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OPTIMIZATION OF IRRIGATION WITH TREATED WASTEWATER ON FLOWER CULTIVATIONS

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ABSTRACT – This paper deals with the Optimization of irrigation with treated wastewater for the cut flowers: a) *Gerbera jasmesonii* and b) for hydroponic culture of *Limonium perezii* and Antirrhinum. *Gerbera jasmesonii* was irrigated with secondary treated wastewater, borehole water and fresh water with or without additional fertilization. Results showed that freshwater produced significantly more flowers per plant than the other water qualities and fertilization had a significant effect on flower production for freshwater irrigated plants but no significant effect on wastewater irrigated plants. Results on *Limonium perezii* and Antirrhinum in hydroponics, showed that both plants irrigated with secondary treated wastewater and treated wastewater from the epuvalisation system were less vigorous and produced significantly less flowers or lower quality than flowers produced from plants irrigated with freshwater with the addition of fertilizer. High salt concentration in wastewater can be a limiting factor for the production of sensitive plants such as Gerbera jasmesonii.

Keywords: treated wastewater, irrigation*, Gerbera jasmesonii, Limonium perezii,* Antirrhinum.

INTRODUCTION

In Cyprus and in most Mediterranean countries, the scarcity of water together with the high cost associated with collecting and using the limited surface rainwater for irrigation have become real constrains for our irrigated agriculture. Because of this, particular emphasis is placed on the water use efficiency and the cultivation of crops with high return per square meter and volume of water (Chimonidou, 2002 and 2003).

The irrigated agriculture in semi arid countries like Cyprus demands large amounts of water and faces the serious challenge to increase or at least sustain agricultural production while coping with less and/or lower quality water. Application of recycled water to agricultural land for irrigation could be an alternative water source for the Mediterranean countries facing severe water shortage.

Over the years, the severe shortage of water, primarily in the arid and semi-arid regions, has promoted the search for extra sources currently not intensively exploited. Treated wastewater is now being considered and used in many countries throughout the world, as a new additional, renewable and reliable source of water, which can be used for agricultural production. By releasing freshwater sources of potable water supply and other priority uses, treated wastewater reuse makes a contribution to water conservation and expansion of irrigated agriculture, taking on an economic dimension. It also solves disposal problems aimed at protecting the environment and public health and prevents surface water pollution by the direct discharge of pollutants into inland and coastal waters (Papadopoulos and Savvides, 2002).

The benefits, potential health risks and environmental impacts resulting from wastewater use for irrigation and the management measures aimed at using wastewater within acceptable levels of risk to the public health and the environment are well documented (WHO,1973 and 1989, Hespanhol, 1990; Hespanhol and Prost, 1994; FAO, 1992, Jenkins *et al*., 1994; Asano and Levine, 1995, Angelakis *et al*.,1997). Properly planned use of wastewater can reduce environmental and health related hazards, which have been observed with traditional wastewater disposal.

Statistical analysis of rainfall in Cyprus reveals a decreasing trend of rainfall amounts in the last decades. The wastewater generated by the main cities, about 25Mm^3/year, is planned to be collected and used for irrigation after tertiary treatment. About 10 Mm^3/year is conservatively estimated to be available for agricultural irrigation in the near future allowing irrigated agriculture to be expanded by 8-10% while conserving an equivalent amount of water for other sectors (Papadopoulos, 1995).

Flowers are the most profitable crops per volume of water and Floriculture is a new agricultural activity for Cyprus that is rabidly increasing. In the European market, roses cover the 24% of total imports/experts, carnations 15%, chrysanthemums 9.5%, orchids 1.7%, gladioli 0.3% and new cut flowers 50% (ITC, 1997). Although the proportion of roses in the European markets has remained constant, the demand for all other traditional crops is declining compared with new crops (Chimonidou, 2003). Recent trends show that Gerbera is in the top 5 cut flowers at the Dutch auctions with an increase of 3.4%, while the market for all new species i.e. Limonium, Helichrysum, Helipterum, Delphinium, Antirrhinum etc is continually increasing (Flora Culture International, 2002).

