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Comparison between conventional and organic floating systems for lettuce and tomato (*Lactuca sativa* and *Lycopersicon esculentum*) seedling production

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Abstract

The floating system is a common technique for tobacco and vegetable seedling production. Two production systems (CON conventional and ORG organic) and three substrate mixtures (2:1, 1:1 and 1:2 peat:vermiculite, v/v) were evaluated for lettuce and tomato seedling production at 2004 and 2005. Electrical conductivity, dissolved oxygen and pH values of the nutrient solution in ORG system were significantly lower than the corresponding values for CON system. Moreover, the growth and water content of ORG seedlings were the lowest. The presence of mycorrhiza in the ORG can be plausibly ascribed to the better conditions (higher O_2, lower EC) of this water-solution. Quality of seedlings grown under the ORG system as well as the dry weight were higher than those of the CON system. Furthermore, plant height and fresh weight were higher and the root growth was lower in seedlings grown under CON system. The seedlings grown using 1:1 substrate mixture had the highest root growth. The estimated production cost did not indicate any differences between organic and conventional systems.

***Key words**: Conventional, cost, floating system, lettuce, mycorrhiza, organic, substrate mixtures, tomato.*

Introduction

Organic transplant production is the major problem for organic agriculture in Greece. Concerning conventional tomato (*Lycopersicon esculentum)* and lettuce *(Lactuca sativa),* seedling production can be labor intensive [28]. The floating system is a less labor-intensive alternative as watering is not required. Floating system technology is used extensively to produce tobacco seedlings in greenhouses but is rarely used for horticultural crops [3]. Potential advantages include lower production costs, more efficient use of water and nutrients, reduced foliar disease levels since foliage stays dry, easier control of the exposure to disease agents as well as reduced risk of groundwater being contaminated by fertilizers and pesticides. However, if nutrient levels are not handled carefully, seedlings can grow too fast, resulting in tall, leggy, low quality seedlings [17-23].

Large root volume, high root fibrosity and an increased number of first–order lateral roots have shown some correlation with improved field performance [21]. Physiological seedling quality assessment is commonly practiced through evaluation of root growth potential [8].

Moreover, there is a lack of extensive research on floating bed seedling production for crops other than tobacco. The improved quality of seedlings using organic inputs in floating system can be attributed to the low electrical conductivity (EC) values of the water solution, assuming that the salinity and EC directly influence the germination, root development and mycorrhizal symbiosis of tomato [7-5].

Arbuscular mycorrhizal (AM) symbiosis is common among crop plants. It is believed that it ameliorates plant mineral nutrition, enhances water stress tolerance and contributes to greater soil aggregate formation [27]. These are key factors for successful low-input farming. Hence, the formation and functioning of the AM symbiosis is expected to play an important role in sustainable agriculture [25]. Cultivated lettuce is known to be responsive to mycorrhizal colonization, which can reach 80% of the total root length and contributes to the P and N increase [2, 12, 15]. Higher plants require oxygen for growth and metabolism, but they frequently experience limited oxygen availability, mainly due to flooding. During flooding, the diffusion of O_2 to submerged underground roots is severely limited, so that roots must cope with oxygen shortages [4].

The objectives of this study were to compare: i) conventional and organic seedling production in the floating system and ii) three different substrate mixtures evaluating their effects on seedling establishment and growth.

Materials and Methods

Experiments were conducted at the greenhouse of the Tobacco Research Station in West Greece (Lat. 38°36´57.01 North, Long. 21°24´33.64 East, alt. 62 m) in 2004 and replicated in 2005. Annual average temperature was 17.2°C for West Greece.

Each experiment was carried out according to a randomized complete block design. There were two basins (of dimensions

110 cm x 130 cm) for each of the four replications (2 systems x 3 substrates x 4 replicates). The volume of each basin was 250 lt. Three different substrate treatments, 2:1, 1:1 and 1:2 (peat: vermiculite, v/v) were used.

