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Yield and Quality of Mini-watermelon as Affected by Grafting and Mycorrhizal Inoculum

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ABSTRACT

Grafting and mycorrhizal fungi have gained interest for the positive effects they can have on vegetable crops. The aim of this work was to study the combined effect of grafting with Vesicular-Arbuscular Mycorrhizal Fungi (AMF) inoculation on fruit yield and quality of mini-watermelon [*Citrullus lanatus* (thumb.) Matsum and Nakai]. Ungrafted plants or grafted onto rootstock RS 841 (*Cucurbita maxima*×*C. moschata*) were transplanted to the field. During cultivation, half of the plants were inoculated with a suspension of AMF. Plant growth and fruit yield and quality were evaluated. The inoculation of AMF resulted in a significant increase of root colonization both for grafted and ungrafted plants. The grafted inoculated plants had a greater vigour and productivity than ungrafted uninoculated plants. Grafting and AMF inoculation caused significant increases in yield and fruit weight. Qualitative characteristics of watermelon fruits were significantly affected mainly by grafting. The combined use of grafting with mycorrhizal inoculation may increase the yield of mini-watermelon fruit, maintaining good quality characteristics.

Keywords: Arbuscular Mycorrhizal Fungi, *Citrullus lanatus,* Fruit quality characteristics, Glomus, Vegetable grafting.

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INTRODUCTION

The environmental concerns and the increasing request for more environmentally friendly plant production systems, both from authorities and consumers, have increased the search for biological resources that might reduce the use of input factors (water, chemical fertilizer, pesticides, etc.). The grafting of vegetables allows combining the characteristics of productivity and quality of varieties with those of resistance/tolerance to biotic (soil-borne diseases) or abiotic stresses of rootstocks, much faster than the time needed for genetic improvement. Grafting has been used in many vegetables, mainly from *Solanaceae* and *Cucurbitaceae* families, under biotic (Blestos *et al*., 2003; Morra and Bilotto, 2006; Crinò *et al*., 2007) or abiotic (Rivero *et al*., 2003; Yetisir *et al*., 2006; Venema *et al*., 2008) stress conditions with different effects on yield (Lee and Oda, 2003; Rouphael *et al*., 2008) and quality (Proietti *et al*., 2008; Flores *et al*., 2010). These differences may be due to the genotype of scion and/or rootstock, to their interaction, and to the environmental conditions and the soil characteristics (fertility, soil-borne pathogen presence, etc.) (Traka-Mavrona *et al*., 2000; Moncada *et al*., 2013; Miceli *et al*., 2014). The roots of both cultivar and rootstocks interact with the populations of microorganisms of the rhizosphere, which may have significant effects on growth, nutrition, and health (Bowen and Rovira, 1999; Mukerji *et al*., 2006). The root interactions with soil

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microorganisms are very complex and involve a great variety of communities of different and heterogeneous environments (Giri *et al*., 2005). Among these microorganisms, some endomycorrhizal fungi (Arbuscular Mycorrhizal Fungi, AMF) have been proven to improve plant growth under various environmental conditions (Azcon-Aguilar and Barea, 1997; Abdel-Rahman *et al*., 2011). These beneficial effects are related to the influence of AMF symbiosis on several aspects of plant physiology, such as mineral nutrients uptake, plant development and protection, and, also, to the effects on soil structure quality (Bethlenfalvay and Schbepp, 1994). The mycorrhizal fungi can increase the supply of mineral nutrients to the plant and can be considered biocontrol agents, as they can reduce or even suppress damage caused by soil-borne plant (Hooker *et al*., 1994); and, also, improve plant resistance to abiotic stress (Azcon-Aguilar and Barea, 1997). In order to improve plant performance in vegetable crops, the presence of functionally compatible AMF available to colonize the developing plant root system is necessary. Therefore, when a population of low-effective propagules is present or when indigenous fungi are absent or in low levels in the rhizosphere, inoculation with AMF can be feasible and rewarding. Several researches have been published on grafting and mycorrhizal inoculation, but their joined use has not been widely studied. Therefore, the aims of this research were to confirm the growth-promoting effects of AMF on mini-watermelon and to test the combined effect of grafting with mycorrhizal inoculation on plant growth, yield, and quality.

