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THE GREENHOUSE STRUCTURES IN MEDITERRANEAN REGIONS-PROBLEMS AND TRENDS

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Abstract: During the last 35 years a huge expansion of the plastics greenhouses has been noticed in many Mediterranean countries. The increase of the demand of out of season vegetables, the introduction of the plastics films, the development of low-cost plastics greenhouses, the mild climatic conditions of some regions and the introduction of some simple technologies were the major contributing factors for this expansion. Today a very big variety of plastics greenhouses have been developed in Mediterranean regions and the most common shapes are of the round arched, of saddle-roof, of round-arched with vertical sides, of pointed arched with vertical sides, of the uneven span etc. The most important technical problems which the structures of the plastics greenhouses are facing are those related with the mechanical strength, the dimensions and the sizes of the structures, the roof slop, the adequate ventilation, the light transmission, the assembly of the covering material, the collection of rain water and the cost of the structures.

INTRODUCTION

After Eastern Asia with its three huge greenhouse centers of China, of Korea and of Japan and the 138 200 ha of greenhouses, the second largest region in the world where greenhouses found big applications is the Mediterranean region (Castilla and Hernandez 1995; Sadao 1995). The first greenhouses in Mediterranean regions have been constructed in the middle of 19th century and were covered with glass. After the second world war a big expansion of the glasshouses in north western European countries and in much smaller scale in some southern European countries was noticed. With the introduction of the plastics films in the early sixties a rapid expansion of the plastics greenhouses in many Mediterranean countries was made (Grafriadellis, 1987).

In the table1 the evolution of the greenhouses in some Mediterranean countries is presented. According to this table, Spain is the leading country in hectares of greenhouses, followed by Italy, Turkey, France and Morocco.

According to Castilla and Hernandez (1995) the greenhouses and the high tunnels in the Mediterranean countries have reached to 103.295 ha out of which the 8000 ha were glasshouses (2700 ha in France, 2300 ha in Italy, 2000 ha in Turkey and 1000 ha in other countries) and the rest were covered with plastics sheets or with rigid panels.

The main factors, which have influenced the huge expansion of the plastic greenhouses in Mediterranean regions, are the followings:

- The climatic advantages of some regions (mild temperatures during winter months, large number of sunny days with high intensities of solar radiation etc).
- The possibilities of using low cost frame materials for the construction of the greenhouses (wood, steel, plastic sheets).
- The high heating cost of the greenhouses in north European countries.
- The improvement of transportations.
- The efficient international marketing of the horticultural crops.

Table 1. Greenhouses and high tunnels in the Mediterranean countries

Country	Ha
Portugal	2605
Spain	28350
Morocco	6465
France	9100
Algeria	3500
Italy	24300
Ex. Yugoslavia	5040
Turkey	10800
Syria	2000
Lebanon	1100
Israel	2500
Jordan	1200
Egypt	800
Libya	7
Tunisia	1425
Albania	?
Malta	35
Greece	3975
Cyprus	200
Total	103395

The protected cultivation in Mediterranean countries is synonymous with the plasticulture. From the table 2 it can be observed that the majority of the greenhouses in Mediterranean countries is covered with plastics films. It is also well known that the most plastics greenhouses in these regions are not heated and are mainly employed in the production of vegetables while the most glasshouses are used in floriculture.

Table 2. The evolution of the greenhouses and of the high tunnels in some Mediterranean countries

Country	Glasshouses (ha)			Plastics greenhouses (ha)			
	1965	1977	1985	1965	1977	1985	1994
Portugal	-	-	20	-	400	1200	2600
Spain	-	-	-	350	5800	15000	28350
Morocco	-	-	-	-	-	6160	6465
France	650	-	1500	180	2300	4000	9100
Italy	1240	-	2050	1180	17000	17500	24300
Ex. Yugoslavia	-	250	500	-	-	600	5040
Turkey	-	-	1370	-	2000	4600	10800
Israel	-	-	200	2	-	200	2500
Tunisia	-	-	-	-	-	1050	1425
Greece	-	50	70	269	2617	3120	3975
Cyprus	-	-	-	-	-	170	200

Adapted from Grafiadellis 1987; Castilla and Hernandez 1995.