The first basin was achieved by using conventional (CON) water-soluble fertilization, 150 g of Fytosprint (19-19-19) by Fytothreptiki Co. (Athens, Greece) and two fungicides, 30 ml of Previcur 72.2 SL (i.e. propamocarb) and 30 ml of Derosal 51.1 SC (i.e. carbedazim) by Bayer Crop Science (Athens, Greece). The second basin (ORG) was tested with organic inputs, organic water-soluble fertilizer, 100 ml of Fish–Fert (2-4-0.5 and other trace elements) by Humofert Co. (Athens, Greece) and 30 ml of Trichomic (*Trichoderma* sp.) by Trichodex-Spain Co., for root disease control. All organic products were certificated according to EN 2092/91.

Six polystyrene floating trays with 198 cells per tray (17 cm^3 per $cell^{-1}$) were used for each basin and two per each of three substrate mixture. Either lettuce or tomato was used in the experiment.

Experiment I: Lettuce (*Lactuca sativa* var. Paris Island) was hand-sown with one seed per cell on 10th July 2004 and on 5th July 2005. Each seed was placed on the surface of the substrate, without additional covering. In total, 2376 lettuce seeds were used.

Experiment II: Tomato (*Lycopersicon esculentum* var. Pomodoro) was hand-sown, one seed per cell, on 12th August 2004 and 10th August 2005. Each seed was placed on the surface of the substrate, without additional covering. In total, 2376 tomato seeds were used.

Measurements: The germination percentage was computed based on free seedling cells on 25th July and 2nd September 2004 and 20th July and 1st September 2005 for lettuce and tomato, respectively.

Root samples were taken on 7th August 2004 and 30th July 2005 for lettuce and 10th September 2004 and 8th September 2005 for tomato, respectively, based on three plant samples per treatment. A first root sample was cleansed of peat/vermiculite media by soaking the samples overnight in 30 ml of 0.5% solution of sodium hexametaphosphate. Subsequently, the samples were stirred for 5 min and washed over 5 mm mesh-sieve. The roots retained on sieves were transferred to a 0.1% trypan blue FAA staining solution (mixture of 10% formalin, 50% ethanol and 5% acetic acid solutions). For determination of root length (RL) and surface (RS), the stained root samples were put on a high resolution scanner (Hewlett Packard 4c) using a Delta-T software (Delta–T Scan version 2.04, Delta–T Devices Ltd, Burwell, Cambridge, UK) [16].

Also, a second root sample was cleaned and stained with trypan blue in lactophenol, according to the method of Phillips and Hayman [22]. The percentage of root length colonized by AM fungi was determined microscopically with the gridline-intersection method at a magnification of 30-40x [11].

Furthermore, the plant height was measured from the substrate surface to the meristematic point in tomato and the greatest leaf length in lettuce. The seedlings were weighed and then oven-dried at 70°C, for 3 days, in order to measure dry weight (DW) and fresh weight (FW) in grams per plant.

For each basin, EC (Zonder by DOCH Inc.), pH (pH212 by Hanna Inc.) and the concentration of the dissolved oxygen (HI 9142 by Hanna Inc.) of the solution were measured. Finally, all inputs and labor costs were estimated in € per m^2 in 2004.

Statistical analysis: The data were subjected to the analysis of variance, appropriate to the design of the experiment. Significant differences among treatment means were determined using the least significant difference (LSD; $P<0.05$) at the 5% level of probability, using SPSS [26] software.

Results

Water solution measurements

pH-values: There was a remarkable reduction in pH values of the solution for lettuce after the CON, ranging from 7.64 to 7.25 and from 7.72 to 7.21 as far as 2004 and 2005 are concerned respectively (from the start till the completion of the experiment). However, in the case of organic fertilization an increase in pH was observed, ranging from 5.40 to 6.35 and from 5.55 to 6.30 for 2004 and 2005 respectively (Table 1). Similar results were noticed in the tomato treatment, with corresponding pH values stabilizing at approximately 7.14 and 6.14 for 2004 and 7.20 and 6.25 for 2005, for CON and ORG treatments respectively. The lower pH values in the ORG basins are probably the result of low pH values of organic fertilizer.

