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Protected Cultivation in Mediterranean Region: Trends and Needs

Akdeniz havzasında örtüaltı tarımı: eğilimler ve gereksinimler

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ABSTRACT

Protected cultivation has rapidly expanded in many regions all over the world particularly starting from the early 1960's because of the introduction of plastics in agriculture and subsequently during the 1970's when the rise in oil prices resulted in increased heating costs. Thanks to the mild winter climatic conditions and to the possibility of adopting very simple protective shelters, the Mediterranean Region has gained more and more importance, representing now one of the most important areas in the world.

At beginning of the diffusion of protected cultivation in the region, the main objective was to improve crop adaptability to greenhouse conditions, at times not favourable also because of lacking active climate control. Nowadays, environmental concerns play an important role as much as the trader's and the consumers' demands best quality and safe produce. In this paper, after presentation of the protected cultivation industry in Mediterranean region, the main strategies to adapt the production process toward its sustainability will be discussed.

ÖZET

Örtüaltı yetiştiriciliği dünyanın pekçok yerinde, özellikle plastiğin tarımda kullanılmaya başlandığı 1960'lı yıllardan itibaren başlayarak ve ardından ısıtma maliyetlerinin artışına neden olan petrol fiyatlarının yükseldiği 1970'li yıllarda da devam ederek hızla yayılmaktadır. Ilıman iklim koşulları ve böylelikle basit koruyucu yapıların adapte edilebilme olanağı sayesinde bugün dünyanın en önemli alanlarından birini temsil eden Akdeniz Havzası giderek önem kazanmıştır.

Örtüaltı tarımı bu bölgede yaygınlaşmaya başladığında temel amaç, iklimin uygun olmadığı koşullarda aktif iklim kontrolu yapılamadığından bitkinin sera koşullarına adaptasyonunu geliştirmekti. Günümüzde ise gerek çevre ile ilgili konular, gerekse de ticaretini yapan ve tüketiciler tarafından kaliteli ve güvenli ürünlere duyulan talep önemli rol oynamaktadır. Bu makalede, Akdeniz Havzasında örtüaltı tarımı ile ilgili bilgi verildikten sonra, üretim işlemini sürdürülebilir kılabilecek ana stratejiler tartışılacaktır.

INTRODUCTION

Protected cultivation includes different type of structures protecting the plants against frost damage and extending the cultivation season or providing out of season crop production. Commercial protected cultivations appeared first in Northern Europe in the early decades of 20th century and developed broadly after the World War II by using heated glasshouses (Pardossi et al., 2004). For Northern countries, particularly the Netherlands, the important milestones were the apparition of the Venlo-type glasshouse (1935), the use of CO_2 enrichment (1960), the use of energy saving precautions during and

Table 1. Area of protected cultivation in the Mediterranean countries (ha).

Countries		Glasshouse	Greenhouse & PE tunnels	Low tunnels	TOTAL
Algeria	Jouet, 2003		6,000	200	6,200
Cyprus	Vassiliou & Chimonidou, 2006		283	450	733
Egypt	Abou-Hadid, 2006		6,800	25,000	31,800
France	Pardossi et. al, 2004; Jout, 2003	2,300	9,200	15,000	26,500
Greece	Olympios, 2008	69	7,092	7,889	14,981
Israel	M. Teitel, pers. comm.		11,000	15,000	26,000
Italy	Pardossi et. al, 2004	5,800	37,000	30,000	72,800
Jordan	Qaryouti, 2006		2,272	1,467	3,739
Lebanon	Chemali & Gerges, 2004		4,000		4,000
Libya	Ben Kafu, 2006		2,500	2,500	5,000
Malta	Borg, 2003		50	102	152
Morocco	Hanafi, 2006		20,000	3,770	23,770
Portugal	Jouet, 2003		2,700		2,700
Spain	Castilla & Hernandez, 2005; Jouet, 2003	4,800	53,843	13,055	71,698
Syria	Rafeh, 2003		4,372	50	4,422
Tunisia	Kouki, 2003		1,579	7,316	8,895
Turkey	Tüzel et al., 2008	6,840	28,051	17,055	49,746
TOTAL		19,809	191,747	138,854	351,141

