EFFECT OF OXYGEN SUPPLY ON WATER UPTAKE IN A MELON CROP UNDER SOILLESS CULTURE

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SUMMARY

*Soilless culture permits more control on fertigation parameters, especially in arid and semi arid zones with saline water irrigation. The objective of this experiment was to study the effect of potassium peroxide as an oxygen generator on water consumption, yield and quality of a melon (*Cucumis melo *L) crop. The work was carried out in a polycarbonate greenhouse in the Azapa valley, extreme north of Chile. Root oxygenation was provided by potassium peroxide. Two treatments were carried out: standard dissolution without (T0) or with (T1) oxygen supply. The latter was applied once a week, at the last irrigation of the day. Fertirrigation parameters, yield and fruit quality were measured. The results indicate that applying potassium peroxide, used as an oxygen supply, stimulates water consumption and improves significantly the water efficiency in melon in a soilless culture system irrigated with saline water.*

EFECTO DE LA APLICACIÓN DE UN OXIGENANTE SOBRE EL CONSUMO HÍDRICO EN UN CULTIVO DE MELON SIN SUELO

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RESUMEN

*El sistema de cultivo sin suelo permite un mayor control sobre los parámetros de fertirriego, especialmente en zonas áridas y semiáridas con mala calidad de agua. El objetivo de este trabajo fue evaluar la aplicación de un oxigenante en un cultivo de melón (*Cucumis melo *L) y su efecto sobre la producción y consumo hídrico en un sistema de cultivo sin suelo. Para la oxigenación de las raíces se utilizó peróxido de potasio. Se hicieron dos tratamientos. Se utilizó solución nutritiva estándar (T0) y solución nutritiva con oxigenante (T1). Se evaluaron los parámetros de fertirrigación, producción y calidad de frutos. Los resultados indican que la aplicación de peróxido de potasio utilizado como oxigenante estimula el consumo hídrico y mejora significativamente la eficiencia hídrica de un cultivo de melón en sistema de cultivo sin suelo.*

Introduction

Horticultural technology has gone through numerous changes in order to satisfy the demands of the consumers who, apart from seeking products of good quality, value more and more the production processes, especially those related to environmental care. This is of special importance in zones with poor water quality, as it permits providing the plant with the necessary nutrients for its growth and development, and at the same time maintains the salt balance in the rhizosphere with low volume leaching irrigation. Salinity affects crop growth because of disorders in the absorption or distribution of ions that are essential for the development of the plant (Sonneveld, 2004), leading to a premature aging of the plant, whose effect is observed in the diminution of productivity (Tester and Davenport, 2003; Ashraf, 2004; Yamaguchi and Blumwald, 2005). Sodium is the predominant cation in the salinity of the majority of soils in arid and semi-arid zones (Kaya *et al*., 2007). Pardossi *et al*. (2002) concluded that the salt balance in the fertigation solution avoids excessive water consumption under salinity conditions without affecting yield and quality of a melon crop. Another important factor is oxygen, as it has been shown that hypoxia has negative effects on root growth and nutrient consumption (Drew, 1983; Zeroni *et al*., 1983), with yield decrease (Cannell and Belford, 1980; Morard and Silvestre, 1996; Morard *et al*., 2000; Adams, 2002; Tesi *et al*. 2003). Urrestarazu and Mazuela (2005) indicated that the application of an oxygen supply based on potassium peroxide is effective on plants sensitive to hypoxia, such as pepper, and improves the hydric efficiency in case of melon.

In the extreme north of Chile, at the Azapa valley, vegetable production is mainly destined to supply large cities with vegetables during the winter, as in the Mediterranean region (Urrestarazu *et al*., 2008) and in areas of the USA (Korkmaz and Default, 2002). The average yield of a melon crop is 3.5kg·m^{-1}, and the product is absent from the markets in the winter months (May to October), thus presenting an attractive production alternative (Mazuela, 1999). Nevertheless, the main problem that limits horticultural production in the Azapa valley is the quantity and quality of irrigation water. Kaya *et al*. (2007) concluded that applying potassium nitrate in the fertigation had a positive effect on salt tolerance, avoiding sodium toxicity, and improved yield in melon crop. Melon is a crop moderately sensitive to salinity (Maas and Hoffman, 1977)