At the Agricultural Research Institute, different experiments were conducted in the framework of a European Program, on sustainability and optimization of treatment and use of wastewater in agriculture. The research that will be described in this paper included the optimization of irrigation with treated wastewater and the effect of water quality and fertilization on flower production of the species:

a. *Gerbera jasmesonii*
b. Hydroponic culture of *Limonium perezii* and Antirrhinum

MATERIAL AND METHODS

A) Experiment on the Cultivation of *Gerbera jasmesonii*

This experiment was carried out in 2002 using Gerbera of the red variety “testarosa” as the experimental plant, in order to evaluate the effect of four different sources of water with (treatments F1-F5) and without fertilization (treatments W1-W5) on flower production and quality.

The sources of water were:

a. Secondary treated wastewater,
b. Treated wastewater from the epuvalisation system,
c. Borehole water, and
d. Fresh water.

Analysis of the sources is given in Table 1.

Fertilization (treatments F1-F5) consisted of 150ppm N (Ammonium Nitrate), 40ppm P (Urea Phosphate) and 180ppm K (Potassium Nitrate). Once a month 5gr/plant of Fe chelate was applied to all treatments as Gerbera plants are sensitive to iron deficiencies.

Table 1. Chemical analysis of the four sources of water used in the experiment

	Fresh water	Borehole water	Epuvalisation system (channel A)	Secondary treated wastewater
pH	7.38	7.53	8.0	8,2
Conductivity (mmhos/cm)	0.92	3.03	2.8	2,6
Boron (ppm)	0.37	1.15	0.8	0.8
Calcium (ppm)	50	36	60	60
Magnesium (ppm)	52	71	52	52
Sodium (ppm)	103	570	540	540
Potassium (ppm)	2.6	9	31	31
	275	415	482	482
Sulphate (ppm)	160	387	375	375
Chloride (ppm)	124	629	560	560
Nitrate (ppm)	10	10	90	100
SS (mg/lt)			27	31
COD (mg/lt)			45	45
BOD_5 (mg/lt)			80	85

Experimental Design

The plants were grown under 70% shading on ridges 30 cm wide and 40 cm high. The experimental plots were irrigated by drip irrigation using 10lt drippers (Photo1). Water was pumped from the storage tanks near the epuvalisation system with ½ hp electric pumps generated by an electric generator.

The experimental design was factorial with six replications. Each replication consisted of 10 randomized plots, each plot being a 6m long row (ridge) with 13 plants 50cm apart. The distance between rows was 120 cm with a central 120 cm wide corridor separating the three replications.

Photo 1. *Gerbera jasmesonii* cultivation on soil with 70% shading

B) Greenhouse Experiment with Flower Plants Using Hydroponics

Two flower plants *Limonium perezii* and Antirrhinum were planted in a new hydroponic system made from Polygal´s plant beds. The plant beds are manufactured from double walled polypropylene sheets and have a drainage system at the base of the channel, which provide better drainage and aeration. Perlite was used as a substrate in the plant beds and plants were irrigated using 4Lt drippers. The experimental design was factorial with six replications and each replication consisted of four plant beds 2.4m long placed 60cm apart in two rows. In each plant bed six plants from each variety were planted.

Both plants were irrigated with:

a) untreated secondary treated wastewater,
b) treated wastewater from the epualization system
c) fresh water with additional fertilizer of 60 ppm N and,
d) fresh water with additional fertilizer of 120 ppm N.

The aim of the experiment was to investigate the use of wastewater in hydroponic cultures and whether untreated and treated wastewater could be used in hydroponics for flower production without the addition of extra nutrients.

RESULTS AND DISCUSSION

A) Experiment on the Cultivation of *Gerbera jasmesonii*

Results on the productivity and stem weight of Gerbera jasmesonii

From the results of Gerbera flower production per plant it is shown that freshwater produced significantly more flowers per plant than the other water qualities.

During the course of the experiment mentha in the epuvalisation system was not fully established from the beginning of the experiment and as it is shown in Table 1, of the average water analysis of the four sources of water used in the experiment, there was no significant differences between the secondary treated wastewater and the treated wastewater from the epuvalisation channel A. Therefore there was no significant difference in the flower production and quality between the two treatments (Fig. 1and 2).

Fertilization had a significant effect on flower production in the case of freshwater irrigated plants, but no significant effect on wastewater irrigated plants. Plants irrigated with borehole water had a reduction on flower production especially with the addition of fertilizer, when compared with plants irrigated with wastewater. Reduced flower production and quality could be due to the high electrical conductivity and chloride concentration of the borehole water and wastewater as Gerbera plants are sensitive to high salt concentrations (Table 1).

