Sustentable Use of the Wetting Agents in Protected Horticulture

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1. Introduction

The wetting agents in agriculture are materials that are classified within a larger group identified as adjunvants (Cahn and Lynn, 2000; Hazen, 2000; Kosswig, 2000; Thacker, 2003; Young, 2003; Lynn y Bory, 2005). According to their chemical nature, adjuvants are grouped into four families: surfactants, oils, inorganic salts and non-traditional adjuvants (figure 1). Nowdays some of the wetting agentes can be considered inside of called Green Chemistry (Carrasco and Urrestarazu, 2010).

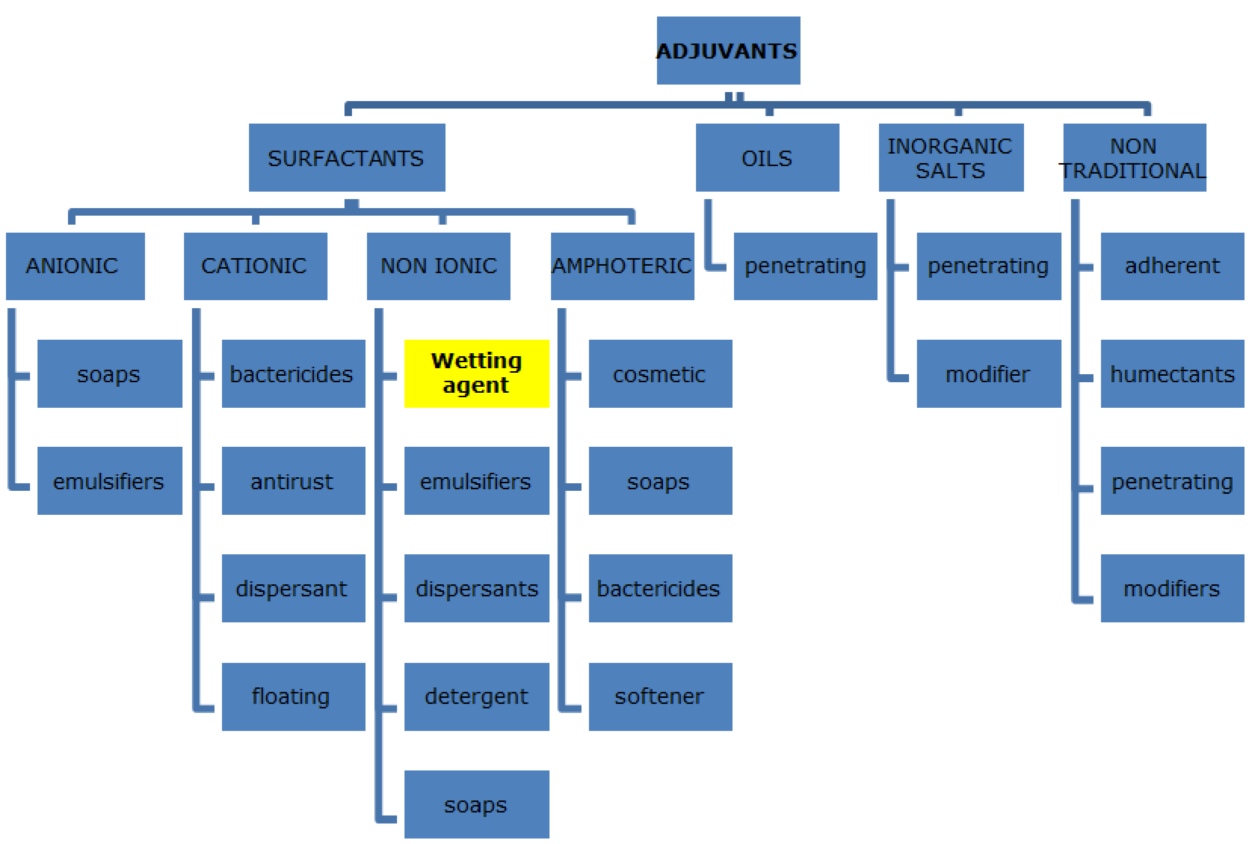


Fig. 1. Classification of adjunvants according to their chemical nature and function

1.1 Surfactant

A common mistake is the use of adjuvantand surfactant terms inter changeably, which arises from the same discrepancy between producers(Young, 2003). The tru this that surfactantisa chemical family of adjuvants that improve emulsion, dispersion, foam, wet or other properties of a fluid to alter the characteristics of surface or interface and surface tension (Hazen, 2000, Thacker, 2003; Young, 2003). The termsurfactantis derived from the contraction of three words Surface Active Agents (Thacker, 2003; Rosen, 2004, RAE, 2001).