The most plastic greenhouses in Mediterranean countries are covered with long life polyethylene (LDPE) films and only in some countries the thermal films and mainly the coextruded LDPE-EVA films found big applications. (Nisen et al, 1990).

In few countries rigid plastic panels made of polyester of 1mm thick, polymethylmethacrylate PMMA single or double-walled up to 14mm thick, the bi-oriented PVC of 0.9mm thick and the double walled polycarbonate of 6mm thick are used.

THE TYPES OF THE GREENHOUSE STRUCTURES

According to the local climatic conditions, the available materials, the prices and the customs, in the different Mediterranean countries very different types of plastics greenhouses have been developed (Nisen et al 1990; El-Aidy 1991; Brun and Lagier 1985; Dimitrijevic and Grafiadellis 1992). The greenhouse shapes most frequently used in Mediterranean countries are of the saddle-roof, the round-arched, the round arched with vertical side walls, the pointed arched with sloping side walls and the pointed arched with vertical side walls (FAO book 1986; Nisen et al 1990; Sirjacobs 1984; Zabeltitz 1990).

In France and in many north African countries the most popular shapes of plastics greenhouses are the single span round arched and the round arched with vertical side walls (fig. 1 and fig.2).

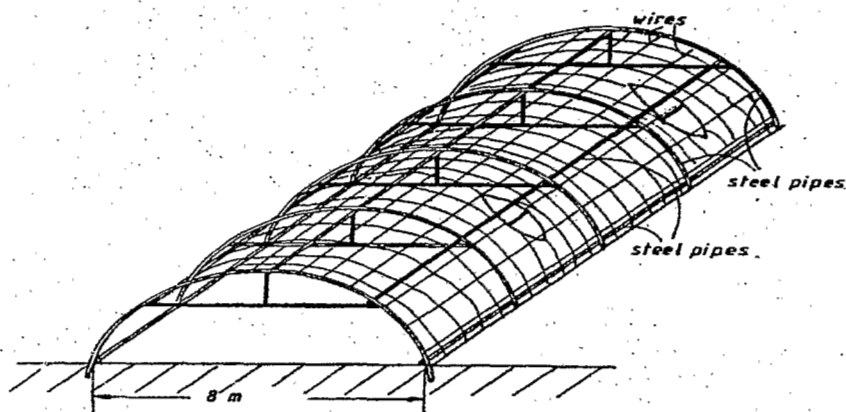


Fig. 1 A single span round arched greenhouse (FAO booklet, greenhouses in Syria).

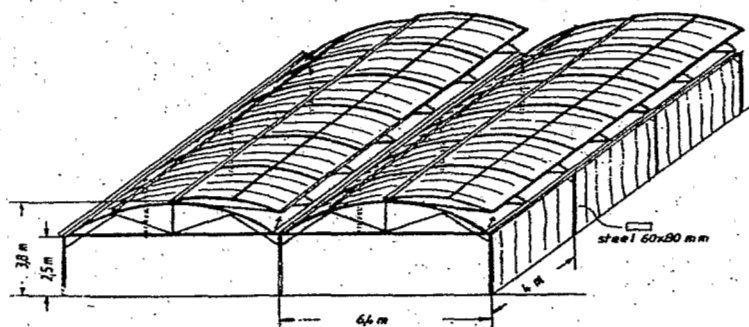


Fig. 2 A round arched greenhouse with vertical sidewalls (FAO booklet, greenhouses in Cyprus).

In Greece and in Italy the saddle-roof greenhouse types made from wood or from steel or from both materials and the round arched with vertical side walls are mainly used (fig.3, fig.4).