after oil-crisis (1975) and computerized climate control in 1980's (Baille, 2001). Today, Dutch protected culture is one of the most intensive farming systems in the world (Goncharova et al., 2004). However, the history is shorter for Mediterranean region. The expansion of protected cultivation was in 1960s by the introduction of plastics into agriculture. Subsequently during 1970s the rise in oil prices resulting in the increase of heating costs enhanced protected cultivation in Mediterranean Region due to mild climate conditions that makes the production possible under very simple shelters. Protected cultivation in the region could be practically accepted synonymous with cultivation under plastic (FAO, 1990). Although during the following years technological improvements were recorded on plastic covering materials and structures, low-tech and low-cost structures characterize protected cultivation in the Mediterranean Region. In this paper, after presentation of the protected cultivation industry in Mediterranean region, the main strategies to adapt the production process toward its sustainability will be discussed.

AREA DEVELOPMENT

The Mediterranean Region (including all the countries that border the Mediterranean Sea) represents one of the most important areas. In 1985, there were 66,000 hectares of greenhouses and 57,000 of low tunnels, by 1995 these figures had increased to 105,000 and 91,000 respectively (Baudoin, 1999). According to data supplied by researchers in the various countries it has reached 351,141 ha in recent years, out of which 211,556 ha are devoted to greenhouses and 138,854 ha to low tunnels (Table 1) which means a 3.4 and 1.5 times increase over a period of 7 years.

TYPES OF COVERS

In terms of distribution of types of covers, over 50% of the area is covered with mulch (Table 2) which is mainly used for weed control, to increase soil temperature and to keep soil moisture resulting in reduction in the use of irrigation water amount. Spain, France and Italy account for 73.5% of the area covered with mulch.

Plastic and glass covered walk-in structures considered as greenhouses have a share of 28.5% and there is a 2.1-fold increase between the years of 1995 and 2002. Italy, Spain and Turkey are the most important three countries in terms of area. In the Mediterranean area, most greenhouses are still of low cost type (Castilla et al., 2004). Glasshouses are very rare in the region excluding Turkey with 19.6% of total greenhouse area.

Low plastic tunnel area changes from year to year due to the price and demand of crops. Although there is an increase in low plastic

tunnel area, the share in total protected cultivation area has a slight reduction during the recent years. Egypt, Italy, Turkey, France and Spain account for 72.1% of the total low tunnel area.

CLIMATIC CONDITIONS

The main advantage of Mediterranean Region in terms of wide spreading of protected cultivation is mild winter climate which compared to the countries located at higher latitudes is characterized by relatively high radiation and mild temperatures during winter (Fig. 1). Growers use only a small amount of energy for controlling the greenhouse environment (Baille, 1999). On the other hand, the growing period is often limited to 7-10 months over the year due to excess temperature and inadequate air humidity during late spring and summer since the shelters are generally not equipped with adequate cooling systems (Baille, 2001).

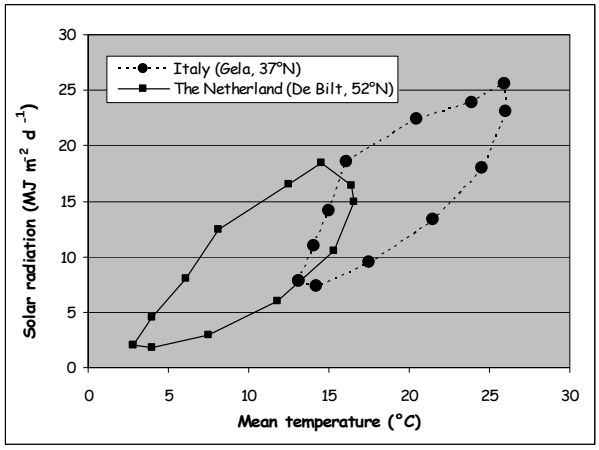

Fig. 1. Comparison of climatic suitability of protected cultivation in Gela (37°N, Italy) and De Bilt (52°N the Netherlands).

CROP PRODUCTION

Vegetable production under protected cultivations is more important in the Mediterranean Region. On the other hand, floriculture has shown an inreasing tendency in some countries (e.g.: Turkey). Concerning fruit crops, besides the usual ones (e.g.: banana, strawberry, etc.), other crops (i.e.: table grape) have grown progressively (Pardossi et al., 2004).

