Effect of organic waste compost and a water absorbent polymeric soil conditioner (hydrogel) on the water use efficiency in a *Capsicum annum* (green pepper) cultivation

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Abstract

A greenhouse experiment was set up to study the effect of Bocashi (BK), an organic waste compost, and two doses of Terracottem (TC1 and TC2) (a mixture of water absorbent polymers, fertilizers, root growth stimulators and lava) on the production of above ground and root biomasses of a green pepper (*Capsicum annum)* cultivation in a sandy soil and this with two irrigation doses to maintain the soil water content either at 100% or 80% of its field capacity (FC). Comparison was made when only fertilizers were mixed with the sandy soil. The efficiency of water use was evaluated in terms of consumption of water after 28 days of cultivation in relation to (1) the total volume of applied irrigation water (2) the above ground biomass (3) root biomass

It was obvious that for all treatments more water is needed to maintain the soil moisture content at 100% of FC than at 80% of FC. The highest above ground biomass production was obtained with the highest Terracottem doses (TC1), and this for the two irrigation doses which results were however not different among each other. The TC treatments resulted in higher root biomass production than BK at the highest irrigation doses.

The lowest water consumption per unit biomass was obtained in the following order TC1, BK, TC2, Control (SS) and fertilizer (FQ). No differences were found between the two irrigation doses and this for all the treatments.

Introduction

Addition of organic waste compost, hydrogels or other soil conditioners in soils can positively affect water use efficiency. Soil conditioners are not only applied to modify the soil structure by stabilizing aggregates, but also to change physical characteristics as water retention, workability, infiltration. (Lentz et al., 1992) The use of soil conditioners to improve aggregate stability and also the water availability can be explained by the linking agent's action among the particles. Tisdall and Oades (1982) pointed out that mucilage associated with the roots or generated by the microbial activity they are contributing to improve the soil aggregation ands ameliorate the absorption of water by plant roots.

Soil conditioners can be natural such as polysaccharides, humus, mulch, and manure or synthetic such as: polyacryl amide, polyvinyl alcohol, bituminous or asphalt emulsions, silicates of magnesium and aluminum in solution (Henriquez, 2000).
The synthetic polymers such as hydrogels are also called 'water absorbents' because of their high capacity for retaining water, developed to improve the establishment and growth of plants in soils of arid an semiarid areas, where the deficit of water is one of the main obstacles for agricultural production (El Sayed et al, 1991; Johnson and Piper, 1997)
Synthetic products like *Terracottem*@(*) have gel fragments acting as small individual reservoirs for available water for plants. The influence of this kind of polymers on the dynamics of the water into the soil has been widely reported (Tayel and El Hady, 1981; Taylor and Halfacre, 1986; Orzolek, 1993).
Rivero et al (1998) found that incorporated organic residues, after three years, produced desirable modifications under the structural conditions of the evaluated soil, manifested particularly, in slight increments in the total porosity and aeration porosity, in water retention to - 33 kPa, and in the saturated hydraulic conductivity, as well as a slight decrease in the values of bulk density.
In order to evaluate the effects of organic waste compost and a hydrogel, a greenhouse experiment with containers (pots) was carried out using a sandy soil from Falcon State in Venezuela with Green pepper as indicator crop.

(*) *Trade names are mentioned for the benefit of the reader and does not imply any endorsement of the authors*

Materials and Methods

Soil

The experiment was carried out in greenhouse conditions with a sandy Haplargids soil from the Falcon State of Venezuela, whose main characteristics are shown in table 1.

Table 1. Characteristics of the soil used in the greenhouse experiments

Clay (%)	Silt (%)	Sand (%)	pH	EC $dS.m^{-1}$	OM (%)	P	K	Ca	Na	Mg
								($mg.kg^{-1}$)		
9,2	5,6	82,2	7,76	0,27	0,65	8	47	530	22	100

EC: Electrical Conductivity
OM: Organic Matter

Treatments

- Two irrigation doses were applied to maintain the moisture content in the soil at 80% (L1) or at 100 % of its field capacity (FC).
- Soil conditioners used were:
  - Organic waste compost named *'Bocaschi'* (BK) mixed with the soil in a 3:1 volume ratio (3 soil/1 compost).
  - The *'Terracottem'* hydrogel (TC) (mixture of 40% polymers, 14-14-14 NPK fertilizer, lava as carrying material, root growth stimulators) was applied in two doses: 4 g per kg of soil (TC1) and 2 g per kg of soil (TC2).
  - A chemical *NPK fertilizer* (18-18-18) (FQ) was mixed with the soil at a doses of 8,6 g/pot. Chemical characteristics of Bocaschi and Terracottem are showed in table 2.
- A control treatment (SS) (without conditioner or fertilizer) was included in the experiments.