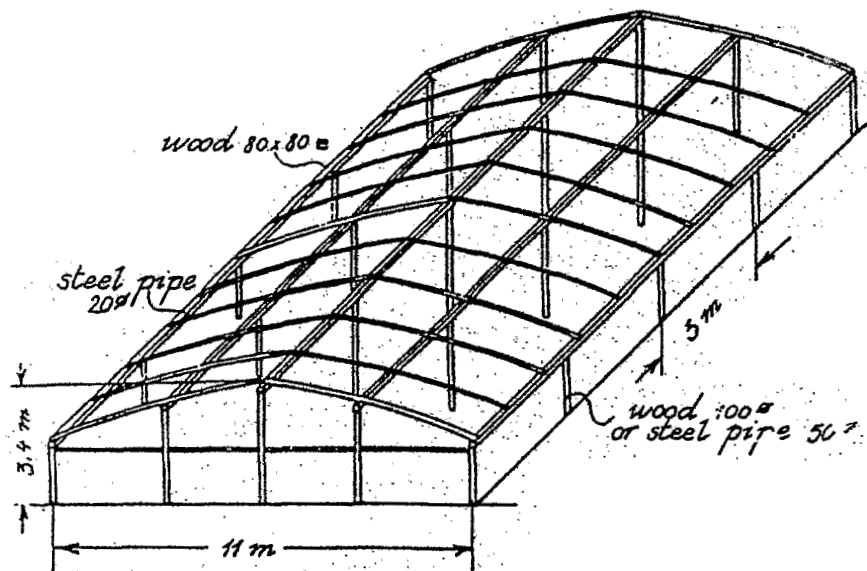


Fig. 3 A saddle roof greenhouse type made from wood and steel pipes in Crete (FAO book).

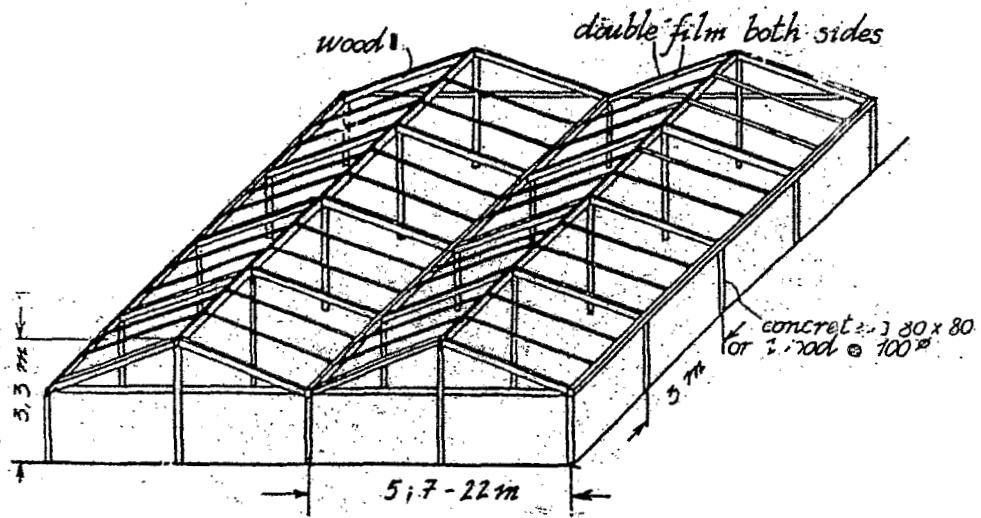


Fig. 4 A saddle roof greenhouse type used in Sicily (FAO book).

The most popular greenhouses in Spain are the Parray type made from steel or wooden posts, linked one to another by wires at their tops between which the polyethylene film is sandwiched

(fig.5). The last years many other greenhouse types of the saddle-roof and round arched with vertical sidewalls have been introduced.