Results on the effects of fertilizer and water quality on flower weight of gerbera plants indicate that high salt concentration in wastewater can be a limiting factor for the production of sensitive plants such as *Gerbera jasmesonii* probably due to the slower uptake of water and fertilizer by the plant. Mixing of wastewater with freshwater could give good results by lowering the salt concentration of the water and also providing some nutrients to the plants.

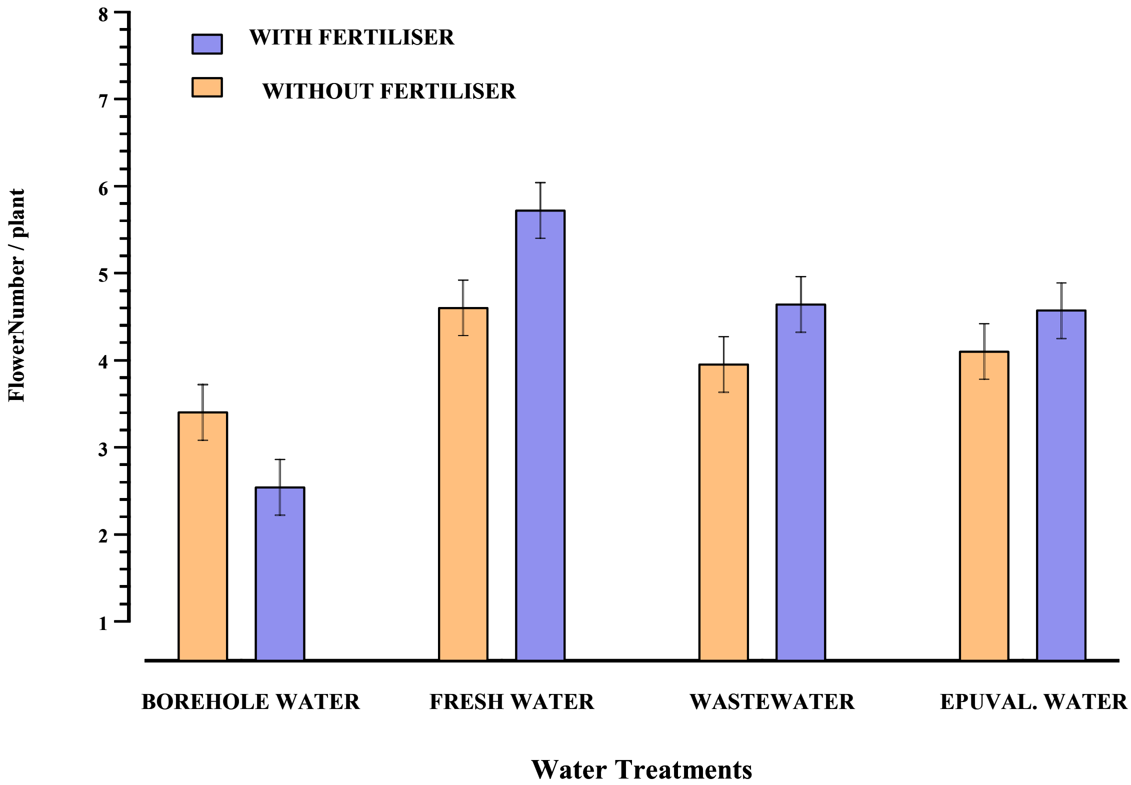


Figure 1. Effect of water quality and fertilizer on flower production of Gerbera plants