MATERIALS AND METHODS

Experiments were conducted on a sandy loam soil located at the "ESA-Campo Carboy Research Farm" near Castelvetrano (TP– Italy; 37° 35' 14" N, 12° 53' 38" E) from March to July for two consecutive years, in soils naturally infested with *Fusarium oxysporum*. The soils were evaluated for pathogens before doing the first and the second planting. The mean annual precipitation of the zone where the trial was carried out was 700 mm. Most of the rainfalls occur in autumn and winter, being highest in October (monthly mean rainfall of 81 mm) and lowest in July (monthly mean rainfall of 2 mm). On average, 3% of the mean annual rainfall occurs during summer, while 42% occurs during winter. The mean annual temperature is 18°C; the hottest months are July and August (monthly means of about 25°C), and the coldest months are January and February (monthly means of 11°C).

Seedlings of ungrafted or grafted plants, obtained by using the slant cut graft technique, were purchased from a local commercial company. One of the most widespread mini-watermelon (*Citrullus lanatus* (Thunb.) Matsum and Nakai) hybrid cultivated in Italy, *cv.* 'Minirossa' (Lamboseeds srl, Bologna, Italy), was used as scion and the widely used hybrid RS841 (*Cucurbita moschata* Duchesne×*Cucurbita maxima* Duchesne; Peto Seed Company, Parma, Italy) was used as rootstock. During cultivation, half of the plants were inoculated with a suspension of Arbuscular Mycorrhizal Fungi (AMF). Treatments were defined by a factorial combination of two grafting treatments (ungrafted and grafted watermelon plants) and two mycorrhizal treatments (uninoculated or inoculated soil with AMF). Each experimental unit was 50 m^2. The treatments were arranged in a randomized complete block design with three replicates per treatment. Before transplanting, fertilizer was broadcast (170 kg ha^{-1} of K_2O) and incorporated into the soil. At the end of March, plants were transplanted 1.0 m apart within rows and 2.5 m apart between rows (this is the conventional plant density used by producers in the region), in soil mulched with a transparent PE film. Additional fertilizer (180 kg N ha^{-1}, 15 kg K_2O ha^{-1}, 20 kg Mg ha^{-1}, 2 kg iron chelate ha^{-1}), calculated on the basis of theoretical uptake, expected yields, and mineral elements in soil, was applied and plants were watered according to seasonal needs through a drip irrigation system during plant growth and fruit development. The suspension of AMF (Rizocore, Intrachem Bio Italia, Italy) was applied by fertigation (0.25 g m^{-2} of *Glomus* spp. propagules) in three different periods of plant growth: at transplant, at the beginning of flowering and after the first fruit setting.