Global consumption of surfactants in agriculture is 250 thousand tons per year, 180 thousand of which are incorporated in the formulation of fitosanitariosy 70 000 tonnes are used as tank mix adjuvants (Thacker, 2003). Besides agriculture surfactants are used in various products such as motor oils for cars, pharmaceuticals, in detergents, in materials used in oil exploration and floating agents in mining, in recent decades has extended its application to electronic printing, magnetic recording, biotechnology and viral research (Rosen, 2004).

Surfactant are molecules of low to middle rate molecular weight, it is amphipathic nature, it is containing a hydrophobic or lipophilic part (carbon chain) and a hydrophilic or lipophobic (Malmnsten, 2002, Rosen, 2004; Tadros, 2005).

The hydrophobic groups are alkyl and alkylaryl groups mostly hydrocarbon, hydrophilic groups can be ionic or nonionic (Kosswig, 2000). According to this type ionic surfactants may be anionic, cationic, amphoteric and nonionic surfactants (Figure 2). In an anionic surfactant hydrophilic segment of the molecule forms an anion when dissolved in water. The opposite occurs in the cationic surfactant in which the active portion of the molecule in the hydrophilic segment is only a cation when dissolved in water. An amphoteric surfactant is capable of forming anions in aqueous solution depending on pH or cations. The nonionic surfactant is a surface active agent without ionic polar group is not ionized in aqueous solution (American Society for Testing and Materials E 1519, 1999, Cahn and Lynn, 2000; Kosswig, 2000; Malmnsten, 2002; Rosen, 2004, Young, 2003, Lynn and Bory, 2005).

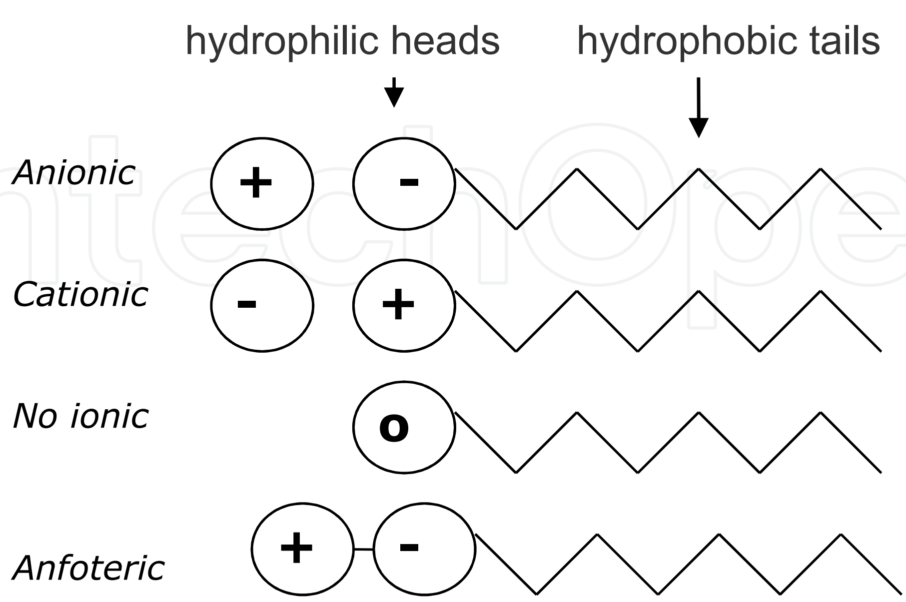


Fig. 2. Diagram of a humectant molecules

Reference	Physicalproperties of substrate				Growth and yield	Uptake of nutrients	Phytotoxicity
	Wettability	AV	WHC	EAW			
Sheldrakeand Matkin (1971)							according surf.
Airhart*et al.* (1980)			increase				according dose
Wilson (1985)		increase					
Powell (1986)	increase	increase					according dose
Milks*et al.* (1989)		increase	decrease				
Bhat*et al.* (1990)					better post-harvest	increase Ca^{2+}	
Bhat*et al.*(1992)							according plant
Handreck (1992)			increase				according dose
Handreckand Black (1994)			increase				
Elliot (1992)	increase		non effect				
Blodgett*et al.* (1993)	increase		non effect	increase			
Cid *et al.* (1993)					increase		
Blodgett*et al.* (1995)							accordingplant
Riviere*et al.* (1996)	increase		increase	increase			
Michel *et a*l. (1997)	increase						
ReinikainenandHerranen (1997)	increase	increase					
Bilderbackand Lorscheider (1997)		decrease	increase		increase		
Cid *et al.* (1998)			increase		increase	increase Ca^{2+}	
Guillen and Urrestarazu (2006)					increase	increase	
Urrestarazu et al. (2008)	increase		increase	increase			according dose

AV: air volume, WHC: water holding capacity, EAW: easily available water

Table 1. Summary of research on the effect of application of wetting agent in ornamental and horticultural cultures on substrate

The nonionic surfactants are chemically less active, but also less phytotoxic (Powell, 1986; Bures, 1997; Reinikainen and Herranen, 1997;) and less irritating than anionic and cationic (Malmnsten, 2002). They can with stand hard water and soluble in water and organic solvents, but can be sensitive to high temperatures (Rosen, 2004). Besides its critical concentration of micelle formation is twice lower than the anionic surfactants (Tadros, 2005). These nonionic surfactants are excellent wetting at very low concentrations (Thacker, 2003). They are the most dominant adjuvants of surfactants commercially available for the application of herbicides, they are less toxic to mammals (Young, 2003).