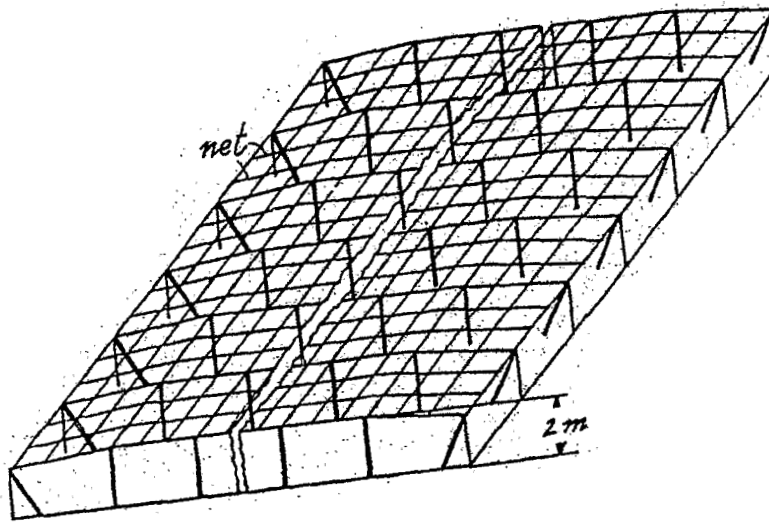


Figure 5. Parral type greenhouse in Almeria, Spain (FAO book)

In Portugal, a saddle - roof wooden type of greenhouse, with the plastic films passing alternatively above and below the wooden sticks in the roof is mainly used (fig.6). The majority of this type of the greenhouses used to be single span structures, which recently have started to turn to multispan.

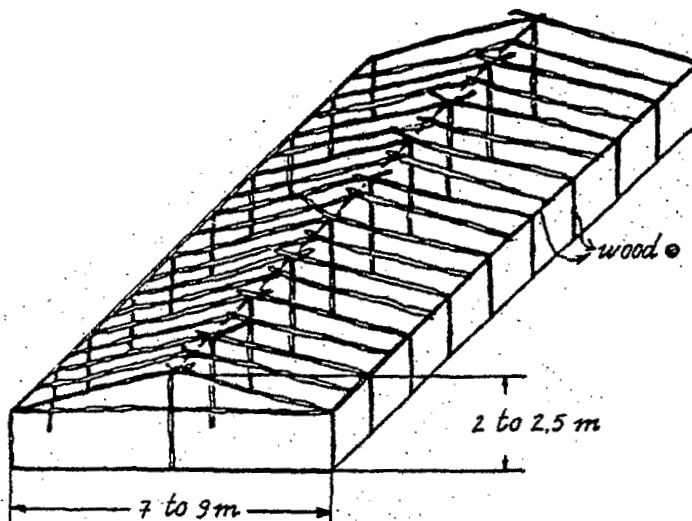


Figure 6. Wooden greenhouse type in Portugal (FAO book)

In Israel several types of plastics greenhouses have been developed, some of which are of saddle roof (fig.7) or of shed roof (fig.8) or round-arched with vertical sides with rolling-up ridge ventilation (fig. 9).

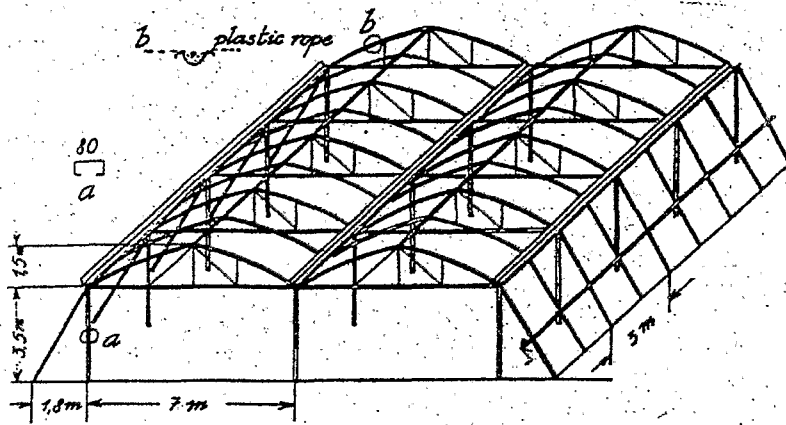


Figure 7. A saddle roof type greenhouse Israel (FAO book)