During plant growth, i.e. 10, 20, and 30 days after transplanting (dat), length of the main vine of the watermelon plants was measured. Fully mature fruits were harvested over a period of 10 days starting 70 dat. Fruits that were cracked, badly misshapen, and weighed less than 1.8 kg were considered unmarketable. The number of fruits, mean fruit weight and marketable yield were determined. After harvesting, plant mortality and root colonization were evaluated. To visualize the mycorrhizal development, three samples of lateral roots from each plant were collected and stained by acid fuchsine. In particular, the Phillips and Haymann's technique (1970), modified by Torta *et al.* (2003), was applied. The Mycorrhization Index (MI= % of stained tissue, with respect to hyaline portion, on the unit of length of the root) was determined on three fragments, determining the average value (Kormanik and McGraw, 1991). Soon after harvesting, ten fully mature marketable fruits randomly selected for each replicate were analyzed for fruit quality parameters. Fruit volume was calculated using the water displacement technique. Each watermelon fruit was gently slipped into a known volume of water until the water completely covered the fruit and then the weight of water displaced by the fruit was recorded. The volume of each fruit was calculated by the following equation: $Actual\ volume\ (cm^3)= W/\gamma$, where W is the weight of displaced water and γ is the weight density of water. Water temperature was kept at 25°C. The bulk density was obtained from the ratio of the weight of the fruits to the volume. Watermelons were cut longitudinally in two halves for further determinations. Color of watermelon pulp was measured on three points of one half of each fruit, using a colorimeter (Chroma Meter CR-400C, Minolta, Osaka, Japan). Parameters L^*, a^* and b^* were recorded. Hue angle (h°) and Chroma (C*) were calculated as $h°= Arctan(b^*/a^*)$ and $C^*= (a^{*2} + b^{*2})^{1/2}$. The firmness of the pulp was determined in three points of one-half of each fruit along the longitudinal axis using a digital penetrometer (mod. 53205, TR Snc. Italy) equipped with a flat 8 mm diameter stainless steel cylinder probe; the mean peak force was calculated in Newton. Rind thickness was measured in two opposite part on the equatorial plane using a standard calliper; watermelon pulp was removed and weighted in order to calculate the edible part of each fruit. A homogenate of the edible part of the middle of each fruit was centrifuged at 3500 rpm for 10 minutes and supernatant was used to determine Titratable Acidity (TA), ascorbic acid, nitrates and Total Soluble Solids (TSS). TA was determined by potentiometric titration with 0.1 M NaOH up to pH 8.1 using 15 mL of juice and expressed as % malic acid equivalents. TSS (°Brix) was determined using a digital refractometer (MTD-045nD, Three-In-One Enterprises Co., Ltd., Taiwan). Nitrate and ascorbic acid contents (mg kg^{-1} of fresh weight) were determined reflectometrically using a Reflectometer RQflex10 Reflectoquant and the Reflectoquant nitrate and ascorbic acid test strips (Merk, Germany) (procedures described in art. 1.16971.0001 and 1.16981.0001 by Merk - http://www.merckmillipore.com/chemicals/).

Analysis of variance of the treatment effects on measured traits was performed using the GLM procedure of SPSS software package (SPSS Inc. Chicago, IL, USA). Combined analysis of variance over 2 years was performed for all measured traits. All parameters were analyzed by two-way analyses of variance within each year. The homogeneity of error variances were tested by applying Bartlett's test. Simple effects tests were used to examine significant two-way interactions and *LSD* procedure was used for pairwise comparison.

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RESULTS AND DISCUSSION

The data collected during the two years of trials showed a similar and superimposable trend. The statistical analysis of the data showed no significant effect of the year of experiment as a main effect. Also, no significant differences were observed on interaction between the grafting or mycorrhizal treatments and the year of experiment (Tables 1, 2, and 3).

Roots were colonized with mycorrhizae in all trials, even those not inoculated, thus confirming the presence of indigenous communities of AMF in our experimental field (Table 1). Soils used for agricultural production have a low diversity of mycorhizal fungi communities and a prevalence of *Glomus* spp. compared with natural ecosystems (Blaszkowski, 1993; Talukdar and Germida, 1993). Low infection potential together with lower incidence of some AMF in high-input agricultural soils was also reported by Douds *et al*. (1993). One reason for this is the low diversity of hosts, which reaches its most extreme form in crop monoculture (Gosling *et al*., 2006). Thus, agricultural use of soil may be an important factor affecting mycorhizal fungi diversity. A significant interaction between the type of plant and soil inoculation was found for the mycorrhization index (Table 1). The lowest Mycorrhization Index (MI, 4.9%) was observed in the roots of uninoculated ungrafted watermelon plants. The roots of the rootstock showed to better associate with AMF naturally occurring in our experimental field as shown by the increase in mycorrhization index (MI, 20.3%) of the uninoculated grafted plants. The introduction of AMF by inoculating the commercial suspension caused a significant increase in root colonization both for grafted

Table 1. Main effects of year, grafting, and mycorrhization on growth and yield of mini-watermelon plants.[a]