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EFEITO DA APLICAÇÃO DE UM OXIGENANTE SOBRE O CONSUMO HÍDRICO EM UM CULTIVO DE MELÃO SEM SOLO

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RESUMO

*O sistema de cultivo sem solo permite um maior controle sobre os parâmetros de fertirrigação, especialmente em zonas áridas e semiáridas com má qualidade de água. O objetivo deste trabalho foi avaliar a aplicação de um oxigenante em um cultivo de melão (*Cucumis melo *L) e seu efeito sobre a produção e consumo hídrico em um sistema de cultivo sem solo. Para a oxigenação das raízes se utilizou peróxido de potássio. Fizeram-se dois tratamentos. Utilizou-se solução nutritiva estándar (T0) e solução nutritiva com oxigenante (T1). Avaliaram-se os parâmetros de fertirrigação, produção e qualidade de frutos. Os resultados indicam que a aplicação de peróxido de potássio utilizado como oxigenante estimula o consumo hídrico e melhora significativamente a eficiência hídrica de um cultivo de melão em sistema de cultivo sem solo.*

which means that it supports an electric conductivity of up to $2.5 dS \cdot m^{-1}$, without affecting production. In soilless culture systems, better management of saline water is possible because of greater control at fertigation, which reduces the saline effect on the plants. (Navarro *et al*., 1999; Shannon and Grieve, 1999; Romero *et al*., 2001; Savvas *et al*., 2005; Carmassi *et al*., 2007).

The objective of this work was to study the effect of potassium peroxide as an oxygen generator and the effect on water consumption in production and fruit quality in melon (*Cucumus melo* L) crop in a soilless culture system.

Material and Methods

The work was carried out in a polycarbonate greenhouse in the Azapa valley, extreme north of Chile, using the *Galia* type melon. Plants were transplanted on 08/14/2006 into bags 1m long containing as a substrate 25 liters of diatomite (skeleton fossils with 95% silica), with three plants per bag. Harvest ended on 12/28/2006. The irrigation water contained ($mmol \cdot l^{-1}$) HCO_3^- (2.9), Cl^- (3.3), Na^+ (2.8), NO_3^- (0.1), SO_4^{2-} (2.3), Ca^{2+} (3.9), Mg^{2+} (1.9) and K^+ (0.3).

Two treatments were carried out. The control treatment (T0) only the standard nutrient solution, similar to that reported by Sonneveld and Straver (1994), was used. In the second treatment (T1), Liberoxi® ($1g \cdot l^{-1}$) was added once a week to the same nutrient solution. Liberoxy® contains ~7% potassium peroxide. A dose of $1g \cdot l^{-1}$ was used according to the recommendations of Urrestarazu and Mazuela (2005). Fertigation was supplied with a localised irrigation system. Every week, for each treatment, drained water and drippings were sampled and determinations were made of the volume, of the pH with a mod. 2000 pH meter (Crison, Barcelona, Spain), and of the electrical conductivity (EC) mod. 525 conductivity meter (Crison, Barcelona, Spain). Chemical analyses of drippers and drainage were also performed weekly according to Gil de Carrasco et al. (1994), using a model 2000i/SP liquid chromatograph (Dionex, Sunnyvale, CA, USA) equipped with AS4A anionic and CS12 cationic columns (data not shown). Water consumption was calculated as the difference in the percentage of water drained in the two treatments. The water efficiency was calculated as the volume of water consumed per kg of fruit produced.

TABLE I
FERTIGATION PARAMETERS, TOTAL WATER UPTAKE AND WATER EFFICIENCY IN MELON CROP WITHOUT (T0) AND WITH (T1) OXYGEN SUPPLY

	Drainage			Water uptake ($l \cdot m^{-2}$)	Water efficiency ($l \cdot kg^{-1}$)
Treatment	EC ($dS\ m^{-1}$)	pH	% drainage		
T0	2.64	7.82	18.20	170.39	63.57
T1	3.07	7.79	14.97	176.80	53.25
P	**	ns	*	*	**

*, **, and ns: P≤0.05, P≤0.01, P≤0.001. and not significant, respectively.