Table 2. Characteristics of Bocaschi and Terracottem

	N total (%)	P_2O_5 (%)	K (%)	pH 1:2	EC ($dS.m^{-1}$)	P (%)	Ca (%)	Mg (%)	Na (%)	OC (%)
Bocaschi	0,1	1,46	1,36	7,59	10,71	3,64	8,54	2,63	1,66	17,25
Terracottem	5.0	1.0	4.0							

OC: Organic Carbon ; EC: Electrical conductivity

All treatments were replicated four times. After mixing the soil conditioners 8 kg of soil put in 30 cm high containers (pot). The field capacity was determined after 24 hours of free drainage of the saturated pot of 8 kg soil with or without soil conditioners. The moisture content at field capacity of the different treatments is reported in table 3. Instead of 'field capacity', a better term such as 'pot capacity' could be used. After the Bocaschi, Terracottem and the chemical fertilizer were incorporated the green pepper seedlings (*Capsicum annum*) were planted. The experiment lasted for 28 days.

Table 3. Water content at field capacity in the soil-conditioners treatments

Treatment	Water content (%) at Field Capacity
Soil + Bocaschi (BK)	33.6
Soil + Terracottem (2 g/kg) (TC1)	21.8
Soil + Terracottem (4 g/kg) (TC2)	22.3
Soil + Chemical Fertilizer (FQ)	12.2
Soil without conditioner (SS)	12.2

Measurements

Water content of each pot was determined gravimetrically by weighing the pots every day. The height of plants, above ground biomass and root biomass were also measured at the end of the experiment.

The efficiency of water use was evaluated in terms of consumption of water after 28 days of cultivation in relation to (1) the total volume of applied irrigation water (2) the above ground biomass (3) root biomass

Results

Total water consumption

Figure 1 illustrates the total water consumption after 28 days for the different treatments. It is obvious that for all treatments more water is needed to maintain the soil moisture content at 100% of FC (L2) than at 80% of FC. Because the moisture content at FC is higher with treatments of Bocashi (BK) and Terracottem (TC1 and TC2), compared to the control (SS) and the fertilized soil (FQ), they also need more water to attain the 100% FC (L2). However, the water consumption to attain 80% FC (L1) is not different when comparing the control with the treatments. As water consumption depends on the production of biomass, both above ground biomass and root biomass were determined.