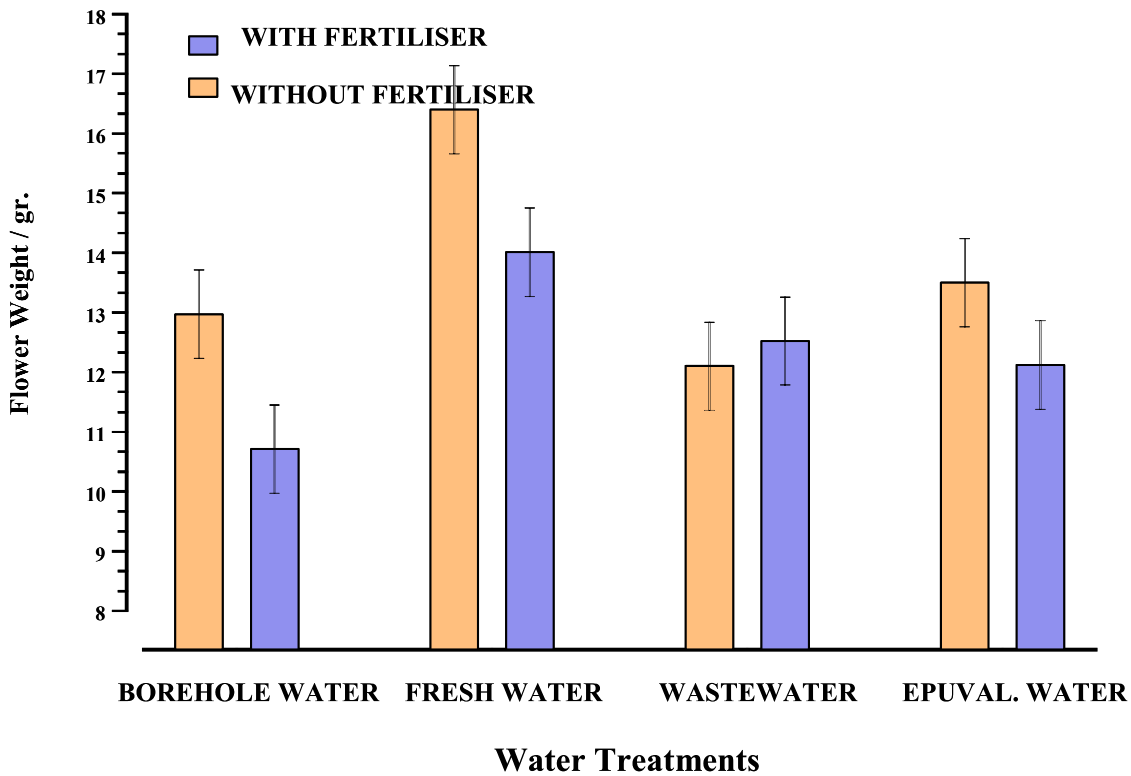
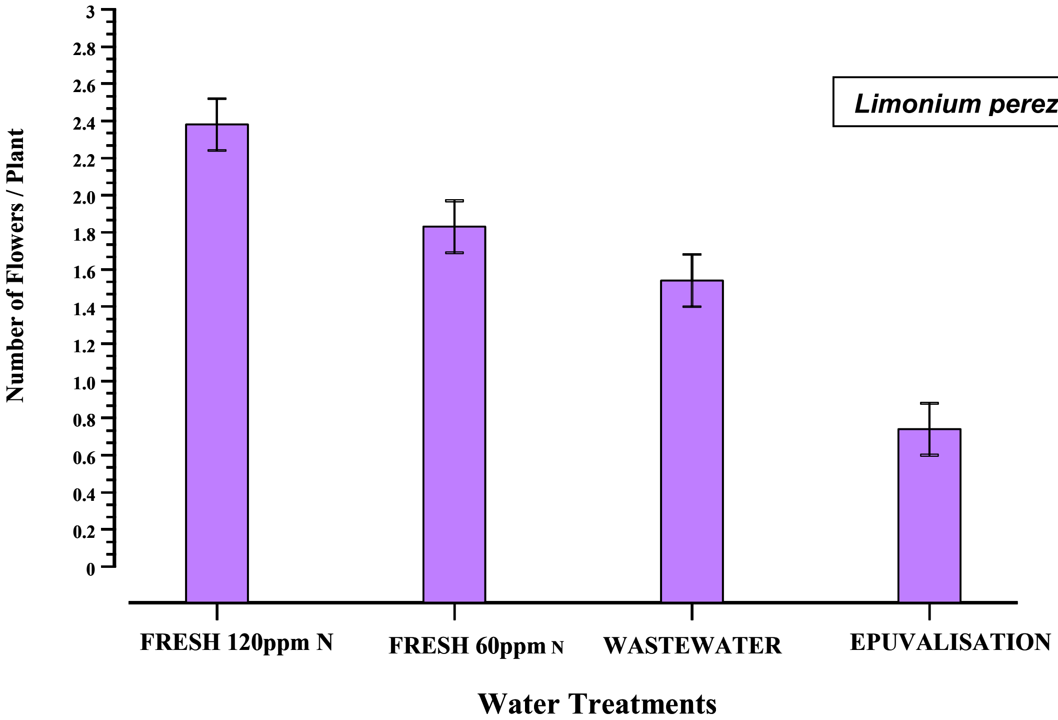