Two different groups of fruits, marketable and non-marketable, were established using EU regulation L 100/11 as standard (OJUE, 2001). For fruit quality, firmness (FF) was measured on three melon fruits per replication and treatment using a pressuretester (7.9mm diameter pressure-tester needle) and expressed in terms of $kg \cdot m^2$ of crop surface. Total soluble solid (SS) contents were measured in the juice from three fruits per replication, using a refractometer, and expressed in ºBrix. Dry matter (DM) was also measured.

Each experiment was conducted using a randomized complete block design using two treatments and three replications. Each plot (experimental unit) had 12 melon plants. Single t-Student probability was used to separate the means of treatments. The experimental designs and data analysis were based on the procedure described by Little and Hills (1987) and Petersen (1994). Calculations were made with a statistical package (Stagraphics, 1999).

Results and Discussion

Table I shows fertigation parameters, water consumption and efficiency. Water uptake of T1 was significantly higher than that of the control. This result agrees with that reported in tomato (Morard *et al*., 2000) and sweet pepper (Urrestarazu and Mazuela, 2005) when plants were grown in soilless culture with oxygen supply. The values of EC, pH and the percentage of drainage are of interest, because in practice they are used by growers and technicians to control the horticultural crops in soilless culture (Urrestarazu, 2004), and thus, it is useful to know whether after treatment applications the values of these parameters are different. There were significant differences between treatments in EC, percentage of drainage and water efficiency, which was significantly different to the control and linked to a higher water uptake. A decrease in the oxygen content of the nutrient solution, together with a corresponding increase in the respiration rate at a certain time of the day (Hansen, 1977) could limit growth, at least for part of the day, unless the nutrient solution oxygen content was increased, suggesting the need to increase the oxygen content around midday.

This suggests that the supply of oxygen as potassium peroxide in the nutrient solution stimulates water consumption under high salinity conditions, as reported by Kaya *et al*. (2003, 2007). More temporarily available oxygen could be the reason for a higher water absorption, and using the oxygen depletion concept of as defined by Gilderød and Adams (1983), a higher consumption in T1 can be assumed. Sonneveld and Voogt (2001) have shown that roots are versatile enough to take up water and nutrients from the parts in better conditions, while the rest of the roots are under more limiting conditions. This does not affect production. Even though these studies have been carried out to study water and nutrients, they could be equally valid for oxygen absorption. Further research on the effect of oxygen content distribution in the root environment on certain crop parameters, as has been done for other fertigation studies are needed.

Table II shows yield and fruit quality parameters. There was no significant differences in yield and quality of melon with oxygen supply. These results agree with those reported by Bonachela *et al*. (2010) and are different from those reported by Urrestarazu and Mazuela (2005), where oxygen enrichment significantly increased the total production and number of fruits. The observed response could be attributed to the absence of an oxygen deficiency in T0, or to hypoxic periods of intensity or duration insufficient to affect productivity significantly.

Growers and technicians must consider that the depletion of the oxygen available to the roots occurs gradually under field conditions. Moreover, for high value crops, the determination of periods of increasing demand for oxygen, or knowing when hypoxic conditions may occur, is of great interest as it permits adapting crop management practices or the use of oxygen enrichment techniques (Amstrong and Drew, 2002).

TABLE II
YIELD AND QUALITY PARAMETERS IN MELON CROP WITHOUT (T0) AND WITH (T1) OXYGEN SUPPLY

	Yield		Quality		
Treatment	$kg \cdot m^2$	Nº fruits/m^{-2}	SS (ºBrix)	FF (kg)	% DM
T0	2.68	2.50	14.89	3.20	9.66
T1	3.32	3.75	14.56	3.13	9.68
P	ns	ns	ns	ns	ns

ns: not significant.
SS: soluble solids, FF: fruit firmness, DM: dry matter.

Conclusion

Oxygen supply has an effect on water uptake and improves water efficiency in terms of kg produced per liter of water consumed. There were no differences in yield and fruit quality, which could be attributed to the absence of an oxygen deficiency in the control treatment, or to hypoxic periods of insufficient intensity or duration to significantly affect productivity.

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