1.2 Wetting agent

Wetting agent is a substance used to reduce surface tension (Figure 3) and lead to better contact of a solution or suspension with a surface (WSSA Herbicide Handbook, 1994). Generally wetting agentis a surfactant, whose effectiveness is measured by the increase of spread of a liquid on a surface or the contact angle of liquid with the surface (Shurtleff and Averre, 1998).

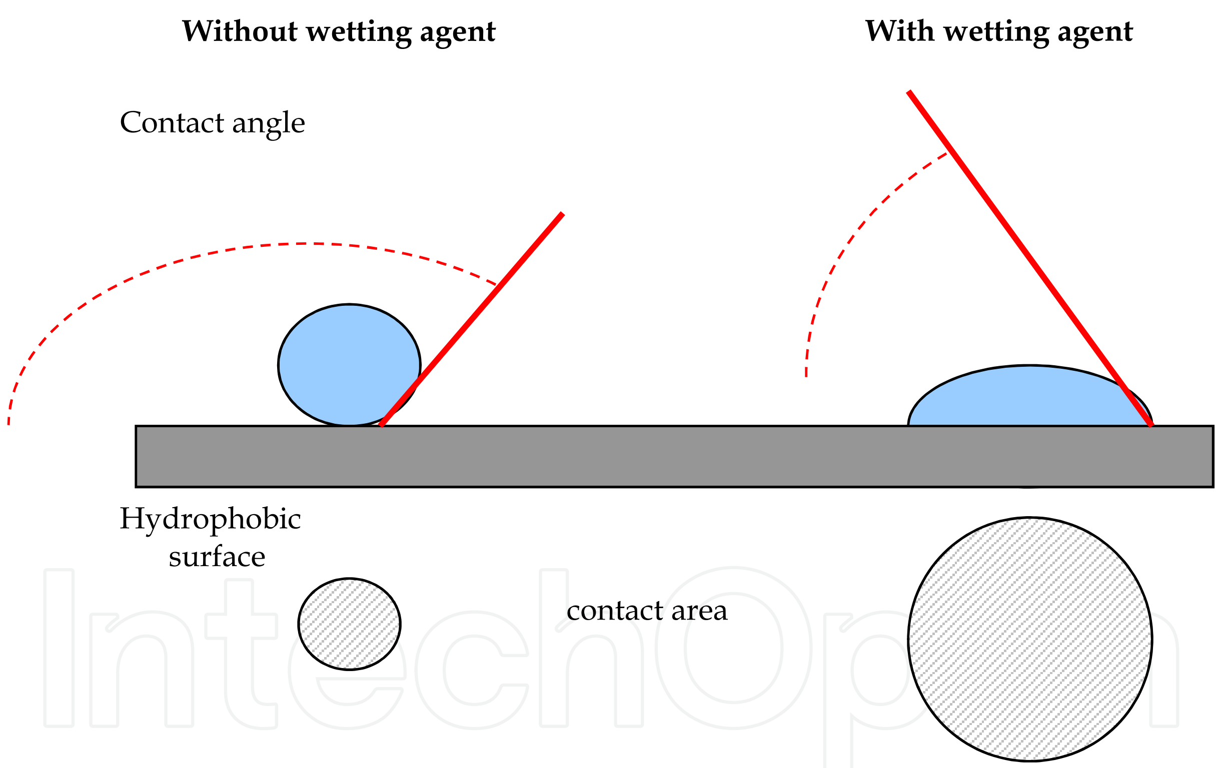


Fig. 3. Contact angle and contact area for a drop water with and without a wetting agent on a hydrophobic surface

The wetting agents have been successfully used to improve the uniformity of wetting, improve relationships air: water of organic substrates and to improve nutrient availability to plants, without altering the physical characteristics of the substrate (Powell, 1986; Baht et al., 1992, Cid et al., 1992, Blodgett et al., 1993).

Crabtree and Gilkes (1999) indicate that the wetting agent also apply water repellent soils and have several benefits for the soil-plant system because it improves the soil wet releases the fertilizer applied in the soil solution increases the mineralization of organic matter, wet consistency, improves water infiltration, reduces the flooded surface, reduces evaporation and increases the efficiency of water use in farming.

In trade, de Linan (2006), we found in the group of adjuvants to 30 products, among which are 17 active substances to wetting (Table 2).