The vegetable growing area and production has constantly increased. In particular Solanaceous crops (tomato, pepper, eggplant) and cucurbits (melon, zucchini, watermelon) exceed 80% of the protected area. In terms of economic point of view the prices has shown a decreasing tendency which means less income for the growers (La Malfa and Leonardi, 2001). Vegetable crops are grown in autumn (from August till January) and spring (from January/February till July) seasons as short cycle in order to avoid from the cold temperatures in winter time or as long cycle starting from September/October till July. In the region, in most of the countries hybrid cultivars are used due to their higher disease resistance than open-pollinated types. Each year new cultivars are available in the market released by seed companies resistant or tolerant to new diseases.

Yield obtained in the Region compared with climate controlled glasshouse conditions is much lower, i.e. the average yield of long cycle tomato varies between 18 and 22 kg/m^2 in Mediterranean contries whereas it is 3-fold higher in the Netherlands. Also, production cost in the "high-tech" Dutch greenhouse agrosystem is much higher due to the intial investment cost and use of high technology and energy inputs in sophisticated structures (Castilla et al., 2004; Castilla and Hernandez, 2005). However, primary fuel consumption per kg of tomatoes, sweet peppers and cucumbers is estimated to be 13, 14-17 and 9 times greater respectively in the Netherlands (Van der Velden et al., 2004). On the contrary, the sales costs in Spain are substantially higher than in the Netherlands, in particular caused through higher transport costs (Verhaegh and de Groot, 2000).

TECHNOLOGY

There are large differences in the design of shelters and in the use of technology and low and high technology greenhouses are identified in the Region.

For out-of season production, the main type shelter is low-tech greenhouses with PE covering material. Production is carried out in unheated conditions excluding precautions against frost damage. Insufficient ventilation is one of the most important problems in such greenhouses causing high daily variation in temperature and high relative humidity at nights resulting in the use of high

pesticide amounts during cultivation period due to the incidence of fungal diseases. Also the average size of each enterprise is small, i.e. 91% of glasshouses and 64% greenhouses are less than 0.3 ha in Turkey (Sevgican et al., 2000).

In the region there is an increasing attention to the application of more advanced technologies to improve either climate control or growing practices due to the requirement of sustainable production techniques. Climate-controlled high-tech greenhouses are required due to the need to increase the yield and quality and to have a better timing. In those ones the construction material is galvanised iron and long-life plastic material or double layer is used in order to improve internal climatic conditions. Since climatic factors, namely temperature (air & root), humidity, light and CO_2 are controlled, the indoor conditions are independent from the outdoor.

Soilless culture has now become a part of a well established technology for intensive greenhouse production. However the area covered by soilless culture systems has expanded slowly but steadily (Baudoin, 2004). At present, it is estimated that about 7752 hectares are grown on soilless culture (Table 4). This area is only 3.6% of the total geenhouse area.

Table 4. Soilless culture in Mediterranean countries (ha)

Cyprus	18.7	Israel	1000	Morocco	426
Egypt	150	Italy	400	Spain	4000
France	1400	Lebanon	0.69	Tunisia	24.7
Greece	150	Malta	1.5	Turkey	180

* Data referred by Leonardi (pers. com.); Castilla et al., 2004; Abou-Hadid et al., 2004; Chemali and Gerges, 2004; Attard & Debono, 2004; Hanafi & Merzouk, 2004; Pardossi et al., 2004; Kouki et al., 2004; Vassiliou & Chimonidou, 2006; Olympios, 2008; Tüzel et al., 2008.

Different local materials are being tested but perlite, sand, pumice, rockwool, and coconut fiber appear to be the most commonly used substrates. The use of re-circulating soilless systems reducing environmental impact is very limited, due to the increase of salinity and requirement of a disinfection unit in the system for pest and disease management. However, serious efforts are being made to develop simple systems adapted to Mediterranean conditions (Castilla et al., 2004).