Treatments	MI (%)	Main shoot lenght (cm)			Plant mortality (%)	Yield		Fruit plant^{-1} (n)
		10 dat	20 dat	30 dat		(t ha $^{-1}$)	(kg plant^{-1})	
Year								
1	21.2	40.6	107.7	183.4	6.3	61.9	16.3	5.5
2	21.8	39.2	106.5	181.8	6.9	58.7	15.8	5.2
Type of plant								
Grafted	30.2	48.3	123.2	198.8	3.1	71.9	18.5	5.7
Ungrafted	12.8	31.5	91.0	166.3	10.0	48.7	13.5	5.0
Soil Inoculation								
mycorrhized	30.4	42.0	109.7	185.8	3.4	66.6	17.1	5.7
non mycorrhized	12.6	37.8	104.5	179.3	9.8	54.0	14.9	5.1
Significance								
Year (Y)	ns	ns	ns	ns	ns	ns	ns	ns
Type of plant (P)	**	***	***	***	*	***	***	*
Soil Inoculation (M)	**	***	***	***	*	*	***	*
Y×P	ns	ns	ns	ns	ns	ns	ns	ns
Y×M	ns	ns	ns	ns	ns	ns	ns	ns
P×M	**	ns	ns	ns	ns	*	*	ns
Y×P×M	ns	ns	ns	ns	ns	ns	ns	ns

[a] ns: Not significant; * Significant at $P< 0.05$; ** Significant at $P< 0.01$, *** Significant at $P< 0.001$. MI= Mycorrhization Index, dat: Days after transplanting.

Table 2. Main effects of year, grafting, and mycorrhization on quality characteristics of mini-watermelon fruits.[a]

Treatments	Fruit weight (g)	Fruit volume (ml)	Bulk density	Rind thickness (mm)	Edible part (%)	Pulp firmness (N)	TSS (°Brix)	TA (%)	Ascorbic acid (mg kg^{-1} fw)	N-NO_3^- (mg kg^{-1} fw)
Year										
1	2924.6	3027.2	0.96	6.7	52.1	16.2	10.5	0.78	77.5	231.7
2	3005.7	3125.6	0.97	7.1	51.6	16.8	10.2	0.75	75.3	221.6
Type of plant										
Grafted	3217.0	3348.2	0.96	8.9	50.1	19.8	11.2	0.72	79.9	237.5
Ungrafted	2713.3	2804.7	0.97	4.9	53.6	13.3	9.5	0.82	72.9	215.8
Soil Inoculation										
Mycorrhized	3002.2	3156.7	0.96	7.0	52.4	17.3	10.5	0.69	80.8	215.8
Non mycorrhized	2928.2	2996.1	0.97	6.8	51.2	15.7	10.3	0.85	72.0	237.5
Significance										
Year (Y)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Type of plant (P)	**	**	ns	***	ns	***	***	ns	*	ns
Soil Inoculation (M)	ns	ns	ns	ns	ns	ns	ns	*	*	ns
Y×P	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Y×M	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
P×M	ns	ns	ns	ns	ns	ns	ns	ns	*	ns
Y×P×M	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[a] ns: Not significant; * Significant at $P< 0.05$; ** Significant at $P< 0.01$, *** Significant at $P< 0.001$.

Table 3. Main effects of year, grafting, and mycorrhization on pulp color characteristics of mini-watermelon fruits. [a]

Treatments	*L**	*a**	*b**	Chroma	Hue°
Year					
1	39.3	25.9	19.9	32.7	37.5
2	38.4	26.9	20.3	33.8	37.0
Type of plant					
Grafted	38.7	27.9	21.5	35.3	37.6
Ungrafted	39.0	24.9	18.7	31.2	36.9
Soil Inoculation					
Mycorrhized	39.2	27.1	21.3	34.4	38.1
Non mycorrhized	38.5	25.8	19.0	32.1	36.3
Significance					
Year (Y)	ns	ns	ns	ns	ns
Type of plant (P)	ns	**	**	**	ns
Soil Inoculation (M)	ns	ns	**	*	*
Y×P	ns	ns	ns	ns	ns
Y×M	ns	ns	ns	ns	ns
P×M	ns	*	*	**	ns
Y×P×M	ns	ns	ns	ns	ns