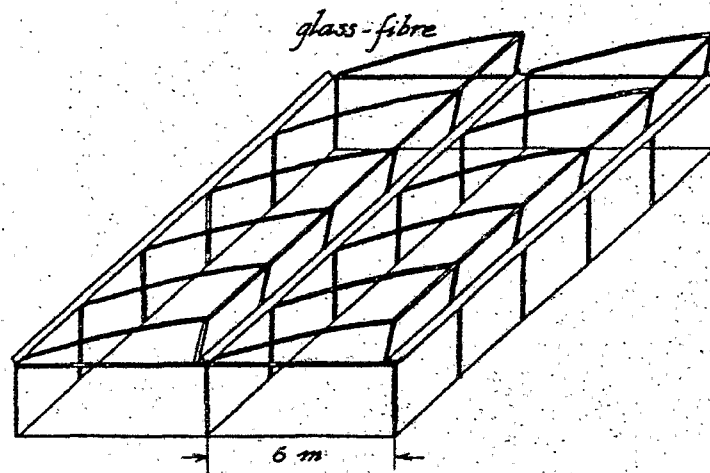


Figure 8. A shed roof type greenhouse in Israel (FAO book)

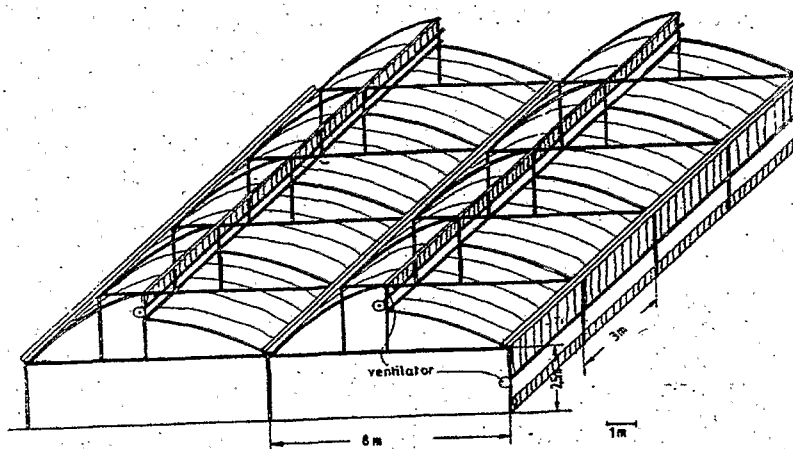


Fig. 9. A type of greenhouse with roiling - up ridge ventilation in Israel (FAO booklet, greenhouses in Cyprus).

In Cyprus, the most interesting type of the plastics greenhouses is the pointed arched with the vertical sides, developed in the Agricultural Research Institute of Nicosia (Fig.10).