CULTIVATION PRACTICES

***Seedling production**:* In some countries seedlings are raised by farmers themselves in conditions that are less than ideal or by private nurseries (Hanafi and Papasolomontos, 1999). The main problems in seedling production are high temperature and insect spreading in summer for autumn season and/or long crop cycle, whereas low temperature and light in winter time for spring season cycle. Also the absence of skilled management and satisfactorily hygienic conditions at farmers' conditions have caused poor quality seedling resulting in lower yield and poor quality in the production. However in the most important countries for protected cultivations in the region (i.e.: Spain, Italy and Turkey) seedling are produced by private seedling nurseries and the number of seedlings either for protected cultivation or for open field production in high tech climate controlled greenhouses has increased in many of the Mediterranean countries, i.e. the number of nurseries and transplants between 1999 and 2006 increased 4.2 (from 12 to 50) and 87-fold (from 500,000 to 43.4 million) in Turkey (Tüzel et al., 2008). Therefore in some countries (i.e. Italy, Spain and Turkey) almost all of the seedlings are produced by specialised nurseries. Some of those nurseries are more and more producing grafted seedling –particularly on resistant rootstocks- which is one alternative to reduce chemicals for fumigation (Leonardi and Romano, 2004).

Irrigation: Protected cultivation considerably increases water use efficiency (WUE) compared with open-field conditions (Stanghellini, 1992; Castilla, 2000; Pardossi et al., 2004) which could be one of the reasons for the spread of protected cultivation all over the world due to reduced potential evaporation (less sun radiation; less wind and higher humidity); increased production (better control of pathologies; better control of climate parameters); application of advanced irrigation techniques (drip irrigation; re-use of drain water) (Stanghellini et al., 2003). Also, high WUE induces an improved fertilizer efficiency contributing to reduce fertiliser leaching (particularly N) (Castilla et al., 2004). Irrigation water, with few exceptions (i.e., in Tunisia where furrow irrigation is still substantially practiced), is generally provided by drip

irrigation. However, little attention is given to providing water according to actual plant needs (Hanafi and Papasolomontos, 1999). In some Mediterranean countries there is water shortages regarding to the amount and/or quality of water often coupled to an increase in their price (Stanghellini et al., 2003).

Fertilization: Generally fertigation system (fertilization by drip irrigation system) is used. However, the amount of fertilizers applied is often based on visual observations instead of any leaf and/or soil analysis resulting in misuse of fertilizers in many cases, i.e. P and K content in the soil is much higher than crop requirement (Tüzel & Eltez, 1997; Anac and Eryuce, 2003).

Plant protection: Pesticide misuse, in terms of frequency of application and dosage, inaccurate diagnosis resulting in the use of wrong pesticide, etc. is one of the important problems in the Mediterranean countries. It is estimated that 19, 16 and 24 times more active ingredients are applied per kg of tomatoes, sweet peppers and cucumbers respectively in Almeria than in the Netherlands (Van der Velden et al., 2004). Those figures threaten the sustainability and competitiveness of production. Integrated plant protection (IPP) practices are already increased in most of the countries through demonstration projects and also due to the demand of the market. On the other hand biological control is still limited in the Region.

FUTURE PROSPECTS

The Mediterranean protected cultivations, also with the differences characterising it, needs a continuous adaptation of its configuration from the technical, agronomic and management point of view, in order to correspond to a changing scenario dealing particularly with:

- The increasing globalization resulting in better communications and shipping opportunities,
- The evolution of consumers' expectations, considering more and more attentively produce safety and quality,
- The attention to environmental impact determined by intensive production agrosystems (i.e. protected cultivation) and to safeguard of the natural resources (i.e. water, soil).

According to the above scenario the protected cultivation will probably be concerned by an evolution process aimed at facing with an increasing competition of the produce obtained in different countries and with the need to adapt the production process in order to obtain a better compromise between quality, quantity and environmental impact. Considering this, the following are the most important objectives to be reached in the next years: - Product innovation, - Production cost reduction, - Yield increase, - Production qualification, - Environmental impact reduction.

All the above objectives are aimed at increasing the economical, social, environmental sustainability of protected cultivation within the Mediterranean Region.

