51 c	6,14 b	5,00 b	1,15 a
Total amount	**688,21**	**861,29 d**	**798,53 d**	**361,70 bc**	**569,54 c**	**639,88 cd**	**184,76 a**	**281,63 b**	**323,88 bc**
TERPENS									
linalool	113,94	161,51 c	136,51 c	n.d. a	132,72 c	96,89 b	n.d. a	n.d. a	n.d. a
a-terpineol	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2,3-epoxigeranial	33,39	54,40 c	8,04 a	22,73 b	27,15 b	29,80 b	8,15 a	7,38 a	5,12 a
neral	40,51	63,45 c	37,60 b	25,88 ab	39,82 b	37,87 b	11,18 a	8,99a	6,12 a
geranial	75,97 b	110,66 c	95,83 c	37,60 ab	64,64 b	73,50 b	22,90 a	24,09 a	34,59 ab
β-damascenone	52,42	70,96 d	67,10 d	29,75 b	42,60 c	41,90 c	15,94 ab	9,54 a	4,15 a
neryl acetone	29,34 b	57,08 c	68,11 c	17,65 b	40,39	46,89	5,12 a	20,71 ab	33,05 b
β(Z)-ionone	7,08 a	34,86 c	149,65 d	3,88 a	35,18 c	26,00 b	28,35 b	24,24 b	25,43 b
β(E)-ionone	20,29 bc	35,49 d	40,53 d	2,16 a	20,75 bc	21,47 bc	15,16 b	17,32 b	10,16 b
(E,E)-pseudoionone	22,95 b	27,00 bc	33,06 c	4,14 a	15,44 b	18,83 b	5,04 a	20,08 b	4,74 a
Total amount	**395,89 b**	**615,41 c**	**636,43 c**	**143,79 ab**	**418,69 b**	**393,15 b**	**111,84 a**	**132,35 ab**	**123,36 a**
PHENOLIC DERIVATIVES									
2- methoxyphenol	4,45b	9,15 c	26,23 d	2,88 a	2,01 a	4,84 b	1,08 a	28,60 d	1,18 a
eugenol	119,19 c	69,18 b	132,02 c	60,51 b	58,73 b	36,64 ab	20,12 a	66,91 b	80,81 bc
methyl salicylate	42,82 b	103,99 c	216,55 d	5,14 a	164,21 cd	113,79 c	5,14 a	196,54 d	44,48 b
Total amount	**166,46 b**	**182,32 b**	**374,80 d**	**68,53 b**	**224,95 c**	**155,27 b**	**26,34 a**	**292,05**	**126,47 b**

Table 5. Quali-quantitative composition of identified volatile components in Faino F_1 tomatoes. n.d.= not detected.

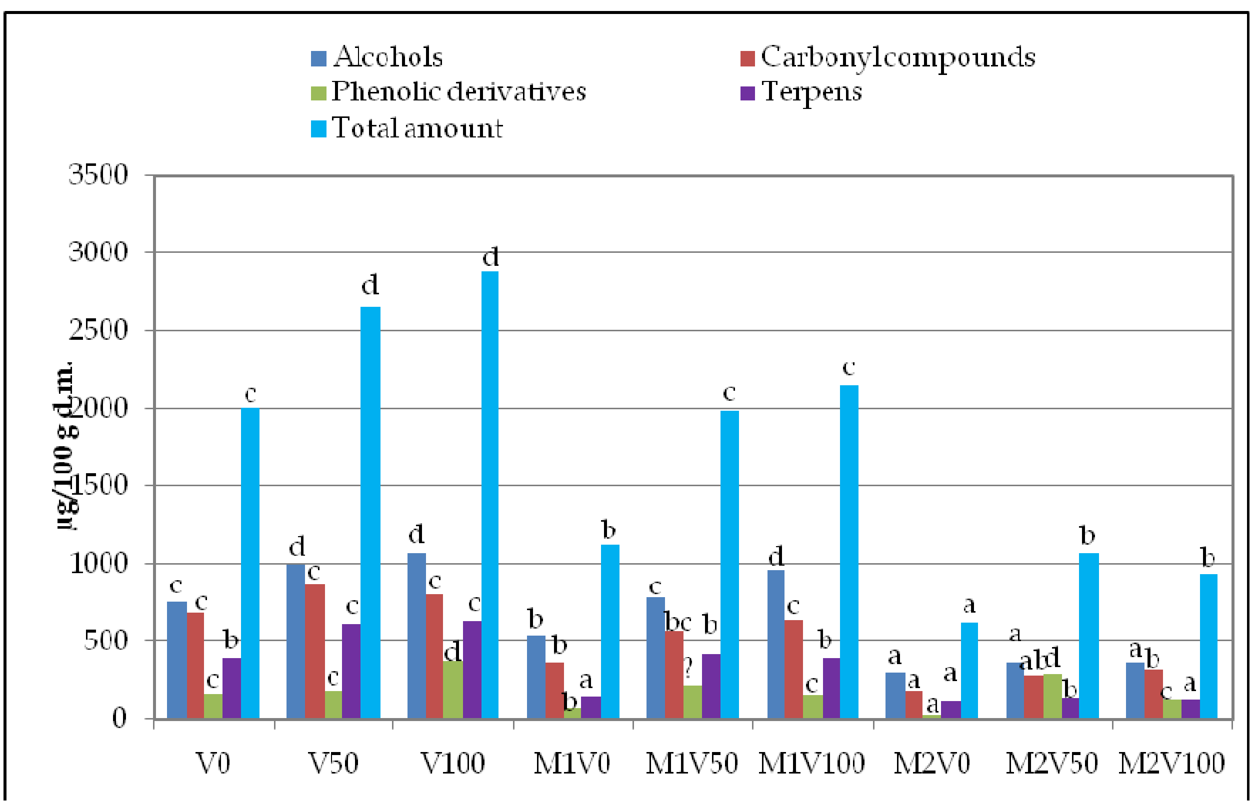
As concern the characteristic volatile compounds, Fig. 4 showed that hexanal had the highest value in unmycorrhized samples V_{50} and V_{100} with respect to the untreated sample (V_0). A constant content of 2(E)-hexenal was noted for unmycorrhized and irrigated samples. 2-isobutylthiazole, among the same samples, had the highest concentration in V_{50} and the lowest in V_{100}. In the irrigated and treated with two different kinds of mycorrhization samples, a decrease of all the characteristic volatile compounds was noted, especially for M_2 treatment. If the total content of characteristic volatile compounds was considered, the sample with the highest content was V_{50}, while M_1V_0 and M_2V_0 showed the lowest levels.