[a] ns: Not significant; * Significant at $P< 0.05$, ** Significant at $P< 0.01$.

and ungrafted plants: watermelon roots recorded a colonization of 20.7%, similar to those recorded by Westphal *et al*. (2008) in watermelon seedlings inoculated with mycorrhizae from commercial formulations. The highest *MI* (40.0%) was observed in the roots of inoculated grafted plants. These differences may be due to the level of 'susceptibility' to indigenous and/or introduced AMF that vary greatly for different plant species, and even for cultivars within the same species (Azcón-Aguilar and Barea, 1997). Watermelon plant growth was influenced by grafting and by mycorrhizal inoculation. During 30 days after transplant (dat) (Table 1), grafted plants were always significantly bigger than ungrafted plants. When averaged over year and inoculation treatment, the length of the main shoot of the grafted plants (198.8 cm) 30 days after transplanting was, on average, 32.5 cm longer than the ungrafted plants. Similar results were found by other authors, even though watermelon growth performance may vary depending on the rootstock used (Alan *et al*., 2007; Bekhradi *et al*., 2011; Petropoulos *et al*., 2014). Mycorrhizal inoculation resulted in an increase in main stem length both for grafted and ungrafted plants. This increase ranged from about 10% after 10 dat to about 3.5% after 30 dat. Our field trial confirmed the plant growth enhancing effect resulting from inoculation with mycorrhizal fungi (Ban *et al*., 2007; Westphal *et al*., 2008; Abdel Latef, 2013). During crop growth and production, some plants showed symptoms of infestation by *Fusarium oxysporum*. At the end of crop cycle, plant mortality was reduced by grafting and soil inoculation. Ungrafted plants had the highest mortality (10.0%), whereas grafted plants were more vigorous and tolerant to soil-borne pathogen and showed a survival rate of 100% when the soil was inoculated with AMF. Grafting is generally used to control soil-borne disease

(Yetisir *et al*., 2003) and the rootstock RS 841 confirmed to increase plant survival (Crinò *et al*., 2007). Plant mortality decreased as root colonization increased, thus, indicating a correlation between mycorrhizae and plant tolerance to soil-borne disease. AMF can reduce or even suppress damage caused by soil-borne plant pathogens (Hooker *et al*., 1994) and this can explicate the increased plant survival when the roots of the rootstock had a higher *MI*.