Electrical conductivity: The EC values are shown in Table 1. The seasonal course of EC revealed a similar pattern between the two experiments. In all treatments, EC exhibited increasing values over the course of the observation periods. EC was affected by fertilization treatment, as evidence of the consistently greater values in conventional plots (basins) (1.230–1.498 and 1.180–1.520 mS cm^{-1},

Table 1. Water–soluble, pH and electrical conductivity (EC) values for the two floating systems and two plant species.

Days after sowing (das)	Lettuce				Tomato			
	CON		ORG		CON		ORG	
	2004	2005	2004	2005	2004	2005	2004	2005
				pH (1:1 H_2O)				
1	7.64	7.72	5.40	5.55	7.55	7.65	5.50	5.45
7	7.55	7.61	5.60	5.75	7.48	7.60	5.55	5.65
15	7.37	7.42	5.90	6.00	7.31	7.45	5.69	5.95
21	7.24	7.29	6.09	6.15	7.22	7.25	5.83	6.00
28	7.25	7.21	6.35	6.30	7.14	7.20	6.14	6.25
				EC (mS cm^{-1})				
1	1.230	1.180	0.690	0.710	1.280	1.240	0.552	0.620
7	1.260	1.250	0.720	0.730	1.295	1.310	0.635	0.712
15	1.367	1.355	0.780	0.776	1.345	1.365	0.687	0.754
21	1.467	1.420	0.818	0.812	1.422	1.444	0.744	0.788
28	1.498	1.485	0.841	0.865	1.450	1.520	0.782	0.812

CON conventional and ORG organic floating system.

for 2004 and 2005, respectively) relative to organic plots (0.552-0.841 and 0.620-0.865 mS cm^{-1}, for 2004 and 2005, respectively) throughout the observation periods, for both plant species (Table 1). The chemical composition of inorganic fertilizer is the reason for the higher value of EC in CON solution [24].

Dissolved O_2: The patterns of the dissolved oxygen for the two experiments are shown in Fig. 1. Dissolved oxygen concentrations in the CON treatment did not exhibit major fluctuations during the observation periods and ranged from 6.65 to 5.78 ppm lt^{-1} and from 6.80 to 5.94 ppm lt^{-1} for lettuce and tomato, respectively. In contrast, corresponding values in the ORG treatment, exhibited a systematic and high reduction from the beginning to the end of the observation periods. The reduction in dissolved oxygen can be ascribed to the significantly higher consumption of oxygen by *Trichoderma* in the ORG treatment [9-13]. This tendency for reduction was observed for both lettuce and tomato (starting at 6.17 and 6.48 and reaching 3.72 and 4.98 ppm lt^{-1} for lettuce and tomato, respectively, for 2004; and starting at 6.50 and 6.60 and reaching 4.40 and 5.00 ppm lt^{-1} for lettuce and tomato, respectively, during 2005). The higher level of dissolved oxygen in the tomato experiment is possibly associated with the relatively lower temperature of this water solution compared to the growth solution of lettuce seedlings.

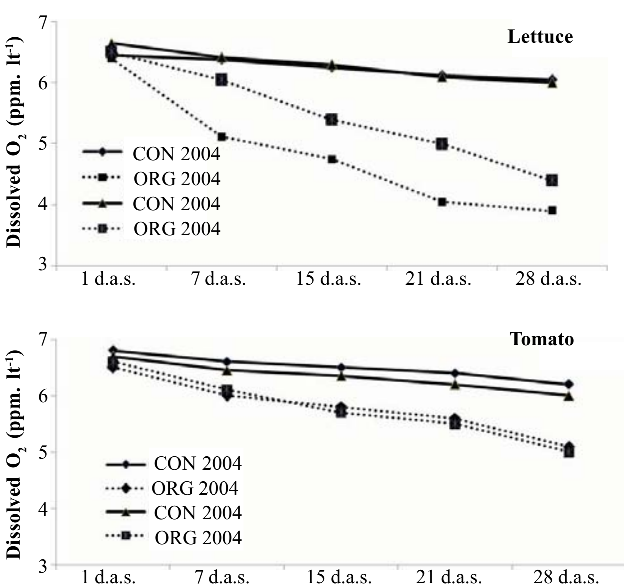

Figure 1. Dissolved oxygen in water solution at conventional (CON) and organic (ORG) floating system. (a: lettuce; b: tomato) at two years.