Fig. 5, concerning the contributor volatile compounds, showed that in the unmycorrhized irrigated samples alcohols, carbonyl compounds and terpenes had the highest content in V_{50} and V_{100}, except for phenolic derivatives, only in V_{50}. Besides, in the irrigated and mycorrhized samples, contributor volatile compounds were always lower than unmycorrhized and irrigated samples. This trend was more evident when the total content of contributor volatile compounds was considered.



Different letters indicate significant difference (ρ≤ 0.05).

Fig. 4. Effects of irrigation and mycorrhization on characteristic volatile compounds of Faino F_1 tomatoes.



Different letters indicate significant difference (ρ≤ 0.05).

Fig. 5. Effects of irrigation and mycorrhization on contributor volatile compounds of Faino F_1 tomatoes.

The other alimentary quality parameters were reported in Table 6.

The dry matter (d.m.) showed similar values in the irrigated and unmycorrhized samples. Among the samples treated with M_1, the value of M_1V_0 was slightly higher than the other samples (M_1V_{50} and M_1V_{100}), but with little statistically significant differences. Among all examined thesis, M_2V_0 had the highest d.m. value, while M_2V_{100} the lowest one. So, a light positive influence of mycorrhization system, and particularly of M_2, was noted in the unirrigated samples.

Among the unmycorrhized samples, V_0 had the lowest value of pH, while V_{100} the highest one. A similar trend was observed for irrigated and mycorrhized samples. Among all the samples, the lowest pH was noted for M_2V_0, while the highest values in V_{100} and M_1V_{100}.

Since pH is the expression of the organic acids content, the same table showed that to higher organic acids content corresponded lower pH, as demonstrated for M_2V_0. These two parameters are very important in processed tomatoes, because a pH=4.3 ensures a microbiological stability during the conservation in the sterilized products (Silvestri & Siviero, 1991).

As concern soluble sugars, both glucose and fructose showed the highest content in the unirrigated sample (V_0) and mycorrhized samples (M_1V_0 and M_2V_0). Furthermore, their content was always higher in mycorrhized sample than untreated one.

			SOLUBLE SUGARS (g/100 g w.w.)			**ORGANIC ACIDS** (mg/100 g w.w.)			
	d.m. (%)	pH	Glucose	Fructose	Total amount	Oxalic	Citric	Malic	Total amount
V_0	7,05 a	4,38 a	1,22 b	1,42 b	2,64 b	3,72 a	501,94 bc	30,58 b	536,23 bc
V_{50}	6,88 a	4,44 a	1,10 ab	1,47 b	2,58 b	4,86 b	460,63 b	18,41 a	483,89 b
V_{100}	7,15 b	5,66 b	1,00 a	1,31 ab	2,31 ab	3,94 ab	454,88 b	17,65 a	476,47 b
M_1V_0	7,21 b	4,35 a	1,44 b	1,56 b	3,00 b	3,79 a	548,36 c	32,24 b	584,39 bc
M_1V_{50}	6,81 a	4,86 a	0,91 a	1,19 a	2,10 a	3,86 a	454,36 b	24,91 ab	483,12 b
M_1V_{100}	6,98 a	5,33 b	0,91 a	1,21 a	2,12 a	3,69 a	403,73 a	17,08 a	424,49 a
M_2V_0	7,63 b	4,02 a	1,35 b	1,53 b	2,88 b	4,11 b	586,38 c	27,89 b	618,37 c
M_2V_{50}	7,21 b	4,42 a	0,89 a	1,14 a	2,03 a	3,94 ab	424,04 b	16,93 a	444,90 ab
M_2V_{100}	6,32 a	4,34 a	0,91 a	1,20 a	2,11 a	3,95 ab	457,33 b	21,37 ab	482,64 b

