Effect of substrate (new or used perlite), plant orientation on the column and irrigation frequency on yield efficiency of strawberry plants (cv. Selva) and fruit quality

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EFFECT OF SUBSTRATE (NEW OR USED PERLITE), PLANT ORIENTATION ON THE COLUMN AND IRRIGATION FREQUENCY ON STRAWBERRY PLANT PRODVCTIVITY AND FRUIT QUALITY

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Abstract: Plants were grown hydroponically on vertical plastic columns, in a glasshouse. Columns were filled with either new or reused perlite and were fixed at 120 cm x 66cm. Nutrient solution used was 50% Hoagland's macronutrients and 100% of micronutrients and it was applied every 2 or 4 hours. Plants were planted at the end of August ,on 4 orientation sites of the column and every 25 cm (East, West, North, South-18plants/column). All flowers and runners produced for a period of 2 months were being removed. Harvest period started at the end of December-early January and finished last week of May. Fruits were harvested twice a week. There were noticed two peaks of production, one on Feb. 13 and a second one on April 27. The first peak represented 36.4% and the second one 47.3% of the total yield. Productivity of plants grown in new perlite was significantly higher by 15% than that of plants grown in reused perlite, however, irrigation every 2 hours of the columns filled with reused perlite resulted in similar plant productivity Plants of the North site were the least productive (110g/plant), whereas those on East and South was the more productive (194 and 192g/plant, respectively). The lowest light intensity was found at the North site (97watt/m^2) of the columns and the highest at the east site (128 watt/m^2). Plants of the North site appeared to have almost 60% lower photosynthetic activity than those on the East site (7 and 18ìmoles $CO_2/m^2/h$, respectively). Plants of the North site had the lowest fresh and dry weight (45.14 and 13.3g , respectively) in comparison with plants of the other sites (67.4 FW and 19.5DW). Fruit malformation (based on the number of fruits) was high (54%), but it did not affect fruit marketability significantly (8% only based on fruit wt.). Soluble solids varied from 4.5% (17/2) to 9.5% (11/5). Low SS percentage was noticed during the peaks of production but in general there was an increase along with the increase of light intensity. There was noticed a great variation in titratable acidity (0.8-1.8%), the lowest values were recorded during the peaks of production , but in general there was an increase along with the increase of light intensity. Fruit quality, in general, was considered to be good.

INTRODUCTION

Out of season strawberry production is very popular among growers because it fetches high prices in local and foreign markets (Paraskevopoulou-Parousi, et al.,1990). Much research has been conducted (De Lint, 1968; Morgan,1974; Tropea, 1976; Jaroski and Skapski, 1980; Petralia et al., 1982, Manios et al., 1985, Linardakis and Manios, 1990 and M. Vasilakakis et al., 1991) to demonstrate that vertical cultivation of strawberry is problematic, even though it permits better solar energy utilisation and more efficient use of greenhouse space (Tropea, 1980). The main problems that the system faces are related to low plant productivity and the high cost of installation and operation. Low plant productivity is due mainly to low energy levels reaching the strawberry plants during the winter period. Used perlite as a substrate proved to result in lower yield than the new one and therefore it is not recommended for use (Anagnostou and Vasilakakis, 1994). Fruit quality depends on cultivar (flesh firmness) and is affected mainly by the plant fruit load (soluble solids, sugars), light intensity (soluble solids, acidity, Vit. C) (Vlachonasios et al.,1994) and photoperiod (color) (S. El Fadl, 1989).

Vertical strawberry cultivation is a very good system for studying strawberry physiology, besides that the results of this kind of studies produce knowledge that can be applied to other crops growing under similar conditions.

In this study the effect of substrate (new or reused perlite), irrigation frequency , plant orientation and the light intensity on photosynthetic activity, plant development, yield and fruit quality was investigated.

MATERIALS AND METHODS

The experiment was carried out at the University farm of the Aristotelian University in Thessaloniki from August 1994 to June 1995. A triple span heated glasshouse (300 m^2) was used. Vertical columns, 120 cm high, 16 cm in diameter, made of milky polyethylene film and filled with new or used perlite were fixed at 1.20 x 0.66 m (1.265 columns/m^2). Elite plants of "Selva" were planted on August 16, at 4 orientation sites (E, W, N, S), 18 plants/column (22.7 plants/m^2).