Yield characteristics of mini watermelon plants were significantly affected by grafting and mycorrhizal inoculation and a significant interaction between the type of plant and soil inoculation was found (Table 1). The lowest yield per plant was recorded in ungrafted plant, whether inoculated or not (13.5 kg plant^{-1}, on average). Uninoculated grafted plants yielded more (16.9 kg plant^{-1}) than ungrafted plants, and were positively influenced by mycorrhization that subsequently increased yield by about 19%. This effect was amplified as considering yield per hectare as plant mortality increased in both ungrafted and non-mycorrhized plants. Even this parameter showed a significant interaction between the type of plant and soil inoculation: uninoculated ungrafted plants yielded 44.7 t ha^{-1}, while uninoculated grafted plants yielded 18.7 t ha^{-1} more. Mycorrhization increased the yield of watermelon, but its effect was greater and significant on inoculated grafted plants (+27.0%) than on inoculated ungrafted plants (+17.8%). The number of fruits harvested per plant significantly increased by grafting or by mycorrhization (Table 1). Yield variation was also due to the average fruit weight modification determined mainly by grafting (Table 2). Ungrafted plants produced the smallest fruits (2,713.3 g on average), while grafted plants yielded fruits 18.6% heavier. These results agree with those of Petropoulos *et al*. (2012) and Yetisir *et al*. (2007): they reported that watermelon grafted on interspecific hybrid of *C. maxima*×*C. moschata* had increased fruit size. Kaya *et al*. (2003) found that mycorrhizal colonization increased marketable yield in watermelon plants. In our research, the increase of yield was mainly due to increased fruit number produced per plant as the fruit weight was not significantly influenced by mycorrhization, and this could be explained with the lower colonization recorded in mini-watermelon plants. Thus, the affinity between watermelon variety and mycorrhizal inoculum should be better investigated. On the contrary, the rootstock showed a greater affinity with mycorrhizal inoculum and the joint effect of AMF and rootstock was more pronounced on fruit yield compared to the use of the sole grafting, as also found by Oztekin *et al*. (2013) in tomato. Fruit size was strictly related with fruit weight as confirmed by the small variation of fruit density (Table 2). The fruits of grafted plants had a significantly thicker rind than those of ungrafted plants and this characteristic caused no significant changes in the percentage of edible part (Table 2). Thus, increased rind thickness results in relatively higher wastage at the time of consumption but may be favourable during handling and post-harvest storage (Rouphael *et al*., 2010). Our results agree with those of other authors that recorded significantly higher values of rind thickness in grafted plants (Yetisir *et al*., 2003; Proietti *et al*., 2008; Turhan *et al*., 2012). Pulp firmness and total soluble solids are some of the major characteristics used for assessing watermelon quality (Table 2). These characteristics were enhanced mainly by grafting; fruits obtained from grafted plants were firmer (19.8 N) than the fruits from the ungrafted plants (13.3 N), independent of soil inoculation. Other studies also report a substantial increase in watermelon firmness from grafted plants (Yetisir *et al*., 2003; Davis and Perkins-Veazie, 2005; Huitròn-Ramìrez *et al*., 2009). Even total soluble solids (TSS) was not affected by mycorrhizal inoculation, as also found by Kaya *et al*. (2003), but only by grafting: the fruit produced in the grafted plants had a significantly higher soluble solid content (11.2 °Brix on average) than

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that of ungrafted plants (9.5 °Brix on average), as also found by Petropoulos *et al*. (2012). The influence of grafting on the total soluble solids of watermelon may vary greatly as function of scions and rootstocks (Yetisir *et al*., 2003; Turhan *et al.,* 2012; Petropoulos *et al*., 2012). Grafting watermelon onto some *Cucurbita* spp. rootstocks resulted in decreased soluble solids content of fruits, whereas no significant difference with the control fruits was found in fruits from the scions grafted onto bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) (Liu *et al*., 2006) or onto a squash interspecific hybrid (Colla *et al*., 2006; Huitrón-Ramírez *et al*., 2009). The Titratable Acidity (TA) of mini-watermelons was not influenced by grafting (Table 2), but was reduced in the plants inoculated with AMF. Similar results were found by Subramanian *et al*. (2006) on tomato fruits. A great amount (about 65%) of P (Phosphorus) absorbed by mature plants is transferred to the fruits that are often a major sink for P (Chattopadhyay and Chakrabarty, 1990). Therefore, inoculated watermelon may have translocated considerable amounts of phosphates to the fruits, which in turn neutralize their acidity (Subramanian *et al*., 2006). Grafting and mycorrhization affected significantly the *TSS/TA* ratio. The highest ratio was calculated in the fruits of grafted plants grown in inoculated soil. This parameter is an important index of the flavour of the fruit, as a higher value of *TSS/TA* ratio describes a good balance between sweetness and acidity in fruits (Rouphael *et al*., 2010). Vitamin C is an important component of nutritional value of vegetables and has many biological activities in the human body related to maintenance of human health. Ascorbic acid content was increased by grafting mini-watermelon and by mycorrhizal inoculation. On average, ascorbic acid in grafted plants was significantly higher than ungrafted plants by 9.6%. Similar increase of vitamin C was found in grafted plant of mini-watermelon (Proietti *et al*., 2008). Soil inoculation with AMF had a significant effect on ascorbic acid content only in ungrafted plants (Table 2). The control plants (ungrafted uninoculated) produced fruits with 64.8 mg ascorbic acid kg^{-1} f.w., while this compound was about 25% higher in the fruits of ungrafted inoculated plants (81.0 mg kg^{-1} fw). These fruits had similar ascorbic acid content than those from grafted plants. Therefore, the increase in vitamin C content may be due to increased nutrient uptake, enhanced root system efficiency, enhanced production of endogenous hormones or enhancement of watermelon vigour that can be related independently both to rootstock and mycorrhization. No further increase was recorded with the joint use of grafting and inoculation, probably because the sole rootstock determined the maximum increase in vitamin C production. Mycorrhizal association was effective in improving fruit quality also in tomato by enhancing ascorbic acid content and reducing the acidity (Subramanian *et al*., 2006). The nitrate concentration in the watermelon pulp was low (226.6 mg kg^{-1} fw on average) and was not influenced by the treatments (Table 2).