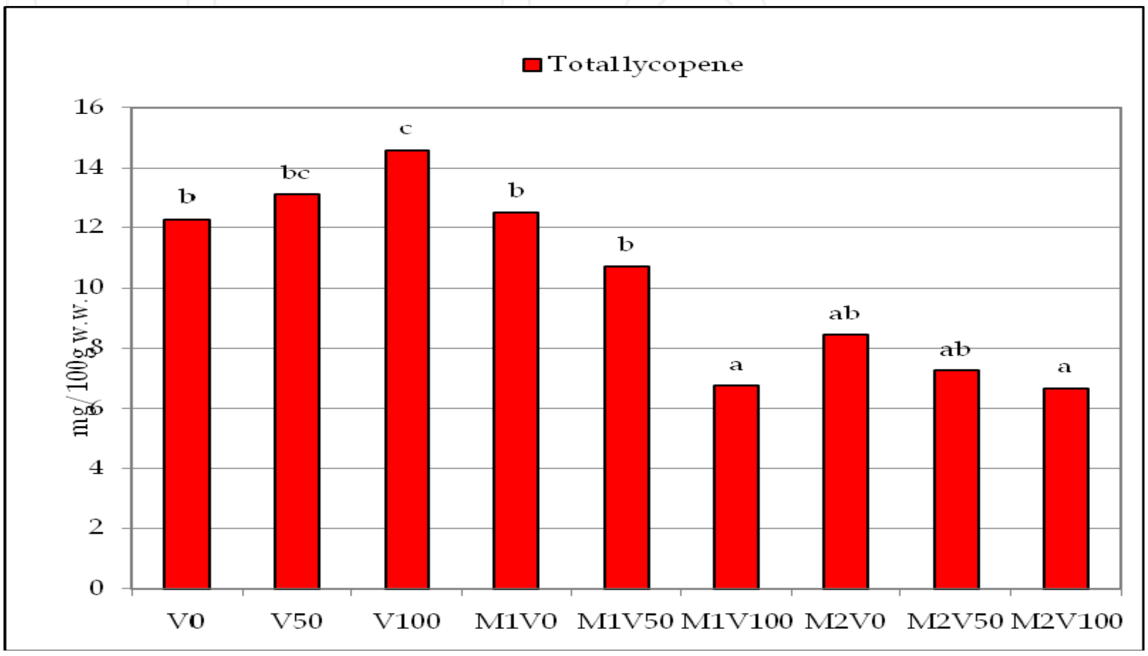
Different letters indicate significant difference ($\rho \leq 0.05$).

Table 6. Effects of mycorrhization and irrigation on chemical-physical parameters of Faino F_1 tomatoes.

3.2.3 Nutraceutical quality

From Fig. 6 it could be deduced that in unmycorrhized and irrigated samples (V_{50} and V_{100}) the total lycopene content significantly increased, in comparison with the control, respectively of 6,58% and 18,54% and this increase was directly proportional to the watering volume. Among the unirrigated samples, M_1V_0 presented the same content respect of V_0, while M_2V_0 showed a deep decrease (-31%). Utilizing the mycorrhizae with a watering regimes corresponding to 50%, the lycopene content decreased both in M_1V_{50} (-18%) and M_2V_{50} (-45%) with respect to V_{50}. In the full irrigated samples (V_{100}), the lycopene content in M_1V_{100} and M_2V_{100} showed a decrease of about -53% in comparison with V_{100}.

From reported data, it could be deduced that the highest concentration of lycopene was obtained in fully irrigated samples without mycorrhization. This trend was more evident for M_2 mycorrhized samples.



Different letters indicate significant difference (ρ≤ 0.05).

Fig. 6. Effects of irrigation and mycorrhization on total lycopene content of Faino F_1 tomatoes.

Recent studies pointed out that lycopene, as well as other carotenoids, are synthesized from isoprenoids that are products of mevalonic acid (MVA) and methylerythritol-4-phosphate (MEP) pathway (Botella-Pavia & Rodriguez-Concepcion, 2006). The use of M_1 and M_2 mycorrhizae could most likely decrease the action of enzymes involved in these pathways such as deoxyxylulose-5-phosphate synthase. This hypothesis seems to be the most plausible to explain the negative interaction of mycorrhization vs. lycopene synthesis, because of the scarce available literature about this behaviour.

However our results about the negative effect of mycorrhization on lycopene content were in contrast with other authors. Ordookhani & Zare (2011) investigated the effects of inoculating tomato (*Lycopersicon esculentum* F1 Hybrid, Delba) roots with plant growth-promoting rhizobacteria (PGPR) and Arbuscular Mycorrhiza Fungi (AMF) on lycopene and other parameters of tomato fruit. PGPR treatments were inoculated with *Pseudomonas putida, Azotobacter chroococcum* and the AMF treatment was inoculated with *Glomus mossea*. In comparison to the untreated sample, lycopene of fruit was increased by PGPR and AMF treatments. In the PGPR × AMF treatment maximum lycopene were found in plants of the *Pseudomonas* + *Azotobacter* + AMF treatment. In the PGPR treatment maximum lycopene were found in plants of the *Pseudomonas* + *Azotobacter* treatment. Data showed that lycopene increased when AMF added to PGPR treatments. Probably, the different behaviour of lycopene vs. Mycorrhization could depend on different composition of the mycorrhizae.

On the other hand, a positive effect of high watering regimes on lycopene content was in accordance with the other authors, as reported in the section relative to the Irrigation/ K-fertilization.

4. Conclusion

It can be deduced that agronomic parameters (yields, waste %, fruit weight etc.) are influenced by agronomic treatments when are separately analysed. Irrigation gives a better commercial yield and higher weight of berries in all examined genotypes. A different behaviour is showed by the other experimental treatments (K-fertilization and mycorrhization). Besides, poor effects on the same parameters were observed for the interactions between the different agronomical treatments and even in this case they seem not to depend on the genotype.

The influence of the agronomical treatments on the biochemical parameters can be detected from Fig. 7 and Fig. 8, where these parameters are compared against the control (I_1K_0 for fig. 7 and V_0 for Fig. 8) equal to 100.