Figure 2. Effect of water quality and fertilizer on stem weight of Gerbera plants

B) Greenhouse Experiment with Flower Plants Using Hydroponics

Effect of Fertilizer and Water Quality on Flower Production of Limonium perezii and Antirrhinum plants

Results show that both plants irrigated with secondary treated wastewater and treated wastewater from the epuvalisation system were less vigorous and produced significantly less flowers of lower quality than flowers produced from plants irrigated with freshwater with the addition of fertilizer (Fig. 3 and 4).



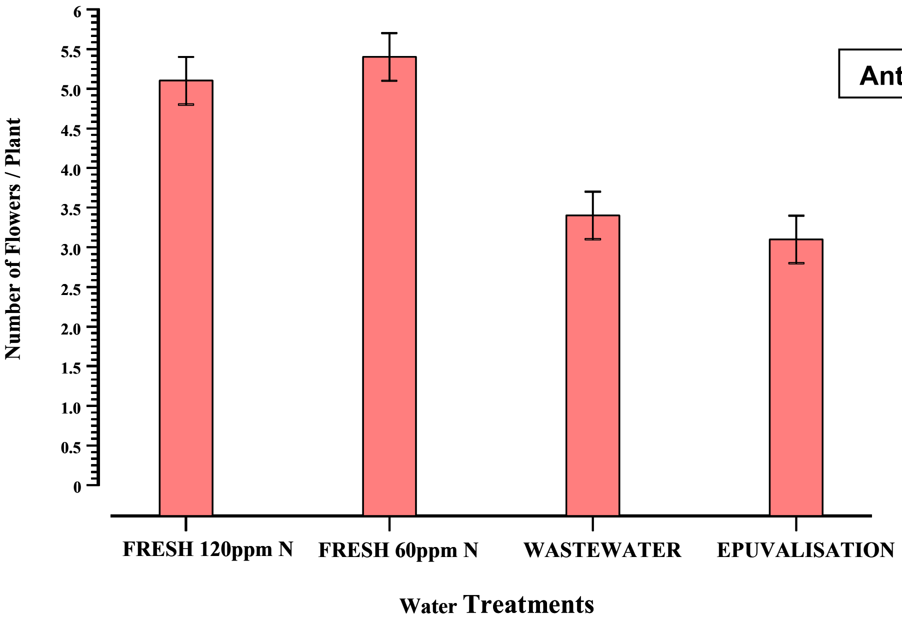
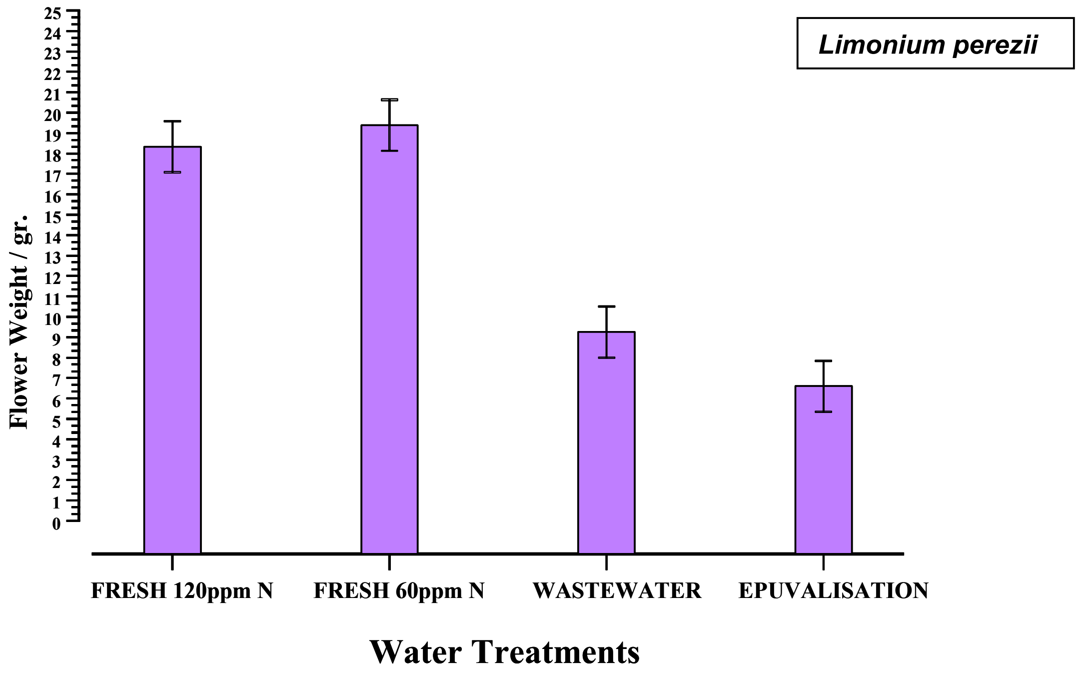