Lettuce seedlings production

Germination: The germination percentage of lettuce seeds ranged between 91 and 95% each period (Table 2). No significant differences were observed between CON and ORG or between substrate mixtures.

Root surface area (RS): The RS values observed in the BL treatment were significantly greater than those in the CON treatment for both years (Table 2). The interaction between ORG and substrate mixture 1:1 was responsible for the highest values of root surface (1940 and 1845 mm^2.plant^{-1}, for 2004 and 2005, respectively), while the most negative effect on root surface was revealed after the use of 2:1 in the CON floating system (1285 and 1150 mm^2.plant^{-1}, for 2004 and 2005, respectively).

The highly positive effect of the 1:1 peat:vermiculite substrate on root surface area was observed in both floating systems and was statistically significant at P<0.05, for both years. There was no statistical difference in root surface between plants grown in 2:1 and 1:2 substrate mixtures for either CON or ORG treatments (Table 2).

Root length (RL): Table 2, also displays the root length measurements recorded during the different treatments. The ORG treatment exhibited significantly greater values for RL relatively to the CON treatment. Root length was the highest for the 1:1 peat:vermiculite substrate (2549 and 2137 mm.plant^{-1}, for ORG and CON, respectively, for 2004; and 2542 and 1840 mm.plant^{-1}, for ORG and CON, respectively, for 2005), and the lowest in the 2:1 substrate mixture. In most cases, the differences among substrate mixtures were statistically significant at P<0.05 for both years.

Fresh weight (FW): Fresh weight was the highest in plants of CON treatment with any substrate mixture. In Table 2 it is also shown that the highest fresh weight was observed in the CON system with 1:1 substrate mixture (16.56 and 17.51 g.plant^{-1} for 2004 and 2005, respectively) and the lowest one in the ORG system with 1:2 mixture (9.52 g.plant^{-1} and 10.56 g.plant^{-1} for 2004 and 2005, respectively). The differences among treatments using fertilizers were statistically significant; the differences between the substrate mixtures were not statistically significant.

Dry weight (DW): Seedling dry weight results were similar to fresh weight results. Dry biomass production of lettuce was not significantly higher in the CON floating system compared to the ORG floating system (see Table 2). Highest dry weight was observed in the CON system with 1:1 substrate mixture (0.612 and 0.655 g. plant^{-1}, for 2004 and 2005, respectively) and the lowest in the ORG system with 1:2 mixture (0.484 and 0.589 g.plant^{-1} for 2004 and 2005, respectively). Seedlings grown in the 1:1 (peat:vermiculite) had significantly higher DW than those in the 1:2 substrate mixture in 2004 but not in 2005.

Height: Plants grown in the CON floating system were significantly taller in both the 2:1 and 1:1 substrates, than those in the ORG system. The differences recorded among the three substrate mixtures were not statistically significant (Table 2).

Arbuscular mycorrhizal (AM) root colonization: Root colonization by AM fungi in the ORG system at substrate mixture 1:1 were 34 and 33% (for 2004 and 2005, respectively) and ranged between 28 and 32% (for 2:1 and 1:2 peat:vermiculite ratio) (see Fig. 2). No significant differences were detected among the different substrate mixtures. The absence of root colonization in the CON floating system is associated with the fungicide application.

Table 2. Effects of two floating systems (CON conventional and ORG organic) and three substrate mixtures (2:1, 1:1 and 1:2 peat: vermiculite, v/v) on lettuce seedling growth parameters. R.S.= root surface, R.L.= root length, F.W.= fresh weight, D.W.= dry weight.