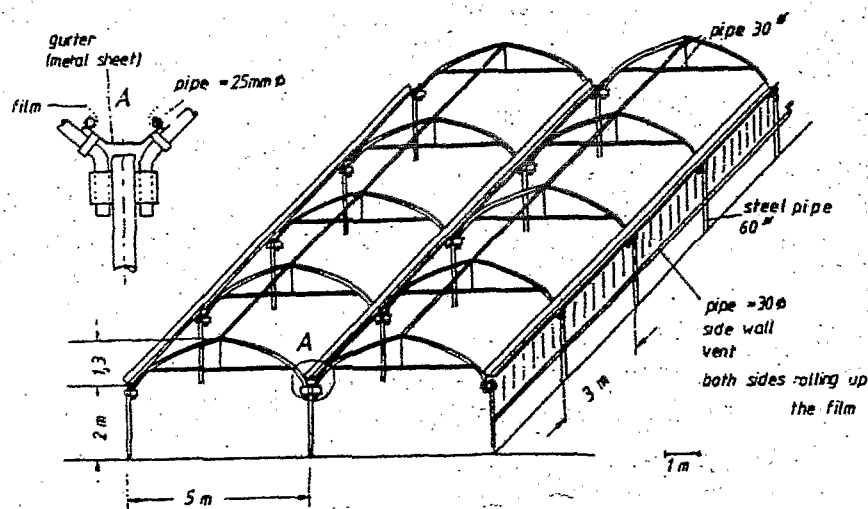


Fig. 10 Pointed arched type greenhouse in Cyprus (FAO booklet).

The main technical problems, which the structures of the greenhouses in Mediterranean regions face, are:

a. Mechanical strength.

The biggest enemy of the plastic greenhouses in the Mediterranean regions is the wind. The huge greenhouse centers of Almeria, of Sicily and of Crete are in very windy regions where the wind speeds something exceed the 40-45m/s (144-162 km/hr). Beside that in some cases the winds are turbulence causing worse problems (Nisen et al 1990; Grafiadellis 1987; Preben and Finn 1992). According to the greenhouse specifications of some Mediterranean countries the greenhouses have been designed to withstand a wind pressure of 34m/s (120km/hr), a snow load of 25kg/m² and a plant weight of 20kg/m² (Vasiliou 1992; Grafiadellis 1987; Waaijbergen 1992). In the Mediterranean regions with higher than 34m/s wind speeds, the growers are obliged to take additional measures such as the use of wind breakers, to orient the greenhouses parallel to the direction of the predominant winds, to use more resistant to strong winds types of greenhouses etc. (Zabeltitz 1984; Dimitrijevic et al 1996; Hanan et al 1978; FAO book 1987).

A second big enemy of the plastic greenhouses in some Mediterranean regions is the snow load. The most plastic greenhouses have been designed to withstand a load of 25cm thick snow or 20-25kg/m². In some regions of France, of northern part of Italy, of northern part of Greece and of Turkey the snow falls usually exceed the greenhouse resistance and the growers should take resistance and the growers should take measures. (Grafiadellis 1987; Preben and Finn 1992). The multispan greenhouses have proved more sensitive to high snowfalls (Grafiadellis, 1987). In order to avoid the damages of the greenhouses by the big snow loads, the growers are using heating, in some cases water spraying on the top of the greenhouses, more resistant greenhouse designs etc (Grafiadellis 1987; WaaiJenberg, 1992).

Every year in Mediterranean regions thousands of hectares of plastics greenhouses are destroyed mainly from wind and secondly from snow, because the growers are not taking the appropriate measures to protect their greenhouses.

b) The shape and the slop of the roof of the greenhouses.

From different research works it was found that the round arched, the shed roof and the asymmetric greenhouse types are more transparent to solar radiation than the saddle-roof types of greenhouses (Jaffrin and Urban 1990; Dimitrijevic et al 1995; FAO 1987). The saddle roof structures in the Mediterranean regions with the very small roof slopes are greatly responsible for the low transmission of solar radiation in the greenhouses, mainly during winter months (Nisen et al, 1990).

As far as the roof slops of the plastics greenhouses concern, it is well known that it effects the run off of the condensed water, the air movement inside the greenhouses and the light transmission (Grafiadellis 1985; FAO 1988). The most Mediterranean saddle roof greenhouses have usually very small roof slops with too many negative consequences. For such greenhouses roof slops of 28° are considered as minimums.

c) The dimensions and the sizes of the greenhouses.