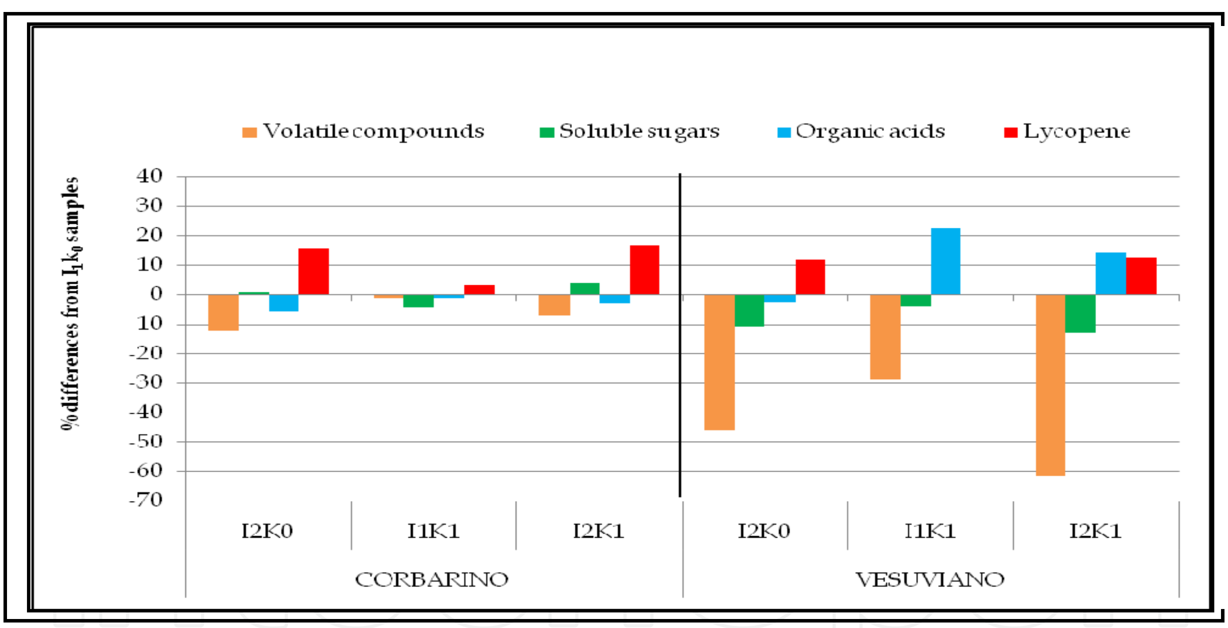


Fig. 7. Comparison of alimentary and nutraceutical parameters of "Corbarino" and "Vesuviano" tomatoes cultivated with different watering regimes and different K-fertilization levels. The percent changes with respect to the control (I_1K_0), assumed equal to 100%, are reported.

In Corbarino and Vesuviano tomato, the irrigation and irrigation/K-fertilization can reduce the flavour synthesis; this effect is more evident in Vesuviano tomato.

In Faino (F1) tomato hybrid, the irrigation enhances the volatile compounds content, while, in combination with mycorrhization, it cause a decrease of the volatile substances, especially with M2 (VAM).

Autochthon tomato varieties, as Corbarino and Vesuviano, are already adapted to the arid climate of the Vesuvius volcano slopes, characterized by low rainfall and difficulties in water supply. In this case, organoleptic characteristic are enhanced when they are cultivated in soil where the lonely water support is represented by rainfall. Besides, in new genotypes, as well as Faino hybrid tomato, the same characteristic are enhanced by high watering regimes. The interaction, as irrigation/K-fertilization and irrigation/mycorrhization, seems to have poor effects on aromatic profiles. A correlation among agronomical treatments and their effects on sugars and organic acids is very difficult. However, the lonely positive effect, on sugar and organic acids content, due to mycorrhization, is evident only in rainfall watered fields.

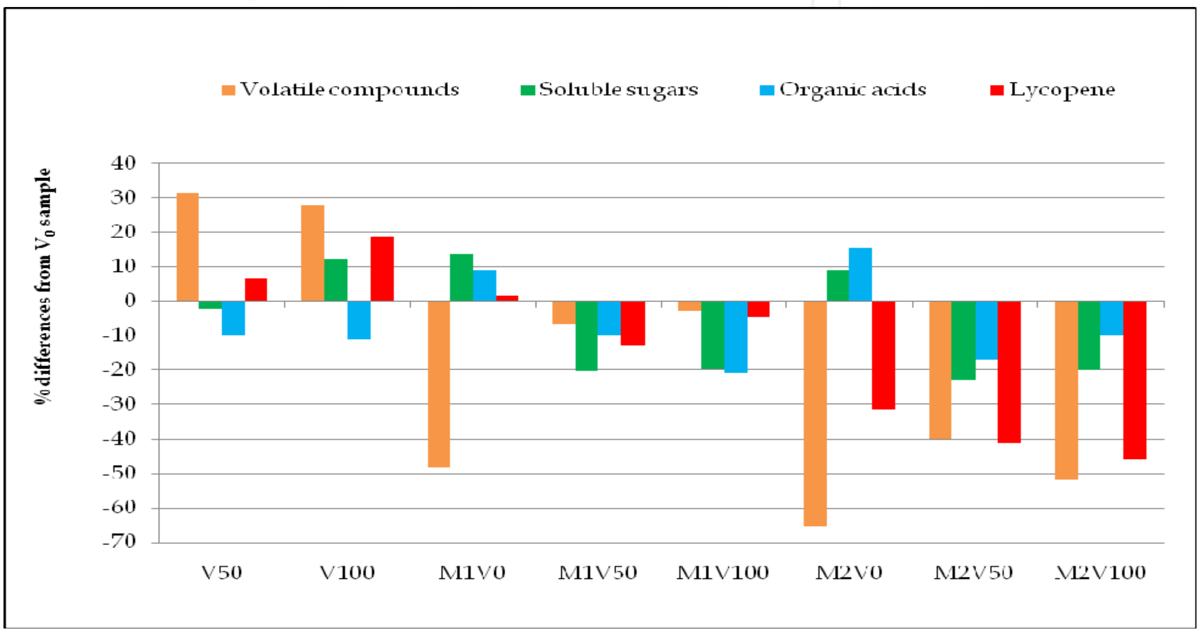


Fig. 8. Comparison of alimentary and nutraceutical parameters of " Faino F_1 tomatoes. The percent changes with respect to the control (V_0) ,assumed equal to 100%, are reported.