Substrate mixture	CON	ORG	$LSD_{5\%}$	CON	ORG	$LSD_{5\%}$	CON	ORG	$LSD_{5\%}$
					2004				
	Germination (%)			R.S. ($mm^2.plant^{-1}$)			R.L. ($mm.plant^{-1}$)		
2:1	92	93	*ns*	1285	1662	*231*	1519	2094	*202*
1:1	94	94	*ns*	1577	1940	*262*	2137	2549	*301*
1:2	95	91	*ns*	1311	1746	*297*	1873	2387	*265*
$LSD_{5\%}$	*ns*	*ns*		*210*	*152*		*217*	*282*	
	F.W. ($g.plant^{-1}$)			D.W. ($g.plant^{-1}$)			Height (cm)		
2:1	12.24	10.20	*0.97*	0.550	0.525	*ns*	19.67	13.67	*4.120*
1:1	16.56	12.10	*2.25*	0.612	0.604	*ns*	19.45	12.00	*3.220*
1:2	14.08	9.52	*2.32*	0.502	0.484	*ns*	19.11	13.11	*ns*
$LSD_{5\%}$	*3.22*	*2.59*		*0.065*	*0.077*		*ns*	*ns*	
					2005				
	Germination (%)			R.S. ($mm^2.plant^{-1}$)			R.L. ($mm.plant^{-1}$)		
2:1	91	95	*ns*	1150	1585	*265*	1380	2112	*352*
1:1	92	91	*ns*	1245	1845	*312*	1840	2542	*366*
1:2	92	93	*ns*	1185	1491	*217*	1560	2078	*378*
$LSD_{5\%}$	*ns*	*ns*		*ns*	*185*		*254*	*310*	
	F.W. ($g.plant^{-1}$)			D.W. ($g.plant^{-1}$)			Height (cm)		
2:1	13.11	10.98	*1.22*	0.615	0.589	*ns*	20.15	14.25	*3.980*
1:1	17.51	11.99	*2.56*	0.655	0.642	*ns*	22.32	15.22	*4.812*
1:2	15.32	10.56	*3.98*	0.627	0.589	*ns*	19.55	13.65	*3.658*
$LSD_{5\%}$	*2.88*	*ns*		*ns*	*ns*		*ns*	*ns*	

LSD values ($P<0.05$) are reported between columns or rows within a measured parameter, ns not significant.

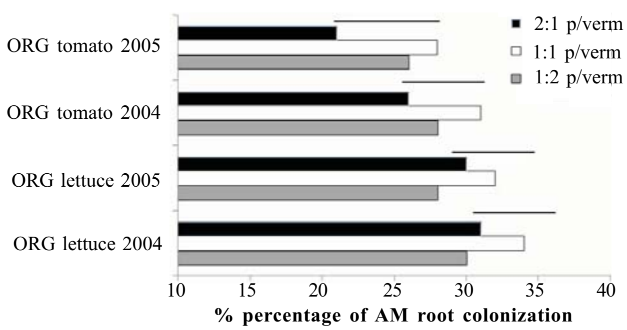

Figure 2. Influence of organic floating system on mycorrhizal colonization of plant roots grown, in three substrate mixtures two plant species and two years. (2:1, 1:1 and 1:2 peat:vermiculite, v/v, CON treatments are not shown, because AMF were absented. Horizontal bars mean *LSD* for $P<0.05$).

Tomato seedlings production

Germination: The germination percentage ranged between 89 and 93%, in both observation periods (Table 3). No significant differences were detected between the CON and the ORG floating system or among the three substrate mixtures.

Root surface area (RS): Root surface values in the ORG system were significantly greater than those of the CON floating system with any substrate during both observation periods (Table 3). Root surface area was greater with the 1:1 substrate in both CON and ORG systems compared to either the 2:1 or 1:2 substrates (Table 3).

Root length (RL): Root length was higher in the ORG treatment with 2:1 substrate than the CON treatment with the same substrate. This was also observed between CON and ORG treatments for 1:2 substrate. On the contrary there was no significant difference between CON and ORG treatments with the 1:1 substrate (Table 3). Regarding the substrate mixtures, root length with the CON treatments was the highest in the 1:1, which was significantly greater than in 2:1 or 1:2 substrates. There was no difference in root length for any substrate within the ORG treatment, during both observation periods.