The nutrient solution used was a modification of Hoagland (50% of macronutrients and 100% micronutrients) and it was applied either every 4 or 2 hours for 6 minutes. pH of the nutrient solution was measured every other day and, if it was necessary, it was adjusted to 6.5 with sulfuric acid. The nutrient solution was replaced when E. C. was reaching the level of 1.2 mmhos/cm at 25 $^{\circ}$C (Schwarz, 1968).

The experimental design was a complete randomized one with 5 reps/treatment, 4 columns/rep.

Flower trusses and runners formed were being removed for a period of 2.5 months, providing well established plants.

Fruits, uniform in color, were harvested twice a week, each site (E, W, N., S) separately. Then, they were transferred to the laboratory for further measurements: Number and fruit weight (g), number of malformed fruit, color (L, a, b-Minolta color meter 2000, anthocyanins-absorbance at 512 mm), TSS(%), pH, titratable acidity. At the end of the experiment fresh and dry wt of the plants, each site separately, were determined.

Light intensity was measured with a lux-meter (PHYWE 07024.00 using the probe type 07024.02) at different levels and sites of the column (E, W, N, S). Lux units were transformed into Watt/m^2. Measurements were made under sunny as well as under cloudy conditions throughout the experimental period.

Photosynthetic activity of plants (μmoles CO_2/m^2/h) on all orientation sites of the column was measured with a CID'S Inc., TYPE CI-301 CO_2 Gas Analyzer.

RESULTS AND DISCUSSION

Harvest period started in January and finished at the end of May. There were noticed two peaks of production, one in the middle of February and a second one at the end of April, representing 36,4% and 47.4% of the total production, respectively (Fig. 1 and 2). Between the two peaks there was a period lasted approximately 40 days that was characterized by low plant productivity, representing 16.2% of the total production. Similar results have been reported previously by other investigators (Vlachonasios et al., 1994; Anagnostou 1994). Total fruit production succeeded under the conditions of the experiment is considered out of season, since strawberries from the open fields reach the market in May.

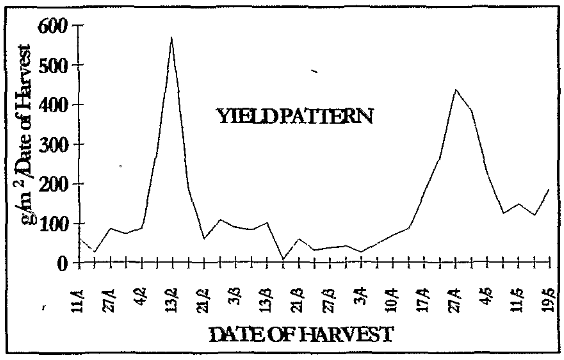

Figure 1. Yield pattern of strawberry plants grown in vertical columns filled with used perlite

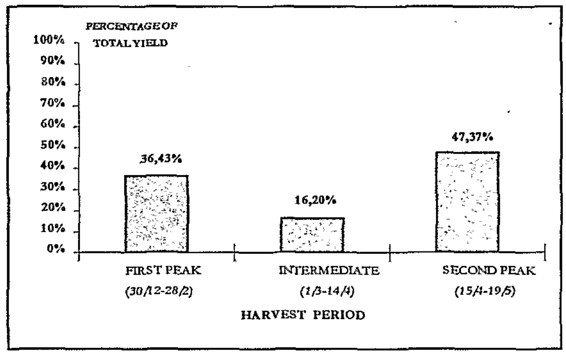

Figure 2. Yield and precocity of strawberry plants cv. Selva grown in columns filled with used perlite

Plant productivity was very low (=40%) compared with that of plants grown in the open field (Paraskevopoulou-Parousi et al., 1990) or on raised beds in high tunnel (Gregoriou and Vakis, 1992).

Plants grown in used perlite and irrigated every 4 hours produced significantly less than plants grown in new perlite. These results agree with those reported by Anagnostou, 1994. However, irrigation of columns filled with used perlite every 2 hours resulted in similar plant productivity with that of plants grown in new perlite (Table1). These results support the finding of Anagnostou who found that used perlite holds less water than the new one, especially at the top of the column. Therefore, used perlite requires more frequent irrigation especially during warm weather conditions.