As concern the nutraceutical quality, high watering regimes can cause an increase of lycopene in three genotypes. Moreover, in Corbarino and Vesuviano tomato, irrigation x K-fertilization considerably enhances the lycopene content in the theses with the highest level of both irrigation and fertilization. On the contrary, a considerable decrease of the lycopene content is noted in the Faino tomato in the theses with irrigation x mycorrhization.

In conclusion, the irrigation seems to be the best agronomical treatment to enhance the organoleptic, nutraceutical and agronomical characteristics of tomatoes, regardless of genotype and origin countries. Besides, the interactions of irrigation with K-fertilization and mycorrhization cause poor effects on biochemical and agronomical characteristics.

5. References

Achilea, O. & Kafkafi, U. (2003). Enhanced performance of processing tomatoes by potassium nitrate-based nutrition. *Acta horticulturae A.*, No. 616, pp. 81-87, ISSN 0567-7572.

Akhtar, M.S. & Siddiqui, Z.A. (2008). Arbuscular mycorrhizal fungi as potential bioprotectants against plant pathogens. In: *Mycorrhizae: Sustainable Agriculture and Forestry* (Siddiqui Z.A., Akhtar M.S. and Futai K. Eds), Springer Netherlands. pp. 61-97, ISBN 978-1-4020-8769-1.

Azcon-Aguilar, C. & Barea, J.M. (1997). Applying mycorrhiza biotechnology to horticulture: significance and potentials. *Scientia Horticulturae*, Vol. 68, No. 1-4, (March 1997), pp. 1-24, ISSN 0304-4238.

Bergmann, W. (1992). Causes, development and diagnosis of symptoms resulting from mineral. Macronutrients: Potassium. In: *Nutritional Disorders of Plants: Development, Visual and Analytical Diagnosis*. (Bergmann, W. and Fischer, G., Eds.). Gustav Fisher Verlag, Jena, Germany.

Boileau, T.W.M.; Boileau, A.C. & Erdman, J.W. jr. (2002). Bioavailability of all-trans and cis-isomers of lycopene. *Experimental Biology and Medicine,* Vol. 227, No. 10, (November 2002), pp. 914-919, ISSN: 1535-3702.

Botella-Pavía, P. & Rodríguez-Concepción, M. (2006). Carotenoid biotechnology in plants for nutritionally improved foods. *Physiologia Plantarum*, Vol. 126, No. 3, (March 2006), pp. 369–381, ISSN 0031-9317.

Brandt, S.; Lugasi, A.; Barna, E.; Hovari, J.; Pek, Z. & Helyes, L. (2003). Effects of the growing methods and conditions on the lycopene content of tomato fruits. *Acta Alimentaria,* Vol. 32, No. 3, (August 2003), pp. 269-278, ISSN 0139-3006.

Branthôme, X.; Plè, Y. & Machado, J.R. (1994). Influence of drip-irrigation on the technological characterisation of processing tomatoes. *Acta Horticulturae,* Vol. 376, pp. 285-290, ISSN 0567-7572.

Buttery, R. G.; Teranishi, R.; Flath, R. A. & Ling, L. C. (February 1989). Fresh tomato volatiles. Composition and sensory studies. In *Flavor Chemistry, Trends and Developments*; Teranishi, R., Buttery, R. G., Shahidi, F., Eds.; ACS Symposium Series 388; ISBN 9780841215702, American Chemical Society: Washington, DC, pp. 213-222.

Buttery, R. & G.; Ling, L. C. (1993). Volatile components of tomato fruit and plant parts. Relationship and biogenesis. In *Bioactive Volatile Compounds from Plants*; Teranishi, R., Buttery, R. G., Sugisawa, H., Eds.; ACS Symposium Series 525; ISBN 9780841226395 American Chemical Society: Washington, DC, pp. 23-34.

Candido, V.; Miccolis, V. & Perniola, M. (2000). Effects of irrigation regime on yield and quality of processing tomato (*Lycopersicon esculentum* Mill.) cultivars. *Acta Horticulturae*, Vol. 537, No. 2, pp. 779-788. ISSN: 0567-7572

Colla, G.; Battistelli, A.; Moscatello, S.; Proietti, S.; Casa, R.; Lo Casco, B. & Leoni, C. (2001). Effect of reduced irrigation and nitrogen fertirigation rate on yield, carbohydrate accumulation, and quality of processing tomatoes. *Acta Horticulturae*, Vol. 542, pp. 187-196, ISSN 0567-7572.

Colla, G.; Casa, R.; Lo Cascio, B.; Saccardo, F.; Temperini, O. & Leoni C. (1999). Responses of processing tomato to water regime and fertilization in Central Italy. *Acta Horticulturae,* Vol. 487, pp. 531-536, ISSN 0567-7572.

Conversa, G.; Elia, A. & La Rotonda, P.; (2007). Mycorrhizal Inoculation and Phosphorus Fertilization Effect on Growth and Yield of Processing Tomato. *Acta Horticulturae*, Vol. 758, pp. 333-338, ISSN 0567-7572.

Copetta, A.; Lingua, G.; Berta, G.; Bardi, L. & Masoero, G. (2006). Three arbuscular mycorrhizal fungi differently affect growth, distribution of glandular trichomes and essential oil composition, appreciated by NIR spectroscopy and electronic nose, in *Ocimum basilicum* var. Genovese. *Acta Horticulturae,* Vol. 723, pp. 151-156, ISSN 0567-7572.