Material		Coadjuvant kind
1	Alkyl ethoxylated fatty amines 73.5% w/v. SL	Surfactant nonionic
2	Alkyl ethoxylated fatty amine / propoxylated 48.7% w/v. SL	Surfactant nonionic
3	Alquil aminas grasas etoxiladas/propoxiladas 92% p/v. EC	Surfactant nonionic
4	Alquilpoliglicol 20% w/v. EC	Nonionic adjuvant
5	Alquilpoliglicol 44% + 1.5% sodium dioctyl w/v. SL	Surfactant nonionic
6	Sodium Alquiletersulfato 29% w/v. SL	Surfactant nonionic
7	Ethylene Alquilfenilhidroxipolioxi + 10.1% synthetic latex 45.45% w/v. EC	Surfactant nonionic
8	Montan wax 20% w/v. EW	Adherent-adjuvant and non-ionic wetting
9	ammonium dodecylbenzenesulfonate 20% w/v. SL	Adjuvant anionic wetting power
10	Ammonium dodecylbenzenesulfonate 20% w/v. EC	Adjuvant anionic wetting power
11	Sodium dodecylbenzenesulfonate 5% + nonilfeniloxietilenatosulfonado 2% w/v. SL	With wetting power
12	Methyl oleate / methyl palmitate 34.5% w/v. EC	It reduces the surface tension
13	Surfactant nonionic 20% p/v. SL	Surfactant nonionic
14	EterNonilfenolpolietilenglicolr 20% p/v. SL	Surfactant nonionic
15	Eter Nonilfenolpolietilenglicol 30% + inorganic acid 30% w/v. SL	With wetting power
16	Copper phthalate, are grouped a series of copper salts of fatty acids a dozen	With wetting power
17	Copper phthalate 66.5% w/v. EC	Adjuvant anionic wetting power

Source: De Liñán (2006)
EC: Emulsifiable concentrate, EW: Emulsion oil-water; SL: soluble concentrate, p/v: weight/volume

Table 2. Wetting adjuvant for agricultural use in Spain

2. Application of wetting agent in crop production

2.1 Assessment of toxicity

It is important before using a new wetting agent, evaluate their toxicity to plants (Handreck and Black, 1994). The bioassays used to assess the phytotoxicity of substrates (Zucconi et al., 1981, Ortega et al., 1996) were used to evaluate the toxicity of some products used in soilless culture (Urrestarazu and Mazuela, 2005). Urrestarazu et al. (2006) reported an adequate concentration of a surfactant with bioassays of tomato and cress.

2.2 Improving substrates

2.2.1 Wettability and water holding of growing media

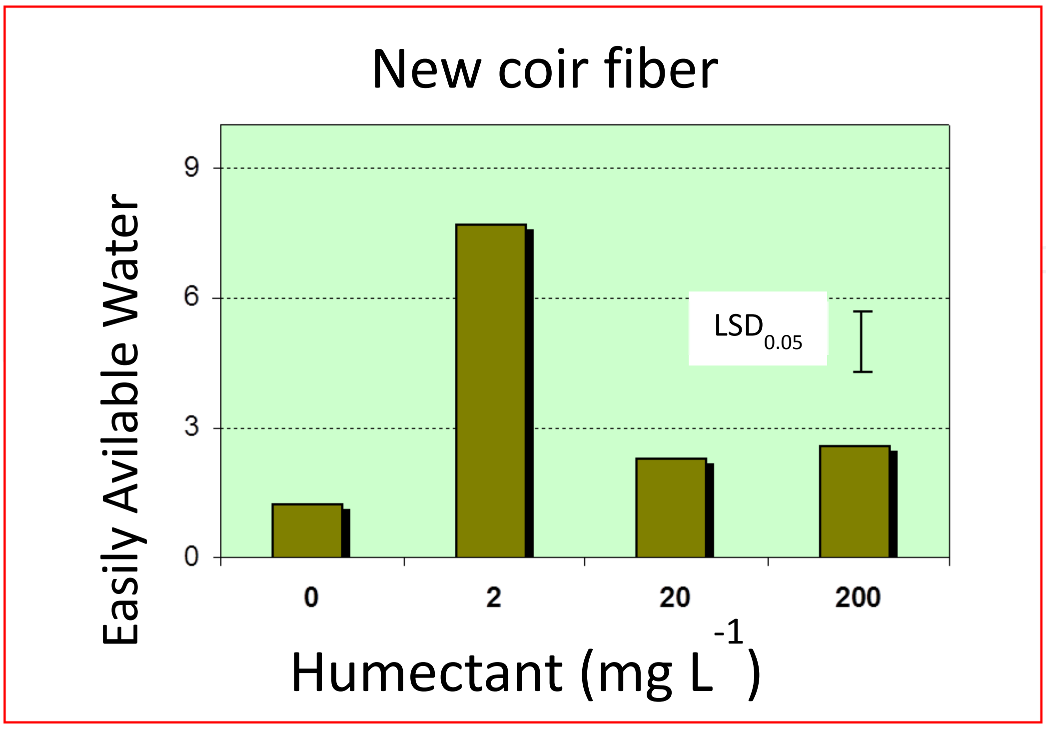
The wettability of growing media (figure 4) is an important characteristic that could be limiting due to alternations of humectation and desiccation or drying accidental events that could modify considerably and reversibly or not the properties of the substrate during growing crops (Da Silva et al., 1993; Otten et al., 1999, Chambers and Urrestarazu, 2004, Lemaire et al., 2005).