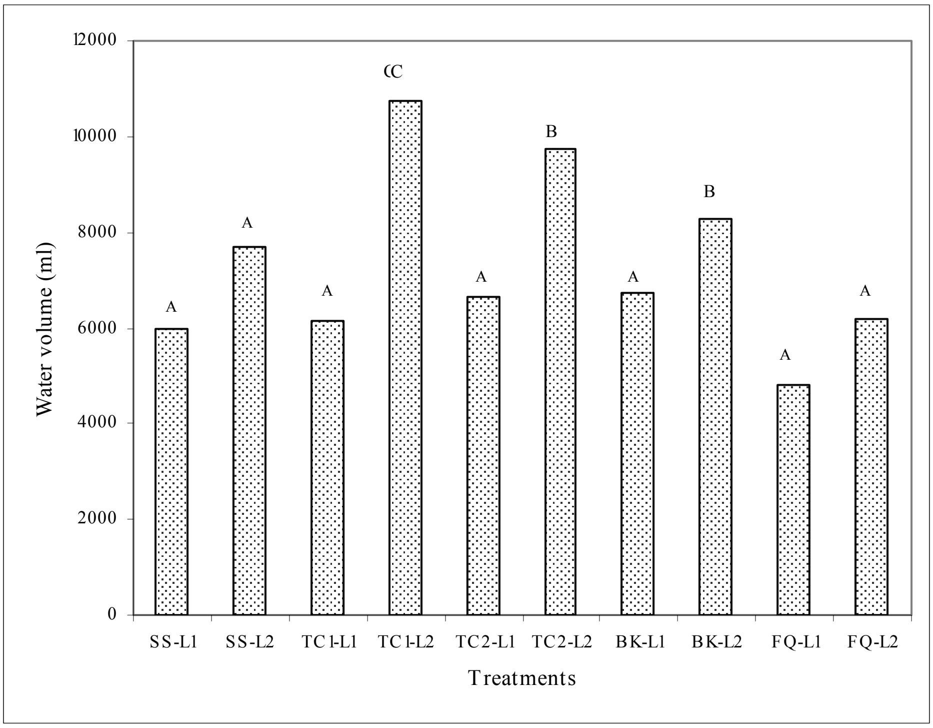

Fig. 1. Total water consumption after 28 days of green pepper cultivation

Above ground biomass

Figure 2 illustrates the above ground biomass after 28 days of Green pepper cultivation and this for the different treatments. The highest above ground biomass production was obtained with TC1, and this for the two irrigation doses L1 and L2 which were however not significant different among each other. Also the BK treatments and the lowest doses of TC2 produced comparable above ground biomasses, but were significant different from the control and the fertilizer treatment.

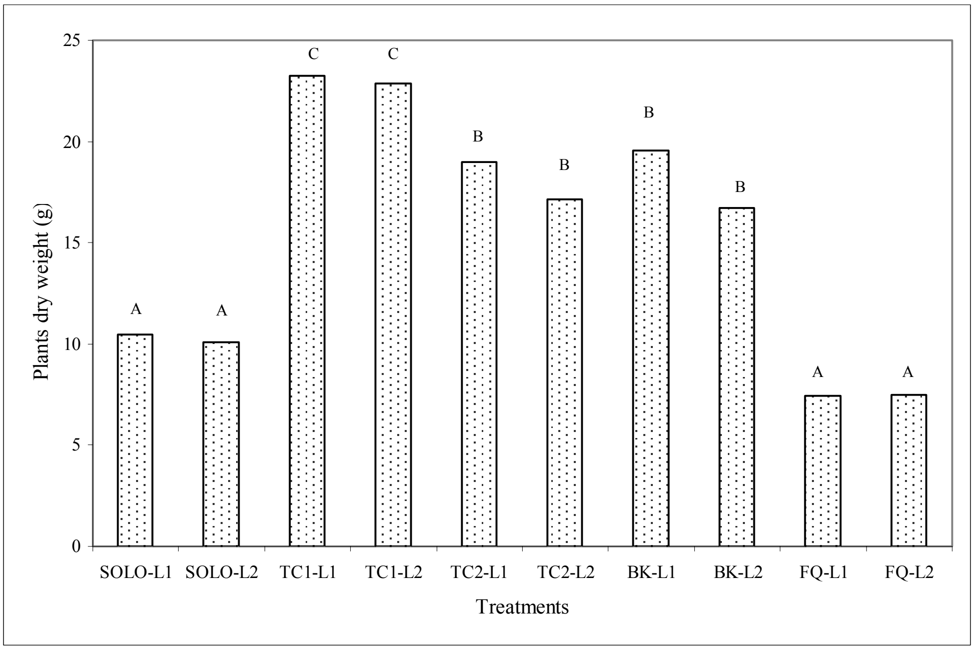

Fig. 2. Above ground biomass production

Root biomass

Figure 3 illustrates the root biomass production after 28 days of Green pepper cultivation. The highest production was obtained with the highest doses of TC1 for L1 and L2 followed by TC2 (L1 and L2). The TC treatments resulted in higher root biomass production than BK at the highest irrigation doses (L1). The BK at the lowest irrigation doses L2 was not significant from the control. The fertilizer application scored the lowest.