Figure 3. Effect of water quality and fertilizer in flower production of *Limonium perezii* and Antirrhinum plants



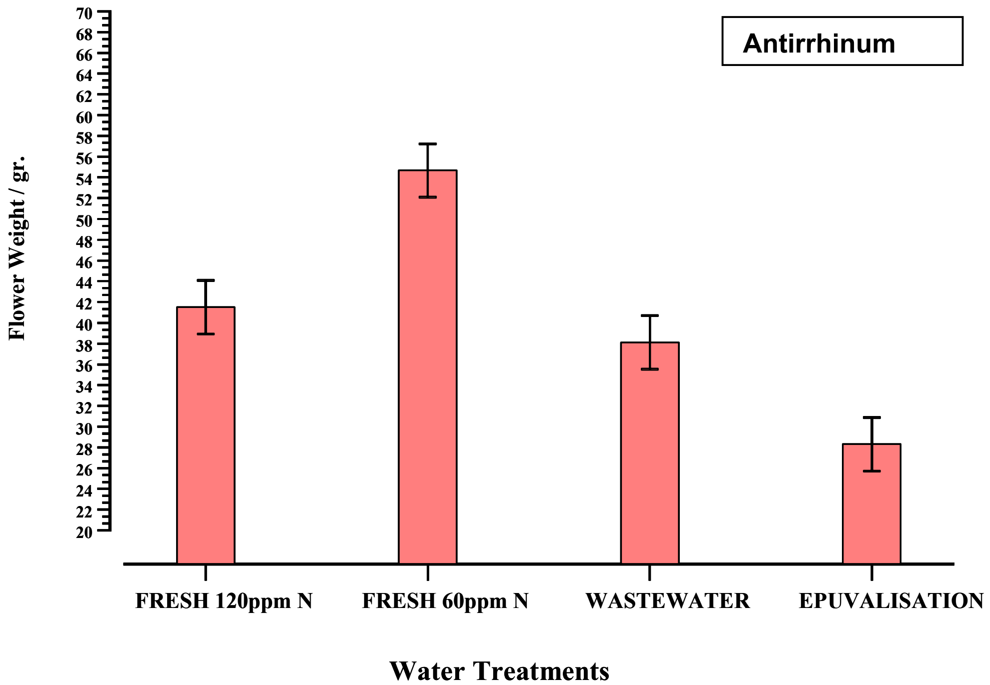


Figure 4. Effect of water quality and fertilizer on the stem weight of *Limonium perezii* and Antirrhinum plants

Limonium perezii produced significantly higher number of flowers when irrigated with fresh water with the addition of 120 ppm N than when irrigated with fresh water with the addition of 60 ppm N, wastewater or treated wastewater from the epuvalisation channel. Antirrhinum, on the other hand, produced significantly more flowers when irrigated with fresh water with the addition of 120 or 60 ppm N, than when irrigated with wastewater or treated wastewater from the epuvalisation system (Fig. 3).

The quality of the produced flowers in both plants (most pronounced effect on Antirrhinum) followed the same trend with significantly higher stem weight (fresh weight) in the cases of fresh water with the lower level of fertilization 60ppm N (Fig. 4).

Limonium perezii plants irrigated with untreated secondary treated wastewater and treated wastewater from the equalization system, had a significantly reduced leaf area compared to plants irrigated with fresh water with additional fertilizer at two levels of nitrogen 60 and 120ppm as shown in Fig. 5 and Photo 2.