Reduction of wettability contributes to vertical flow and goes against horizontal flow and water retention in growing media (Handreck and Black, 1994; Beeson and Haydu, 1995; Dekker and Ritsema, 1994, 1996 and 2000; Salas and Urrestarazu, 2004; Dekker et al., 2005).

Greater water retention capacity at low matrix potential is very important for optimal plant growth (Plaut et al., 1973, Plaut and Zieslin, 1974, Feigin et al., 1988; Raviv et al., 2002, Sahin et al., 2002, Chambers and Urrea, 2004). There have been several experiments to correlate the growth of plants with water retention and air capacity of the substrates and these has been found that the plant qrowth is highly correlated with water retention and low air capacity is associated with a low crop growth (Allaire et al., 1996). These problems of hydrophobia and low holding water in substrates can be overcome by application of wetting agent.

Fig. 4. Water repellency of dry organic substates

It has been shown that surfactants facilitate the movement of water into and through the substrate, control the infiltration of water distribution and drainage, because it affects reserves of moisture, nutrient availability and aeration, with an optimal concentration of these surfactants improve rewetting potential of substrates and reduce root stress related problems, allowing greater control of plant growth (Powell, 1986, Bhat et al., 1990).



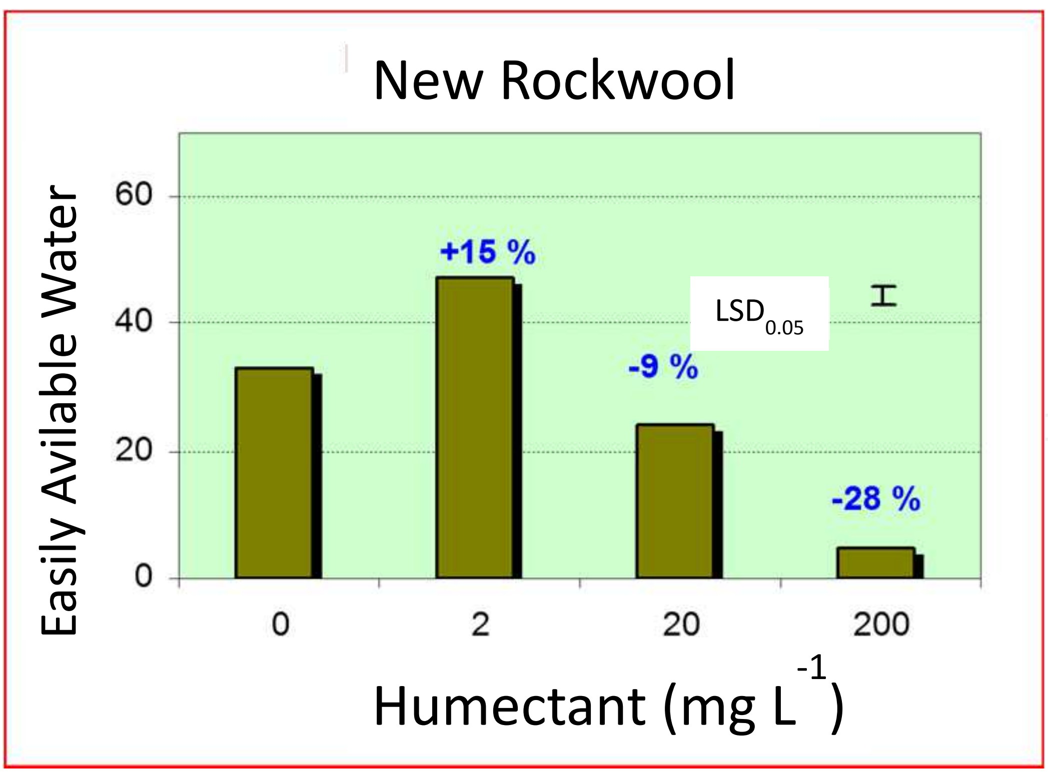


Fig. 5. The square of Humectant delete de red line behind, this must be like de red line as below