Position of the plant on the column (East, West, North, South) affected plant productivity, significantly (Fig. 3). The lowest plant production noticed in plants of Northern site, though the highest one was noticed in plants of Eastern and Southern site. Anagnostou (1994) in his experiments planted his plants only in the East and West site of the columns and may this was the reason that his plant productivity was greater than that of the plants of this experiment, using the same cultivar (Selva).

Table 1. Effect of the substrate (new or used perlite) and irrigation frequency (every 2 or 4 hours) on plant productivity (g) and fruit weight (g) of strawberry plants.

PERLITE	Yield (g/plant)	Fruit weight (g)	IRRIGATION FREQUENCY	Yield (g/plant)	Fruit weight (g)
USED	153,1 b*	10,8 a	2 HOURS	188 a	10,7 a
NEW	180,9 a	11,2 a	4 HOURS	159 b	10,3 a

*Values followed by similar letters are not significantly different at the level 5% p. (t-test).

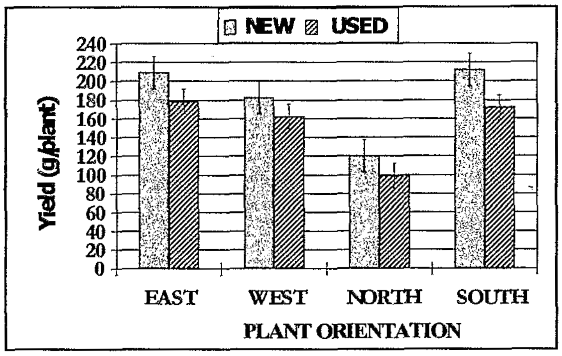

Figure 3. Effect of plant orientation on yield of strawberry plants grown on new or used perlite

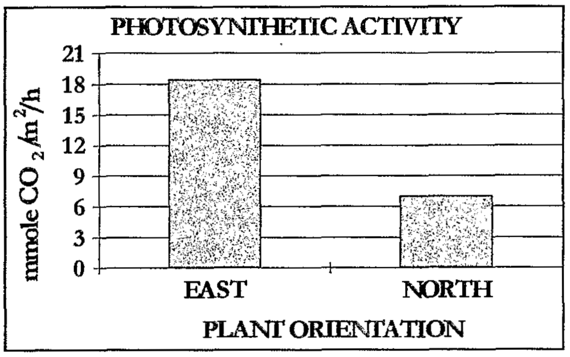

Figure 4. Effect of the plant position on the column on photosynthetic activity

Plant fresh and dry weight was significantly affected by the plant position on the column. The heaviest ones were those of the West site, though the lightest ones were those of the North site (Fig. 5 and 6). However, the position of the plant on the column, top or base, affected Fresh or Dry weight of the plants (results that are in agreement with Anagnostou, 1990) more than the orientation. Plants of the lower part of the column receive less light than top plants and in addition to that compaction of the subtrate is greater at the bottom than it is at the top of the column and it was affect plant growth (Anagnostou, 1990).