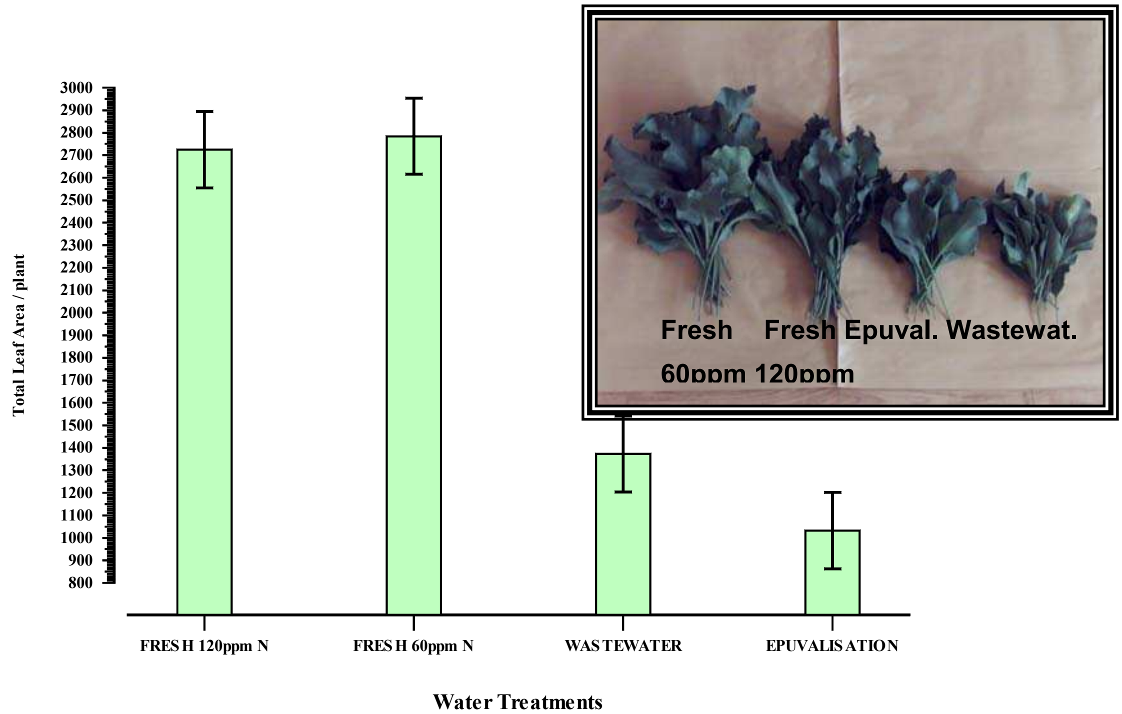


Figure 5. Total leaf area of *Limonium perezii* plants under the 4 different treatments

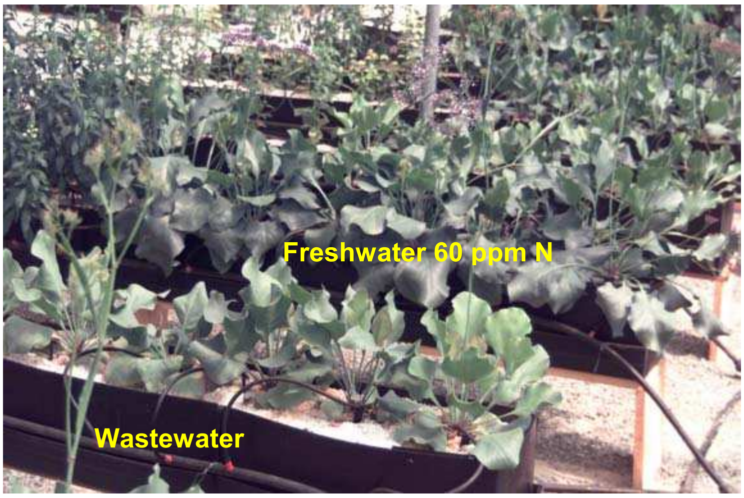


Photo 2. *Limonium perezii* plants grown in hydroponic culture in Polygal´s plant bed system irrigated with wastewater and fresh water with 60 ppm N

Plants irrigated with wastewater and treated wastewater from the epuvalisation system showed nitrogen deficiency symptoms indicating that the low flower production was most probably due to the low nitrogen levels in the wastewater during that period (35ppm N in wastewater and 23ppm N in wastewater treated in the epuvalisation system). Addition of N fertiliser in treated wastewater might be essential when used for irrigation depending on the cultivated plant and the level of treatment of the effluent.