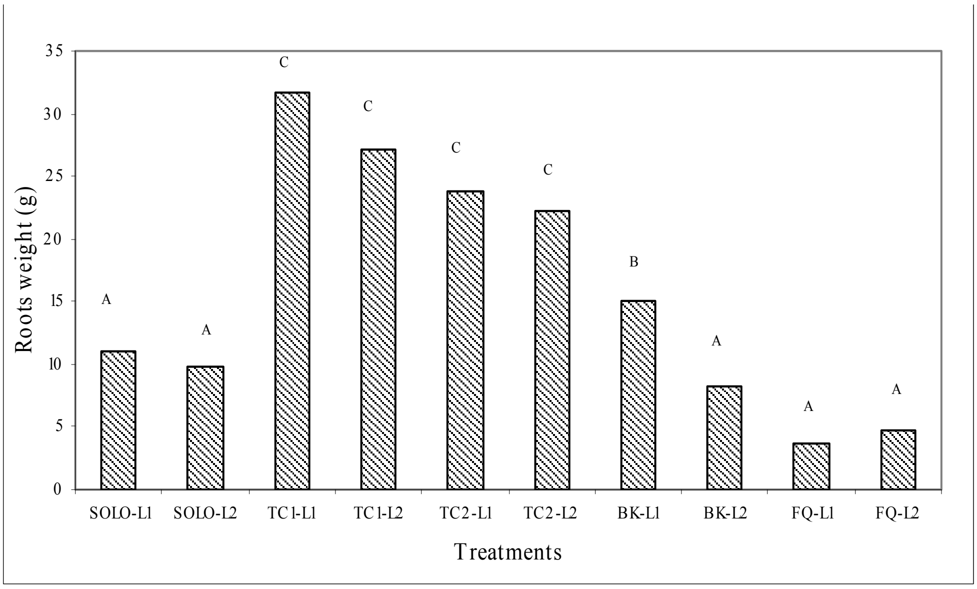

Fig. 3. Root biomass

Water use efficiency (WUE)

Water use efficiency (WUE) can be expressed in terms of water consumption per unit biomass. Figure 4 illustrates the WUE for the above ground biomass production after 28 days of green pepper cultivation.

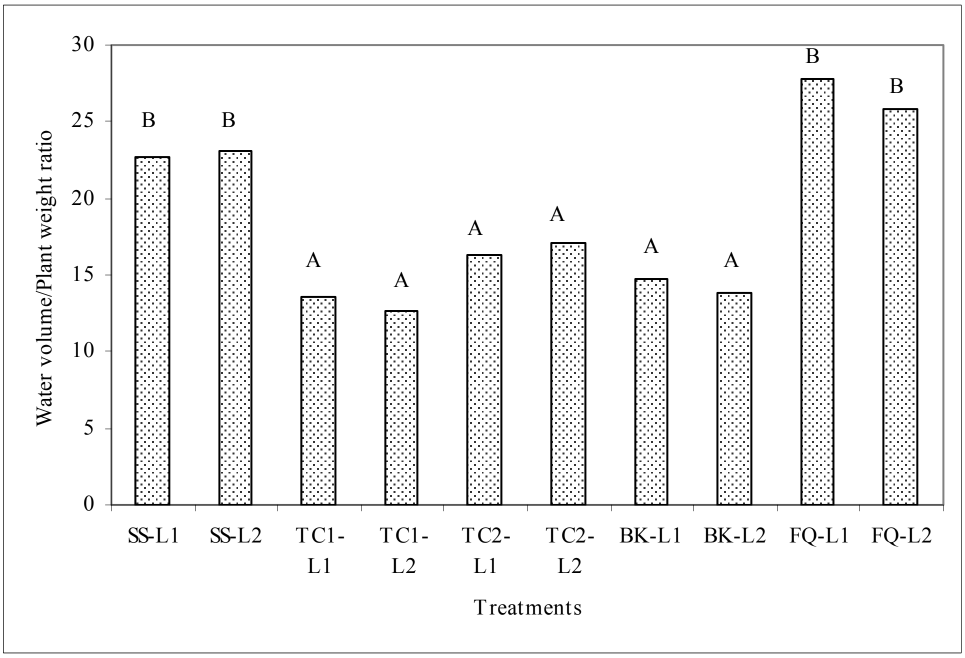

Fig. 4: Water consumption per unit of above ground biomass.

The lowest water consumption per unit biomass was obtained in the following order TC1, BK, TC2, Control (SS) and fertilizer (FQ). No differences were found between the two irrigation doses and this for all the treatments.

Conclusions

One of the most striking results when using soil conditioners in sandy soils in dry conditions is the reduction of water stress on the crop. In those treatments where the Terracottem or Bocashi was applied, not only a higher above ground biomass production was obtained but no differences were found between the two irrigation doses, maintaining the soil moisture condition at 100% or 80% of field capacity. The TC and BK treatments were also most efficient with regard to amount of water needed to produce one unit of biomass. However care should be taken to the high electrical conductivity (EC = 10,71 dSm^{-1}) of the Bocashi which can have an effect on the root biomass production.

References

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