2.2.2 Improving physical properties of substrates

There is a considerable amount of articles about application of surfactants in ornamental and horticultural crops on different substrates. Table1 shows some research on application of wetting agent on crop son substrate. Surfactants applied to organic growing media such as peat and pine fiber can improve absorption of water (wettability) of substrate (Handreck, 1992, Elliot, 1992; Blodgett et al., 1993, Riviere et al., 1996; Michelet al., 1997; Reinikainen and Herranen, 1997), also can increase air capacity, raising the drain (Wilson, 1985; Powell, 1986; Milksetal, 1989; Reinikainen and Herranen, 1997) or can improve the water holding capacity (Airhart et al., 1980; Handreck, 1992; Handreck and Black,1994, Elliot, 1992; Bilderback and Lorscheider, 1997, Cid et al., 1998), increasing the water held inmicropores. May also increase the water content readily available, without increasing the capacity of container (Blodgett et al., 1993) or increase the total available water content with increased water holding capacity (Riviere et al., 1996.). Urrestarazu et al (2008) reported that the effect of wetting agent added through fertigation is directly dependant on the substrate type evaluated and it can reduce the available water and increase the easily avilable water and total water holding capacity.

2.3 Increasing efficiency in ornamentals

Also can improve growth and production of ornamental species if applied at rates not phytotoxic (Bhat et al., 1990, Cid et al., 1993; Bilderback and Lorscheider, 1997, Cid et al., 1998), even allow to increase the availability and absorption of nutrients, especially calcium absorption (Bath et al., 1990, Cid et al., 1998). And apparently the application in fertigation could be the best method of application, less phytotoxic than when initially mixed with the substrate (Bhat et al., 1990).

2.4 Increasing efficiency in vegetables

In application by fertigation, the surfactant increased nutrients uptake, especially potassium ($P = 0.08$), nitrate ($P = 0.15$) and phosphate ($P = 0.25$), in melon crop on coir waste. Also it was observed a decrease in the percentage of drainage and reducing the emission of nitrates, phosphates, potassium and calcium ($P \leq 0.2$) in melon crop, showing its usefulness in lower environmental pollution (Guillen and Urrestarazu, 2006).

This observed in coir mojantesmejoran shows that the properties of the substrate water quality by reducing the hydrophobic effect acquired especially for use. But we have discussed in the previous section that this property is related to the concentration of mojanteque used, hence the application by fertigation should be adjusted to find the desired effect. In short, the goal is to improve efficiency, since the increased incorporation counterpart brings in reducing polluting emissions.

In tomato trial, the first year was observed higher yield in crop on reused coir waste and greater efficiency in water use ($P < 0.10$), proving useful for improving the use of water when a wetting agent is applied by fertigation. Also was observed a greater efficiency in the second year in reused coir waste ($P = 0.07$) and reused rockwool ($P = 0.03$) (Guillen and Urrestarazu, 2006).

It is inferred that the wetting by fertigation is a useful tool to adjust the water relations of sutratos used, which is reflected in higher production volume of water consumed.

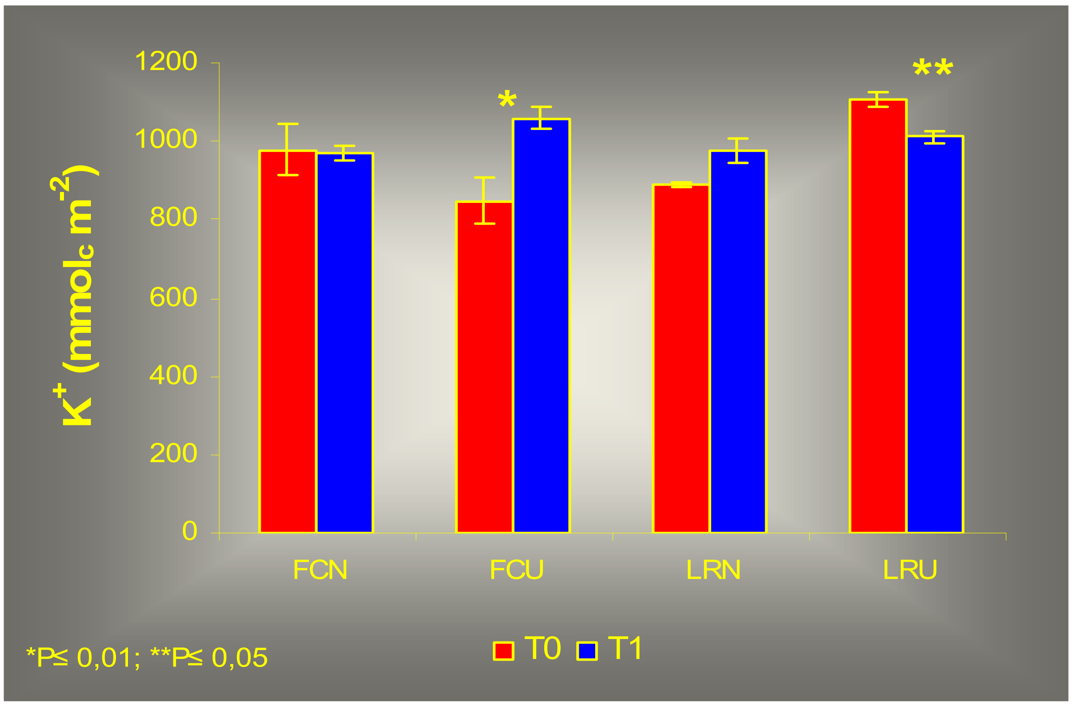


Fig. 6. Significant increases in the incorporation of potassium in melon cultivation of coconut fiber used. T0 = Control, T1 with humectant. FCN: New coir fiber, FCU: Used fiber coir. LRN: New rockwool, FRU: Used rockwool.