The color of watermelon pulp is an important quality characteristic that highly influences the quality perceived by consumer. The color values measured in our study were similar to those recorded by other authors (Perkins-Veazie and Collins, 2004; Davis and Perkins-Veazie, 2005). Grafting and mycorrhizal inoculation determined some modification of the chromatic component of pulp colour, while lightness was not significantly affected (Table 3). Grafting increased significantly redness (a*), yellowness (b*) and colour saturation (chroma), while soil inoculation led to an increase in these parameters only in ungrafted plants. The hue angle did not vary among the fruits of grafted or ungrafted plants, but was significantly higher in both types of plant when cultivated in inoculated soil, indicating that the color of mycorrhized fruit was slightly more orange red. This may be an indication of increased ß-carotene as also found by Davis and Perkins-Veazie (2005).

CONCLUSIONS

Our research confirmed the positive effect of grafting on mini-watermelon plants grafted onto the hybrid RS841 (*Cucurbita moschata* Duchesne×*Cucurbita maxima* Duchesne). Substantial root colonization by AMF of *Glomus* spp. of mini-watermelon and rootstock plant resulted after inoculation of the soil in the root zone at transplanting and during plant growth. Mycorrhization promoted the growth of grafted and ungrafted watermelon plants. It also had a positive joint effect with grafting on mycorrhization index and yield. Quality traits were mainly affected by grafting, while soil inoculation was effective in increasing ascorbic acid content and some color component of the fruits of ungrafted plants only. Thus, the combined use of grafting with mycorrhizal inoculation may increase the yield of mini-watermelon fruit, maintaining good quality characteristics.

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اثر پیوند زنی و تلقیح میکوریز برعملکرد و کیفیت هندوانه کوچک (مینی)

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چکیده

اخیرا، پیوند زدن و تلقیح با قارچ های میکوریز به لحاظ تاثیر مثبتی که روی سبزیجات دارند جلب توجه کرده اند. هدف این پژوهش بررسی تاثیر توام پیوند زدن و تلقیح با قارچ های وسیکولار-آرباسکولار(AMF) روی عملکرد و کیفیت هندوانه های کوچک [*Citrullus lanatus* (thumb.) Matsum و Nakai] بود. بوته های پیوند نخورده و آن هایی که روی پایه RS 841F1 ((*Cucurbita maxima* × *C. moschata*)) پیوند شده بودند در مزرعه نشاء شدند. در طی دوره

داشت، نیمی از بوته ها با مایه AMF تلقیح شدند و رشد گیاه و عملکرد و کیفیت میوه اندازه گیری شد. تلقیح با AMF منجر به افزایش معنی دار کلنی شدن ریشه در بوته های پیوند زده و پیوند نزده شد. نیز، بوته های پیوند زده و تلقیح شده شادابی و بهره وری بیشتری نسبت به بو.ته های پیوند نخورده و تلقیح نشده داشتند. بر اساس نتایج ، پیوند زدن و تلقیح با AMFباعث افزایش معنی دار عملکرد و وزن میوه ها شد. ویژگی های کیفیتی میوه های هندوانه به طور معنی داری عمدتا تحت تاثیر پیوند زدن قرار گرفتند. بر پایه این نتایج، کاربرد توام پیوند زدن و تلقیح با میکوریز می تواند ضمن حفظ ویژگی های کیفیتی میوه، عملکرد مینی هندوانه را افزایش دهد.

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