Fresh weight (FW): Fresh weight of the plants was significantly higher in CON treatment compared to ORG treatment within each substrate class. Among substrate mixture, 1:1 peat:vermiculite had greater fresh weight values than the other two substrate mixtures in either CON or ORG treatments.

Dry weight (DW): Dry weights were higher in the CON floating system with 1:1 substrate mixture (0.981 and 0.901 $g.plant^{-1}$, for 2004 and 2005, respectively) which were significantly greater than the dry weights with the 2:1 substrate within the same system. In the ORG floating system significant differences were not detected among substrate mixtures.

Height: Seedlings grown in the CON treatment were significantly taller than those of the ORG treatment for any of the substrates. Table 3 also shows that in the CON treatment the plants in the 1:1 peat: vermiculite substrate mixture were significantly taller (44.74 and 41.22 cm, for 2004 and 2005, respectively) than those in the other substrate mixtures. In the ORG floating system the plants grown in the 2:1 substrate mixture were significantly shorter (32.12 and 29.45 cm, for 2004 and 2005, respectively) than those in the other substrate mixtures (1:2 and 1:1, with 32.19 and 33.26 cm, respectively, for 2004; and with 30.77 and 32.45 cm, respectively, for 2005).

Table 3. Effects of two floating systems (CON conventional and ORG organic) and three substrate mixtures (2:1, 1:1 and 1:2 peat: vermiculite, v/v) on tomato seedling growth parameters. R.S.= root surface, R.L.= root length, F.W.= fresh weight, D.W.= dry weight.

Substrate mixture	CON	ORG	$LSD_{5\%}$	CON	ORG	$LSD_{5\%}$	CON	ORG	$LSD_{5\%}$
				2004					
	Germination (%)			R.S. ($mm^2.plant^{-1}$)			R.L. ($mm.plant^{-1}$)		
2:1	91	92	*ns*	1781	2030	*222*	2880	3550	*315*
1:1	92	89	*ns*	2053	2250	*213*	3870	4050	*ns*
1:2	89	90	*ns*	1856	2106	*188*	2970	3650	*380*
$LSD_{5\%}$	*ns*	*ns*		*121*	*110*		*320*	*ns*	
	F.W. ($g.plant^{-1}$)			D.W. ($g.plant^{-1}$)			Height (cm)		
2:1	11.00	7.99	*1.19*	0.791	0.831	*ns*	40.63	32.12	*5.76*
1:1	14.02	8.31	*2.22*	0.981	0.897	*ns*	44.74	33.26	*4.58*
1:2	10.97	8.22	*1.32*	0.814	0.857	*ns*	42.11	33.19	*7.58*
$LSD_{5\%}$	*2.23*	*ns*		*0.105*	*ns*		*2.23*	*1.01*	
				2005					
	Germination (%)			R.S. ($mm^2.plant^{-1}$)			R.L. ($mm.plant^{-1}$)		
2:1	90	91	*ns*	1810	2105	*211*	2788	3652	*411*
1:1	93	90	*ns*	2005	2262	*198*	3210	3755	*322*
1:2	92	92	*ns*	1855	2088	*175*	3052	3455	*255*
$LSD_{5\%}$	*ns*	*ns*		*125*	*132*		*385*	*ns*	
	F.W. ($g.plant^{-1}$)			D.W. ($g.plant^{-1}$)			Height (cm)		
2:1	12.32	9.55	*2.05*	0.805	0.879	*ns*	39.45	29.45	*7.25*
1:1	15.11	9.25	*2.45*	0.901	1.042	*0.105*	41.22	32.45	*8.65*
1:2	11.22	8.45	*2.22*	0.875	0.922	*ns*	40.23	30.77	*8.25*
$LSD_{5\%}$	*2.65*	*ns*		*ns*	*ns*		*ns*	*1.65*	

LSD values ($P<0.05$) are reported between columns or rows within a measured parameter, ns not significant.