CONCLUSIONS AND RECOMENDATIONS

In the experiment of irrigation of Gerbera plants with secondary treated wastewater, borehole water and fresh water with and without additional fertilization, freshwater produced significantly more flowers per plant than the other water qualities. Fertilization had a significant effect on flower production for both freshwater and borehole water, but no significant effect on wastewater irrigated plants. There was a significant difference in flower number between wastewater and borehole water treatments compared to the freshwater irrigated plants as a result of the high electrical conductivity and chloride concentration of both waters as Gerbera plants are sensitive to high salt concentrations.

Plants of *Limonium perezii* and Antirrhinum irrigated with secondary treated wastewater and treated wastewater from the epuvalisation system were less vigorous and produced significantly less flowers of lower quality than flowers produced from plants irrigated with freshwater with the addition of fertilizer. Addition of fertilizer at 120ppm N produced fewer flowers than addition of 60 ppm N showing that addition of fertilizer above 60ppm N had a negative effect on flower production. Plants irrigated with wastewater and treated wastewater from the epuvalisation system showed nitrogen deficiency symptoms indicating that the low flower production was most probably due to the low nitrogen levels in the wastewater during that period (35ppm N in wastewater and 23ppm N in wastewater treated in the epuvalisation system). Addition of N fertiliser in treated wastewater might be essential when used for irrigation depending on the plant used and level of treatment of effluent.

REFERENCES

Angelakis, A. N., Asano, t., Marecos do Monte, M. H. 1996. Necessity and basis for establishment of European guidelines for reclaimed wastewater in the Mediterranean region. Wat. Sci. Tech., 33 (10-11), 303-316.

Asano, T. and Levine, A.D. 1996. Wastewater reclamation, recycling and reuse: past, present and future. Wat. Sci. Tech., 33(10-11),1-14.

Chimonidou D. 2002. Country report of Cyprus. In Proceedings of the Regional Experts Meeting on Flowers for the Future. Ismir-Turkey, 8-10 Oct, 2002, p.15-30.

Chimonidou D. 2003. Flowers under protected cultivation with special emphasis on roses and new cut flowers. FAO/AUB First National Conference on Integrated Production and Prodection Management of Greenhouse Crops, p.105-114.

FAO. 1992. Wastewater as a source for crop nutrients. Extension publication. Rome, Italy.

Flora Culture International, 2002. World News in Floriculture. *In Flora Culture International*, June 2002.

Hespanhol, I. And A.M.E. Prost. 1994 WHO guidelines and national standards for reuse and water quality. Wat. Res. Vol. 28: 119-124.

Hespanhol, I. 1990. Guidelines and integrated measures for public health protection in gricultural reuse systems. J. Wat. SRT-Aqua 39: 227.249.

ITC. 1997. Product and Market Development cut flowers (a study of major markets). International Trade Center UNCTA/WTO, Geneva.

Jenkins, C.R., I. Papadopouloos and Y. Stylianou. 1994. Pathogens and wastewater use for irrigation in Cyprus. In Proceedings “Land and water resources management in the Mediterranean region”. Bari, Italy, 4-8 sept., 1994.

Papadopoulos I. and Savvides S. 2002. Optimisation of the use of nitrogen in the treated wastewater reused for irrigation. In proceedings of IWA Regional Symposium on Water Recycling in Mediterranean Region. Iraclio, Greece, 26-29 September 2002.

Papadopoulos I. 1995. Present and perspective use of wastewater for irrigation in the Mediterranean basin. 2nd Intern. Symposium on Wastewater Reclamation and Reuse (A.N. Angelakis *et al*., Eds.), IAWQ, Iraklio, Greece, October, Vol.2: 735-746.

WHO. 1973. Reuse of effluents: Methods of wastewater treatment and health safeguards. A report of WHO Meeting of Experts. Technical Report No. 517. Geneva Switzerland.

WHO. 1989. Health guidelines for the use of wastewater in agriculture and aquaculture. Report of a Scientific Group. Technical Report No. 778.