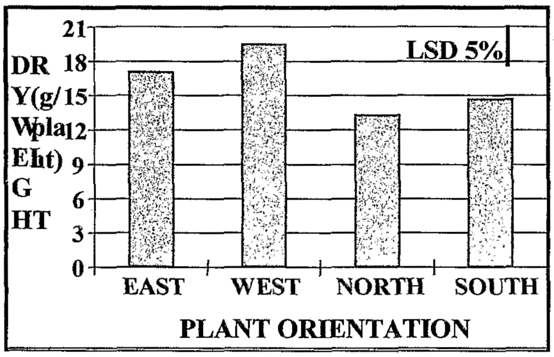

Figure 5. Effect of plant position on the column plant dry weight

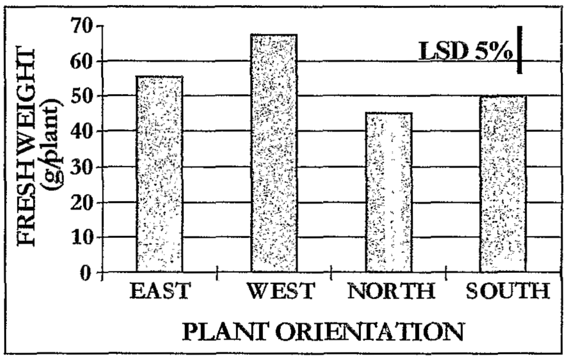

Figure 6. Effect of plant position on the Column on plant fresh weight

Light intensity was very low (below 100 W/m^2) during the winter period (Nov.-Jan.), especially when the weather was cloudy. From February and thereafter light intensity started increasing significantly (Fig. 7). Major differences in light intensity were noticed between sites of the column, the lowest one was noticed at the North site, as well as between top and base of the column.

Plant photosynthetic activity was significantly lower in plants of the North site, as a result of the lower light intensity that was noticed (Fig. 4). The very low light intensity during the winter period is responsible for the very low strawberry plant productivity, even though strawberry plant uses light more efficiently than other crops (Stavrakas and Drogoudi, 1996). Therefore, any device or technique that will improve light intensity or light distribution among plants will improve plant productivity.

Flesh firmness varied from harvest to harvest (0.6 -1.4kg, with 8 mm probe) (Fig.7). Fruit of "Selva" is considered as a hard one (0.8 kg on the average) and very suitable for transportation.

Soluble solids % varied from harvest to harvest (5%-8%) (Fig. 7), but there was a tendency to increase along with the increase of light intensity. High values of SS were noticed during reduced plant fruit load. Titratable acidity varied between 0.8 and 1.8 and was negatively affected by the plant fruit load (Fig. 7). Anthocyanin content varied considerably from harvest to harvest. High values were noticed after the first peak and during the second peak (Fig. 7).

Fruit malformation was noticed during the whole experimental period,, it was about 55% on the average, based on the total number of fruits produced (Fig. 8). However, malformation based on weight of total fruit production represented only 8% and it is not considered significant.

Fruit quality, in general, compared with fruits produced under field conditions, is considered good. The average size of the fruit produced, however, was smaller than the accepted one for "Selva" (Table 1) (Gregoriou and Vakis, 1992, Paraskevopoulou et al, 1990). The smaller size of the fruit produced under the conditions of the experiment, was one of the main factors responsible for the low plant productivity.