Research done by institutions and the experience of the growers have proved that the higher vertical side walls of the greenhouses help the ventilation, the mechanization of the transport of the crops and the better development of the tall crops (FAO 1987; Nisen et al 1990). According to the Greek specifications, the height of the side walls of the plastics greenhouses should be at least 260 cm (Grafiadellis, 1987).

The most greenhouses in Mediterranean regions usually have very short side walls, too many construction parts and very small volume in m^3/m^2 (Nisen et al, 1990).

In many cases the growers are constructing too big greenhouses without sufficient ventilation (Nisen et al, 1990).

d) Light transmission.

During the colder months, the light is limited factor in the Mediterranean greenhouses, because of the short and cloudy days. Other factors affecting light transmission in the greenhouses are: the number and the size of the structural members, the orientation of the structures, the shape of the roof, the moisture condensation, the dust accumulation, the transmissivity of the glazing materials and the small roof slops. (Castilla 1994; FAO 1987; Jaffrin and Urban 1990).

e) Ventilation.

Almost all the greenhouses in Mediterranean regions are suffering from adequate ventilation. The research and the experience of the growers have shown that in the naturally ventilated greenhouses the ration between the opening area and the greenhouse floor area should be at least 22-25% and that the multispan structures which are wider than 18m should have roof ventilation (Grafiadellis 1987; Bailey 1985; Triki et al, 1984). In some cases forced ventilation have also found some practical applications mainly in floriculture (Grafiadellis, 1987).

f) The plastic films.

The research and the experience of the scientists and of the growers have proved that the duration of the polyethylene films for the Mediterranean conditions should be at least three years, the plastics films should not be fastened with nails, should require little work to be changed, should have as better as possible thermal and optical properties and should be stretched tightly (Nisen et al 1990; Zabeltitz 1990).

g) The collection of the rainwater by the greenhouse gutters.

In cases that the irrigation water is of bed quality, it is recommended to mix it with the rain water collected by the greenhouse gutters (Zabeltitz, 1984).

h) The cost of the greenhouse structures.

The research has proved that in Mediterranean conditions the expensive constructions although have some interesting advantages are not always the economical ones for practical applications (Tzouramani et al, 1995). The cost of the greenhouse structures and its effect on the cost of the products it has not well studied. (Tzouramani et al, 1995).

NEW TRENDS AND DEVELOPMENTS OF THE PLASTICS GREENHOUSES

According to Castilla (1994) from the 103395 ha of greenhouses in Mediterranean regions only the 7900 ha were covered with glass and the rest with plastics materials. From the table 2 it can be observed that the tendency is towards the plastics greenhouses.

Today the most plastics greenhouse structures are constructed from galvanized steel and from treated wood with side walls as high as possible. Beside that the growers are taken measures to protect the greenhouses from wind and from snow loads, by constructing wind breakers, by using more resistant types of greenhouses, by heating or by water spraying on the roof of the greenhouse etc.

As far as the shapes of the greenhouse structures concern the round arched with vertical sides are gaining in popularity although they are very costly and quite sensitive to strong winds.

In most Mediterranean regions the growers are constructing more and more multispan greenhouse structures with higher volumes and with bigger roof slopes. In order to improve light transmission in the greenhouses they are also trying to avoid moisture condensation on the glazing materials, to improve the orientation, to minimize the structural members, to select better roof shapes etc.

In the natural ventilation the tendency is towards higher rates of openings even 40% and mechanization mainly of the roof openings and secondly of the side ones. The forced ventilation although has found limited application in floriculture is meeting big problems in order to be adapted.

From the covering materials the long life polyethylenes of three years duration are gaining popularity. The thermal and the antifogging films due to the higher costs and to some technical problems are doing slow progress. The rigid plastic panels have also found some applications only in few Mediterranean countries.

The collection and the use of the rainwater due to high cost has only found very few applications.

The expensive greenhouse structures although have some very important advantages and are pushed to the growers by the greenhouse producing factories have not proved economical.

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