Davies, Jr. F.T.; Olalde-Portugal, V.; Aguilera-Gomez, L.; Alvarado, M.J.; Ferrera-Cerrato, R.C. & Boutton, T.W. (2002). Alleviation of drought stress of Chile ancho pepper (Capsicum annuum L. cv. San Luis) with arbuscolar mycorrhiza indigenous to Mexico. *Scientia Horticulturae*, Vol. 92, No. 3, (February 2002), pp. 347-359, ISSN 0304-4238.

De la Peña, E.; Rodríguez Echeverría, S.; van der Putten, W.H.; Freitas, H. & Moens M. (2006). Mechanism of control of root-feeding nematodes by mycorrhizal fungi in the dune grass *Ammophila arenaria*. *New Phytologist,* Vol. 169, pp. 829-840, ISSN 0028-646X.

Di Cesare, L.F.; Forni, E.; Viscardi, D. & Ferrari, V. (2003). Valutazione della composizione aromatica e chimico-fisica di alcune cultivar di pomodoro da impiegare per il consumo diretto o per la trasformazione. *Industria Conserve*, Vol. 78, No. 2, pp. 195-206, ISSN 0019 7483.

Dirinck, P.; Schreyen, L.; van Wassenhove, F. & Schamp, N. (1976). Flavour quality of tomatoes. *J Sci Food Agric.*, Vol. 27, No 6, (June 1976), pp. 499-508, ISSN 0022-5142.

Dorais, M.; Papadopoulos, A.P. & Gosselin A. (2001). Greenhouse tomato fruit quality: the influence of environmental and cultural factors. *Hortic Rev*, Vol. 26, pp.239–319, ISSN 0163-7851.

Dorais, M. (2007). Effect of cultural management on tomato fruit health qualities. FAV Health (2005). QC, Canada. *Acta Horticulturae,* Vol. 744, pp. 279–293, ISSN 0567-7572.

Dorais, M.; Ehret, D. L. & Papadopoulos, A. P. (2008). Tomato (*Solanum lycopersicum*) health components: from the seed to the consumer. *Phytochem Rev*, Vol. 7, pp. 231–250, ISSN 1568-7767.

Dumas, Y.; Leoni, C.; Portas, C. A. M. & Bièche, B. (1994). Influence of water and nitrogen availability on yield and quality of processing tomato in the European Union Countries. *Acta Horticulturae,* Vol. 376, pp. 185-192, ISSN 0567-7572.

Dumas, Y.; Dadomo, M.; Di Lucca, G. & Grolier P. (2003). Effects of environmental factors and agricultural techniques on antioxidant content of tomatoes. *J. Sci. Food Agric.*, Vol. 83, No. 5, (April 2003), pp. 369-382, ISSN 0022-5142.

Elia, A.; Conversa, G. & La Rotonda, P. (2006). Effect of mycorrhizal inoculation and P rates on yield and quality of processing tomato. *Abstracts V International Conference on Mycorrhyza "Mycorrhiza for Science and Society"*, Granada (Spagna), 23-27 July 2006, pp. 217.

Elsen, A.; Gervacio, D.; Swennen, R. & De Waele, D. (2008). AMF-induced biocontrol against plant parasitic nematodes in *Musa* sp.: a systemic effect. *Mycorrhiza*, Vol. 18, pp. 251-256, ISSN 0940-6360.

Favati, F.; Lovelli, S.; Galgano, F.; Miccolis, V.; Di Tommaso, T. & Candido, V. (2009) Processing tomato quality as affected by irrigation scheduling. *Scientia Horticulturae*, Vol. 122, No. 4, (November 2009), pp. 562–571, ISSN: 0304-4238.

Fontes, P.C.R.; Sampalo, R.A. & Finger, F.L. (2000). Fruit size, mineral composition and quality of trickle-irrigated tomatoes as affected by potassium rates. *Pesq. Agropec. Bras. Brasilia*, Vol. 35, No. 1, (January 2000), pp. 21-25, ISSN 0100-204X.

Gera Hol, W.H. & Cook, R. (2005). An overview of arbuscular mycorrhizal fungi-nematode interactions. *Basic and Applied Ecology,* Vol. 6, pp. 489-503, ISSN 1439-1791.

Gerster, H. (1997). The potential role of lycopene for human health. *Journal of American college of Nutrition*, Vol.16, pp. 109-126, ISSN 0731-5724.

Ghebbi Si-smail, K.; Bellal, M. & Halladj, F. (2007). Effect of potassium supply on the behaviour of two processing tomato cultivars and on the changes of fruit technological characteristics. *Acta Horticulturae,* Vol. 758, pp. 269-274, ISSN 0567-7572.

Gianinazzi, S.; Oubaha, L.; Chahbandar, M.; Blal, B. & Lemoine, M.C. (2003). Biotization of microplants for improbe performance. *Acta Horticulturae,* Vol. 625, pp. 165-172, ISSN 0567-7572.

Giordano, I.; Pentangelo, A.; Villari, G.; Fasanaro, G. & Castaldo D. (2000). Caratteristiche bio-agronomiche e idoneità alla trasformazione di pomodori dell'ecotipo "Corbarino". *Industria Conserve*, Vol. 75, pp. 317-329, ISSN 0019 7483.

Giovannucci, E.; Ascherio, A.; Rimm, E.B.; Stampfer, M.J.; Colditz, G.A. & Willett, W.C. (1995). *Journal of National Cancer Institute,* Vol. 87 (special issue), pp. 1767-1776, ISSN 0027-8874.

Gosling, P.; Hodge, A.; Goodlass, G. & Bending, G.D. (2006). Arbuscular mycorrizal fungi and organic farming. *Agriculture, Ecosistem and Environment*, Vol. 113, pp. 17-35, ISSN 0167-8809.