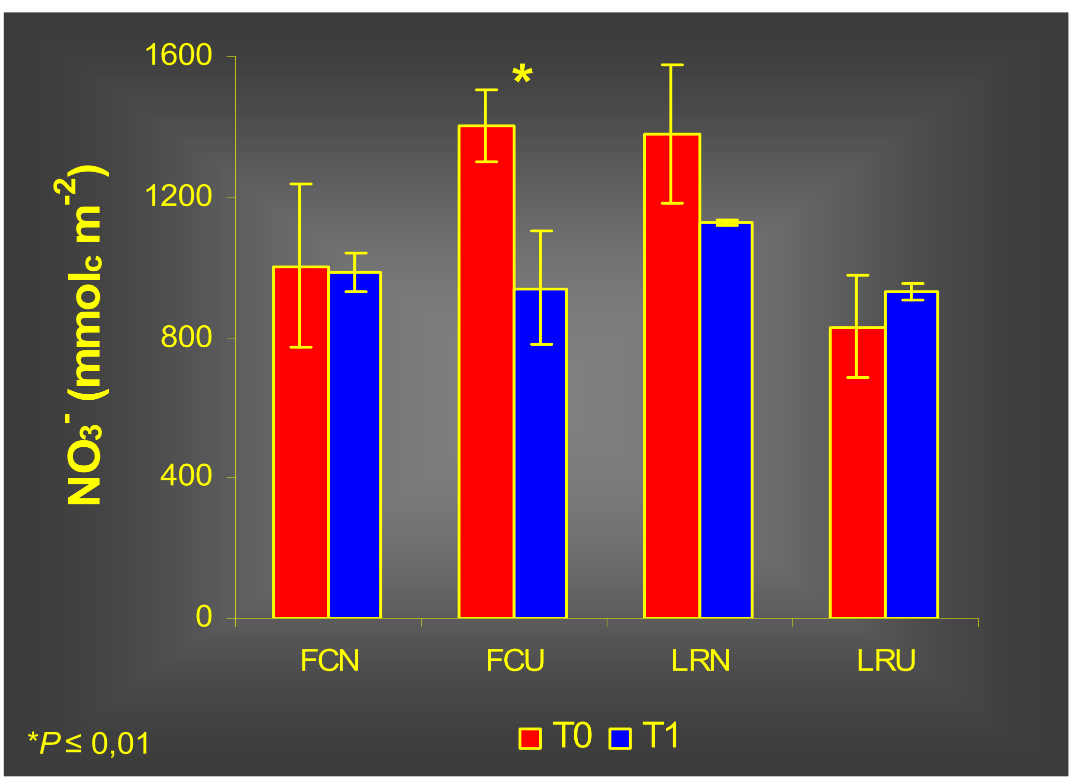
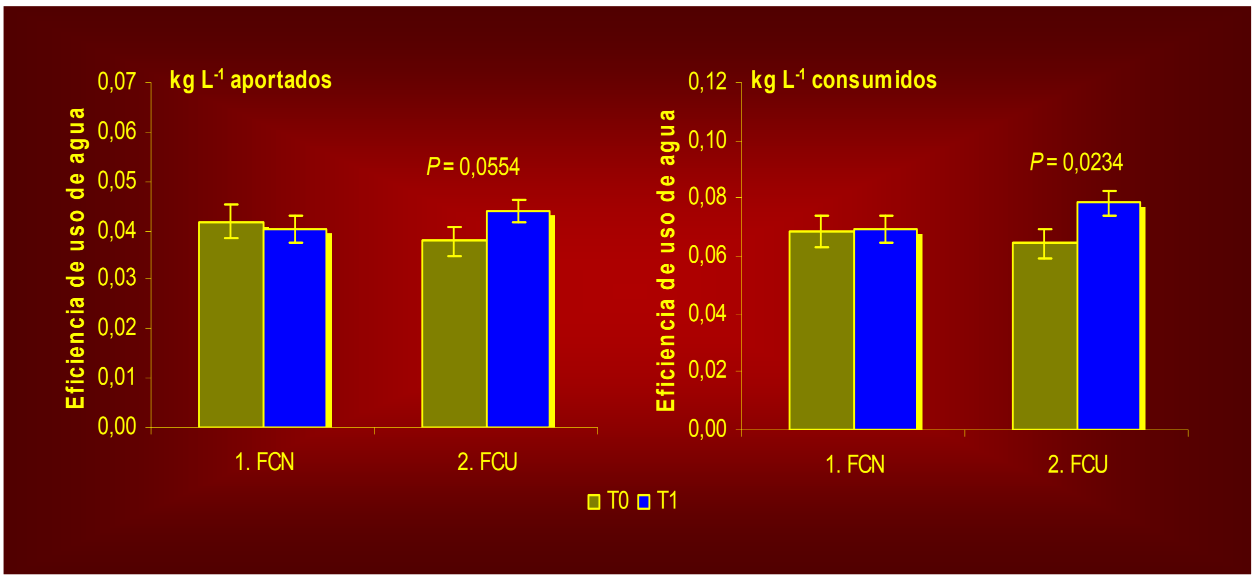