Arbuscular mycorrhizal (AM) root colonization: As in the lettuce production system, the absence of tomato root colonization by AM fungi in the CON floating system is associated with the fungicide application in the CON treatment during both observation periods. Root colonization by AM fungi was highest in ORG system in substrate mixture 1:1 peat:vermiculite (31 and 28%, for 2004 and 2005, respectively). In substrate mixtures 2:1 and 1:2, root colonization by AM fungi was 26 and 28%, respectively, for 2004; and 21 and 26%, respectively, for 2005 (see Fig. 2). No significant differences were recorded among all substrate mixtures. Particularly, addition of organic fertilization may have a beneficial effect on the growth of indigenous AM fungi in nutritional elements [6]. Organic modifications enhance spore production, extra radical proliferation of hyphae and improve colonization of roots [20].

Production costs: The production costs were almost the same between the treatments. The only difference in production costs were the fertilizer differences (organic or conventional) and phyto-protection applications (Table 4). Finally, the cost was 40.73 and 40.32 € per m^2 for organic and conventional system, respectively. The plant material cost was not calculated because it remained the same between the systems.

Table 4. Production costs for conventional and organic systems per m^2 (at 2004).

	Cost € per m^2	
	ORG-organic	CON-conventional
Trays per square metre	4.64	4.64
Perlite per tray (lit)	0.986	0.986
Peat per tray (lit)	1.3804	1.3804
Water (lit)	0	0
Previcur Bayer (cc)	0	0.36
Derosal Syngenta (g)	0	0.18
Trihomic (cc)	0.3	0
20-10-20 (g)	0	0.35
Fishfert (cc)	1	0
Labour		
Installation	15	15
Sequel	5	5
Total cost per m^2	40.73	40.32

Discussion

Significantly lower values of EC and pH in the solution from the ORG treatment can be attributed to the properties of the organic fertilizer applied. The concentration of dissolved oxygen was also lower in the ORG floating system, but above the threshold value for root growth [24]. There was clear evidence of a progressively decreasing trend in dissolved oxygen concentration, possibly because of the increasing activity of *Trichoderma* sp. in the water-solution [9].

The lack of a significant effect of floating system and substrate mixture in lettuce and tomato experiment can be justified by the grounds of the placement of the seed on the substrate surface (thus, seed germination is not significantly affected by the substrate mixture) [14].

The effect of ORG floating system on root system development can be interpreted by means of the properties of the water-solution and mainly its EC and pH values. It has been reported that several root growth parameters are inversely related to high EC values [7]. A great proportion of the total root system is developed in the water solution, while the positive effect of the 1:1 substrate mixture resulted in the higher first stage growth of the seedlings.

Our results clearly indicate that seedling vigor (height and FW) tended to be higher in the CON floating system compared to ORG treatment. The effect of substrate mixture on seedling height was not significant. However, fresh weight of seedlings had the highest value in the 1:1 substrate mixture. Conventional fertilization (mainly nitrogen) [24] effect is probably responsible for the production of tall seedlings. Rideout and Overstreet [23] indicated that greater moisture content of seedlings affects negatively the quality of tobacco transplants.

In our experiments, there was a clear evidence of root colonization by AM fungi in the ORG floating system. In our case a combination of phosphorus from Fish-fert organic fertilizer and *Trichoderma* sp. as well as fungicide absence are responsible for the recorded root colonization [19]. Furthermore, in seedlings there are positive interactions between the ectomycorrhizal fungus and *Trichoderma* sp. [29]. Also, mycorrhizae can stimulate the absorption of trace elements from water solution through roots [10]. Peat, in the close floating system was possibly the initial source of AM fungi [18]. Finally, photosynthetic storage and export rates have been increased by AM fungi [1].

Low electrical conductivity of the water solution in the ORG floating system may have boosted root colonization. The proposal for an interaction between electrical conductivity and AM root colonization is also based on the results of a previous study on tomato [7-14].

Conclusions

Our two years data suggested that the ORG floating system was responsible for a higher quality of seedlings with the same production cost. In conclusion, greater root development, AM root colonization, lower shoot elongation and reduced moisture content resulted in seedlings of higher quality compared to those of the CON floating system. In all, substrate mixtures significantly affected only root growth parameters of lettuce and tomato seedlings.

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