Helyes, L.; Dimény, J.; Bőcs, A.; Schober, G. & Pék, Z. (2009). The effect of water and potassium supplement on yield and lycopene content of processing tomato. *Proceedings of the XIth International Symposium on the Processing Tomato: Toronto, Canada, June 9-11 2008*. Leuven, Belgium: International Society for Horticultural Science. In *Acta Horticulturae,* No.823, pp, ISSN 0567-7572.

Jacquot, E.; van Tuinen, D.; Gianinazzi, S. & Gianinazzi-Pearson, V. (2000). Monitoring species of arbuscular mycorrhizal fungi in planta and in soil by nested PCR: application to the study of the impact of sewage slude. *Plan. and Soi.*, Vol. 226, pp. 179-188, ISSN 0032-079X.

Matsuzoe, N.; Zushi, K. & Johjima, T. (1998). Effect of soil water deficit on coloring and carotene formation in fruits of red, pink and yellow type cherry tomatoes. *J Jpn Soc Hortic Sci,* Vol. 67, No. 4, pp. 600–606, ISSN: 0013-7626.

Mitchell, J.P.; Shennan, C.; Grattan, S.R. & May, D.M. (1991). Tomato fruit yields and quality under water deficit and salinity. *Journal of the American Society for Horticultural Science,* Vol. 116, No. 2, pp. 215-221, (Mar 1991), ISSN 0003-1062.

Morton, J. N. & Bentivenga, S.P. (1994). Levels of diversity in endomycorrhyzal fungi (*Glomales*, *Zygomycetes*) and their role in defining taxonomic and non-taxonomic groups. *Plan. and Soi.*, Vol. 159, pp. 47-59, ISSN 0032-079X

Naphade, A.S. (1993).Effect of water regime on the quality of tomato. *Maharashtra J Hortic* Vol. 7, No.2, pp. 55–60, ISSN 0970-2873

Oded, A. & Uzi, K. (2003). Enhanced performance of processing tomatoes by potassium nitrate based nutrition. *Acta Horticulturae,* Vol. 613, pp. 81–87, ISSN 0567-7572.

Ordookhani, K. & Zare M. (2011). Effect of Pseudomonas, Azotobacter and Arbuscular Mycorrhiza Fungi on Lycopene, Antioxidant Activity and Total Soluble Solid in Tomato (*Lycopersicon Esculentum* F1 Hybrid, Delba). *Advances in Environmental Biology*, Vol. 5, No. 6. pp. 1290-1294. ISSN 1995-0756.

Panagiotopoulos, L.J. & Fordham, R. (1995). Effects of water stress and potassium fertilisation on yield and quality (flavour) of table tomatoes (*lycopersicon esculentum mill.*). *Acta Hort. (ISHS),* No. 379, (June 1995), pp. 113-120, ISSN 0567-7572.

Parisi, M; Pentangelo, A.; D'Onofrio, B.; Villari, G. & Giordano, I. (2006). Studi su ecotipi campani di pomodorino "Corbarino" e "Vesuviano" in due ambienti. *Italus Hortus*, Vol. 13, No. 2, pp. 775-778, ISSN 1127-3496.

Patanè, C. & Cosentino, S.L. (2010). Effects of soil water deficit on yield and quality of processing tomato under a Mediterranean climate. *Agricultural water management*, Vol. 97, No. 1, pp.131-138, ISSN 0378-3774.

Pernice, R.; Parisi, M.; Giordano, I.; Pentangelo, A.; Graziani, G.; Gallo, M.; Fogliano, V. & Ritieni, A. (2010). Antioxidant profile of small tomato fruits: effect of water regime and industrial process. *Scientia Horticulturae,* Vol. 126, No. 2, pp. 156-163, ISSN 0304-4238.

Riggi, E.; Patané, C. & Ruberto, G. (2008). Content of carotenoids at different ripening stages in processing tomato in relation to soil water availability. *Australian Journal of Agricultural Research*, Vol. 59, No. 4 (April 2008), pp. 348–353, ISSN: 00049409.

Rudich, J.; Kalmar, C.; Geizenberg, C. & Harel, S. (1977) Low water tensions in defined growth stages of processing tomato plants and their effects on yield and quality. *J Hort Sci*, Vol. 52, pp. 391–399, ISSN 1611-4426

Ruiz, J. M. & Romero, L. (2002). Relationship between potassium fertilisation and nitrate assimilation in leaves and fruits of cucumber (*Cucumis sativus*) plants. *Annals of Applied Biology*, Vol. 140, pp. 241–245, 0003-4746

Sensoy, S.; Demir, S.; Turkmen, O.; Erdinc, C. & Savur, O.B. (2007). Responses of some different pepper (*Capsicum annuum* L.) genotypes to inoculation with two different arbuscular mycorrhizal fungi. *Scientia Horticulturae,* Vol. 113, pp. 92-95, ISSN 0304-4238.

Serio, F.; Ayala, O.; Bonasia, A. & Santamaria, P. (2006). Antioxidant properties and health benefits of tomato. In: *Recent Progress in Medicinal Plants. Volume 13. Search for Natural Drugs.* (Govil, J. N., Sing, V. K. and Arunachalam, C., Eds.). Studium Press, Houston, TX, USA. 163–183.

Serio, F.; Leo, L.; Parente, A. & Santamaria, P. (2007). Potassium nutrition increases the lycopene content of tomato fruit. *Journal of Horticultural Science & Biotechnology,* Vol. 82, No. 6, pp. 941–945, ISSN 14620316.

Shi, J.; Le Maguer, M. & Niekamp F. (1999). Lycopene degradation and isomerization in tomato dehydration. *Food Research,* Vol. 32, pp. 15-21, 0963-9969

Silvestri, G. & Siviero, P. (1991). *La coltivazione del pomodoro da industria*. Edizioni l'informatore Agrario, ISBN 887220030X, Verona (Italy).