Fig. 7. Significant reduction in the emission of nutrients in a melon crop in reused coco fiber as a result of a wetting agent applied in fertigation. T0 = Control, T1 with humectant. FCN: New coir fiber, FCU: Used fiber coir. LRN: New rockwool, FRU: Used rockwool.



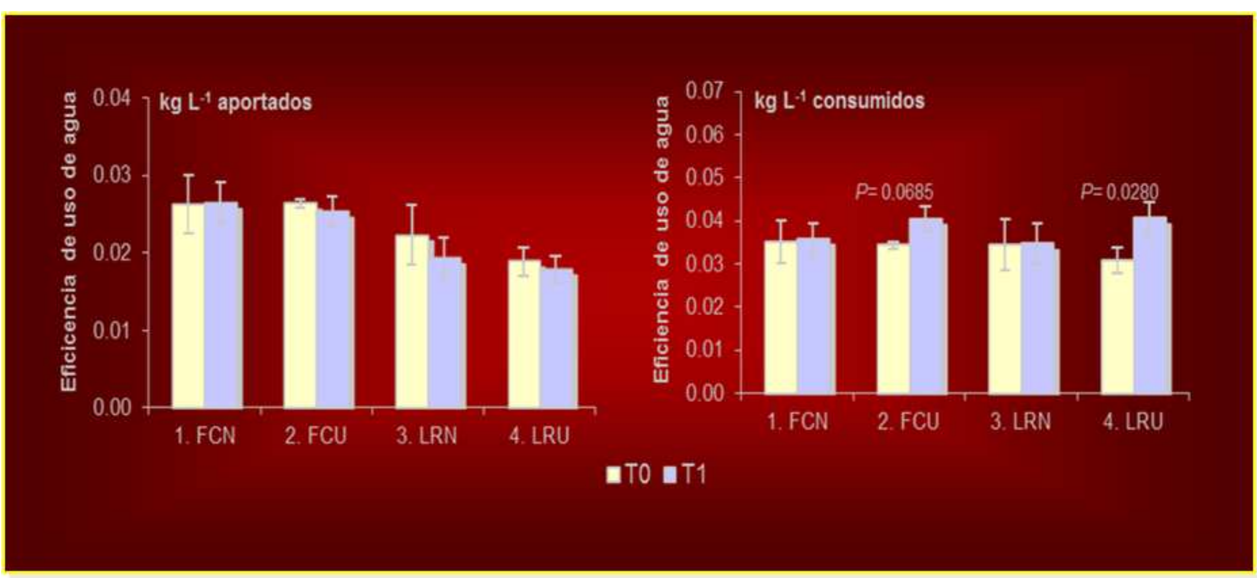


Fig. 8. Efficient water use in different substrates with and without wetting. T0= Testigo, T1 with humectant. FCN: New coir fiber, FCU: Used fiber coir. LRN: New rockwool, FRU: Used rockwool.

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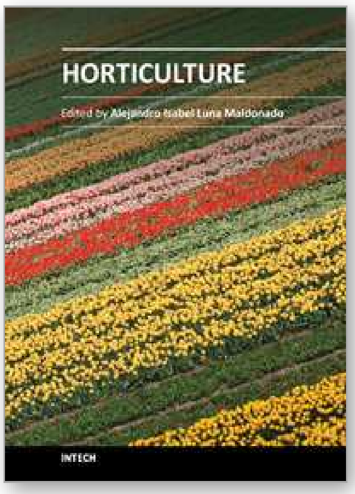

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This book is about the novel aspects and future trends of the horticulture. The topics covered by this book are the effect of the climate and soil characteristics on the nitrogen balance, influence of fertilizers with prolongation effect, diversity in grapevine gene pools, growth and nutrient uptake for tomato plants, post-harvest quality, chemical composition and antioxidant activity, local botanical knowledge and agrobiodiversity, urban horticulture, use of the humectant agents in protected horticulture as well as post-harvest technologies of fresh horticulture produce. This book is a general reference work for students, professional horticulturalists and readers with interest in the subject.