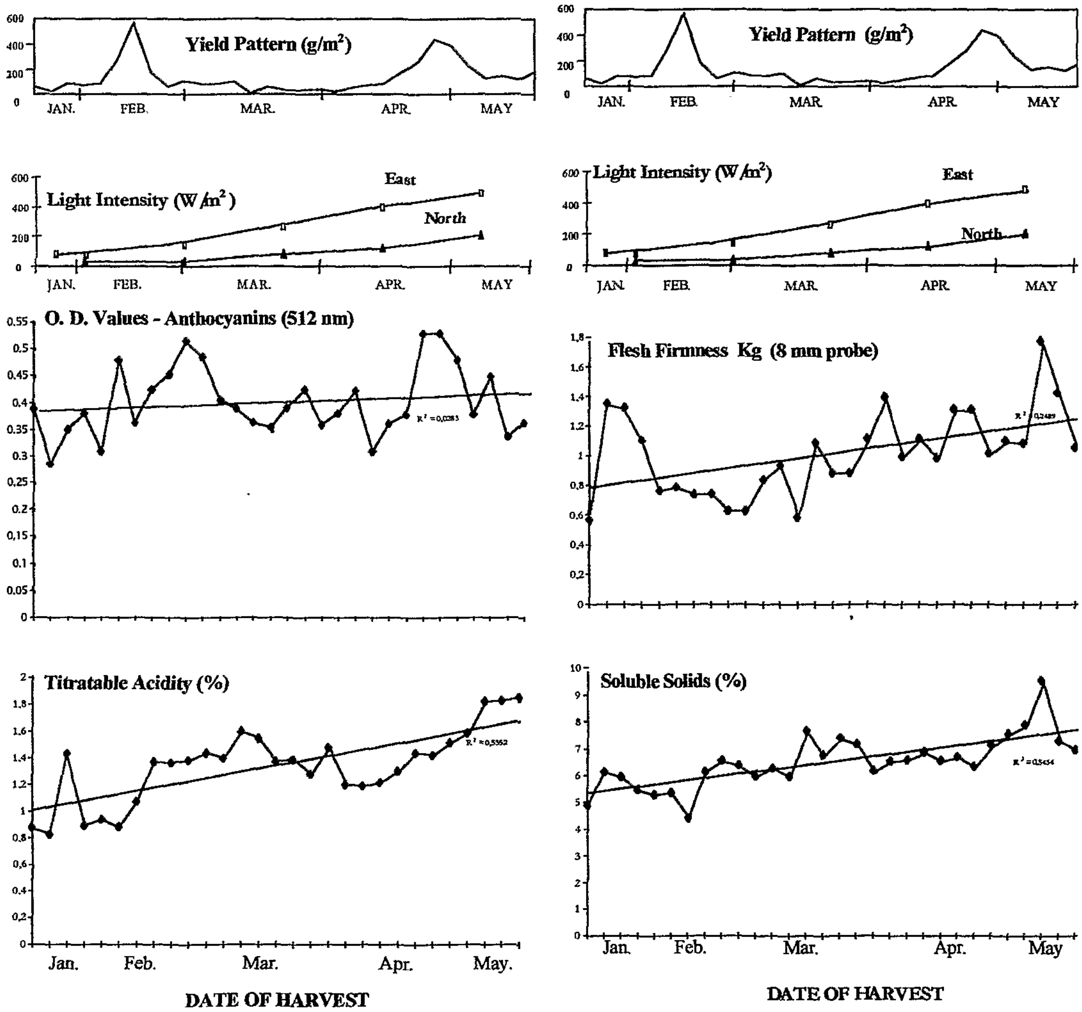

Figure 7. O. D. Values (anthocyanins), Flesh firmness, Titratable acidity and Solublesolids of strawberry fruits in relation to date of harvest

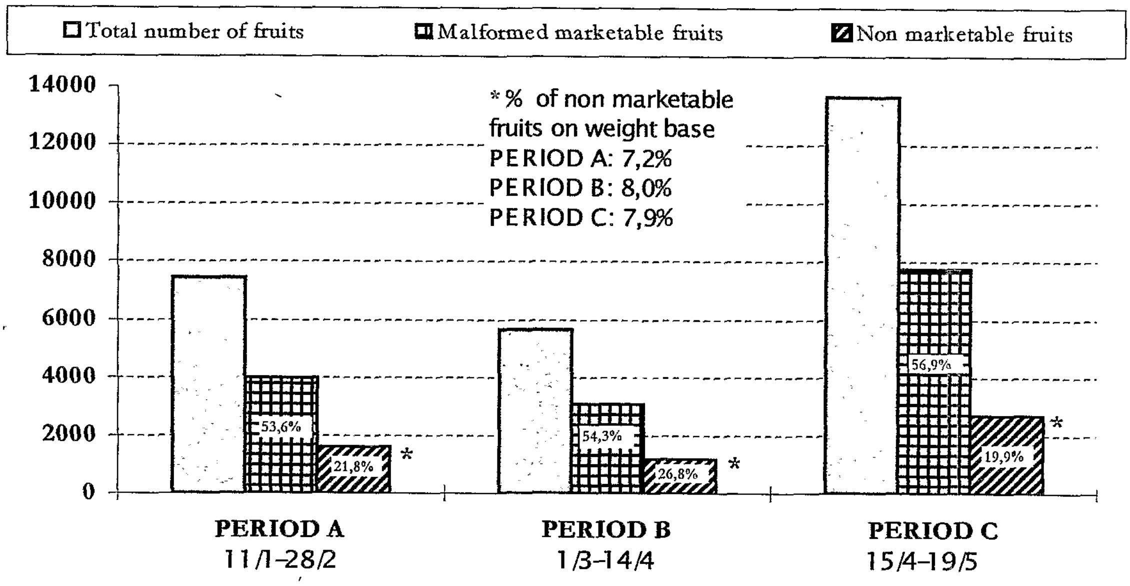

Figure 8. Percentage of malformed marketable and non marketable strawberry fruits in relation to date of harvest

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