Sorensen, J.N.; Larsen, J.M. & Jakobsen, I. (2008). Pre-inoculation with arbuscular mycorrhizal fungi increases early nutrient concentration and growth of field-grown leeks under high productivity conditions. *Plant Soil*, Vol. 307, pp. 135-147, ISSN 0032-079X

Stahh, W. & Sies, H. (1992). Uptake of lycopene and its geometrical isomers is greater from heat-processed than from unprocessed tomato juice in humans. *J. Nutr.,* Vol. 122, pp. 2161-2166, ISSN 0022-3166.

Taber, H.; Perkins-Veazie, P.; Shanshan, L.; White, W.; Rodermel, S. & Yang X. (2008). Enhancement of tomato fruit lycopene by potassium is cultivar dependent. *HortScience*, Vol. 43, No. 1, (February 2008), pp. 159-165, ISSN 0018-5345

Trudel, M. J. & Ozbun, J. L. (1970). Relationship between chlorophyll and carotenoids of ripening tomato fruits as influenced by K nutrition. *Journal of Experimental Botany*, Vol. 21, pp. 881–886, ISSN 0022-0957.

Trudel, M. J. & Ozbun, J. L. (1971). Influence of potassium on carotenoid content of tomato fruit. *Journal of the American Society for Horticultural Science*, Vol. 96, pp. 763–765, ISSN 003-1062.

Turk, M.A.; Assaf, T.A.; Hameed, K.M. & Al-Tawaha, A.M. (2006). Significance of Mycorrhizae. *World journal of Agricultural Sciences*, Vol. 2, No. 1, pp. 16-20, ISSN 1817-3047.

van der Heijden, M.G.A.; Streitwolf-Engel, R.; Siegrist, S.; Neudecker, A.; Ineichen, K.; Boller, T.; Wiemken, A. & Sanders I.R. (2006). The micorrhizal contribution to plant productiviy, plant nutrition and soil structure in experimental grassland. *New Phytol.,* Vol. 172, pp. 739-752, ISSN 0028-646X.

van Tuinen, D.; Jacquot, E.; Zhao, B.; Gollotte, A. & Giannizzi-Pearson, V. (1998). Characterization of root colonization profiles by a microcosm community of arbuscular mycorrhizal fungi using 25S rDNA-targeted nested PCR. *Mol. Ecol.*, Vol. 7, pp. 879-887, ISSN 0962-1083.

Veit-Köhler, U.; Krumbein, A. & Kosegarten, H. (1999). Effect of different water supply on plant growth and fruit quality of *Lycopersicon esculentum. Journal of Plant Nutrition and Soil Science*, Vol. 162, No.6, pp. 583–588, ISSN 0718-9508.

Warner, J.; Tan, C. S. & Zhang, T. Q. (2007). Water management strategies to enhance fruit solids and yield of drip irrigated processing tomato. *Canadian Journal of Plant Science*, Vol. 87, pp. 345-353, ISSN 0008-4220.

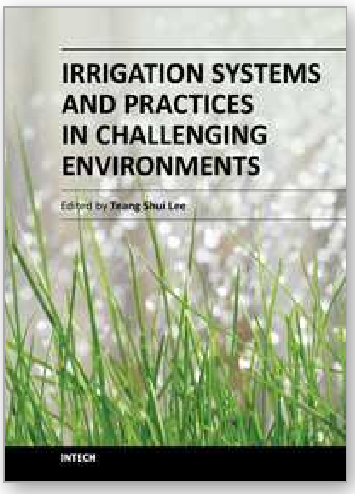
Waterer, D.R. & Coltman, R.R. (1988). Phosphorus concentration and application interval influence growth and mycorrhizal infection of tomato and onion transplants. *J. Am. Soc. Hortic. Sci.*, Vol. 113, pp. 704–798, ISSN 0003-1062.

Wright, D.H. & Harris, N.D. (1985). Effect of nitrogen and potassium fertilization on tomato flavour. *J. Agric. Food Chem.,* Vol. 33, pp. 355-358, ISSN 0021-8561.

Wuzhong, N. (2002). Yield and quality of fruits of solanaceous crops as affected by potassium fertilization. *Better Crops International,* Vol. 16, No. 1, pp. 6-8, ISSN 0006-0089.

Zdravković, J.; Marković, Z.; Zdravković, M.; Damjanović, M. & Pavlović, N. (2007). Proceeding of "III Balkan Symposium on Vegetables and Potatoes", *Acta Horticulturae,* No. 729, pp. 177-182, ISSN 0567-7572.

Zushi, K & Matsuzoe, N. (1998). Effect of soil water deficit on vitamin C, sugar, organic acid, amino acid and carotene contents of large-fruited tomatoes. *J Jpn Soc Hort Sci*, Vol. 67, pp. 927–933, ISSN 0013-7626.



Irrigation Systems and Practices in Challenging Environments
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The book Irrigation Systems and Practices in Challenging Environments is divided into two interesting sections, with the first section titled Agricultural Water Productivity in Stressed Environments, which consists of nine chapters technically crafted by experts in their own right in their fields of expertise. Topics range from effects of irrigation on the physiology of plants, deficit irrigation practices and the genetic manipulation, to creating drought tolerant variety and a host of interesting topics to cater for the those interested in the plant water soil atmosphere relationships and agronomic practices relevant in many challenging environments, more so with the onslaught of global warming, climate change and the accompanying agro-meteorological impacts. The second section, with eight chapters, deals with systems of irrigation practices around the world, covering different climate zones apart from showing casing practices for sustainable irrigation practices and more efficient ways of conveying irrigation waters - the life blood of agriculture, undoubtedly the most important sector in the world.

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