THE CORRESPONDING STRATEGIES

The strategies that can be put in action to the ends of the adaptation of the productive systems in protected cultivation for the improvement of the sustainability level must concern specific innovations regarding one or more segments of the productive chain (i.e. seed company, seed, nursery, field, cooperative, etc.). In some cases it will be dealt to characterize and to introduce new methods, techniques and means of production, in others, more simply, than to replace them.

The theoretically possible innovations are however numerous, particularly if we refer to those suitable to northern Europe, technologically much more advanced compared to the Mediterranean protected cultivation.

With the purpose of individuating suitable innovations it is necessary however preliminarily to verify the degree of technical compatibility with the main traits of the considered protected cultivation.

Some of the strategies which could be considered in Mediterranean area concern:

- Production shelters and covering materials (improvement of climate, control insect diffusion): There is still an enormous scope for improvement of the thermal and optical properties of the cover materials, both plastic films and glass. Waaijenberg (2006) reviewed the possibilities for improving plastic films for greenhouses. The main possibilities are

- Blocking NIR to reduce the natural warming up effect.
- Blocking UV radiation to limit the activity of harmful insects
- Improving the greenhouse effect (blocking the transfer of long wave IR radiation)
- Improving the anti-fog and anti-dust properties.

In Mediterranean climate there is a huge potential for either movable screens, seasonal filters or filters whose optical properties vary with temperatures, presently under investigation (Montero et al., 2008).

The general trends of improving greenhouse design is by increasing roof slope to enhance radiation transmission and to evacuate condensed water (Baille, 2001), and building higher structure adapted to local conditions (La Malfa and Leonardi, 2001).

- ***Closed or semi-closed greenhouses:*** Active thermal storage in natural or artificial aquifers is increasingly applied in closed or semi-closed Dutch greenhouses. Thermal storage could mitigate day/night excursion in un-heated greenhouses and lengthen the growing season, while reducing the use of water and the entrance of pest (Montero et al., 2008).

- ***New species and cultivars (for product diversification):*** The insufficient dynamism in terms of product innovation through the introduction of new species or cultivar represents one sure prerogative of greenhouse industry in the Mediterranean. The number of the new crops that potentially could be introduced is rather wide, but their possibilities to affect significantly the biological structure of protected cultivation appear moderate (La Malfa et al., 1996). As far as the innovation carried out through the introduction of cultivars suitable of supplying new product typologies, the perspectives appear limited to small sized produces e.g.: miniature vegetables or produce with innovative qualitative characteristics (extrinsic and intrinsic).

Besides, a specific opportunity may come from local typologies of wide spread greenhouse crops. In any case the precautions not to be neglect regard the verification of the productive ability to the cultivar, which turning out of the interaction between the genetic characteristics and the tolerance or resistance to the conditions of stresses that characterize the cultivation in protected atmosphere.

- ***New cultivars (resistant to biotic and abiotic stresses):*** The use of resistant cultivars in the protected cultivations has progressively increased during last years and expectably such trend it will be confirmed and it strengthened in the future. Their adoption, in fact, beyond assuring numerous advantages (e.g. less chemical treatments and therefore smaller risks for the atmosphere and the consumers, possibility of cost reduction of production, etc), appears more and more an interesting perspective in relation to the diffusion also for greenhouse of integrated production process, of organic productions, etc. The remarkable attention that the plant breeding assign to the study of the factors that support the resistance to the numerous adverse biotical agents and to the constitution of new resistant cultivars, will concur to make available in the future of cultivar able to exhibit their productive characteristics also in particularly adverse biotic conditions.

- ***Alternatives to methyl bromide (MeBr)***

Grafting: In greenhouse vegetable production, continuous cropping results in soil-borne diseases and nematodes. Grafting is one of the tools to avoid soil-borne diseases such as Fusarium wilt in Cucurbitaceae (Cucumber, melon etc.) and bacterial wilt in Solanaceae (tomato, pepper etc.) (Oda, 1999). It has become an essential technique for the production of fruit-bearing vegetables grown in greenhouses. Grafting has also increased the resistancy of scion to abiotic stress factors.

Soilless culture: Soilless culture systems offer a way of improving water use efficiency and obtaining better water management in crop production (Burrage, 1999), which has become major concern in most Mediterranean areas due to the water quality and scarcity of water supply. On the other hand, the spread of soilless culture, with 3.6% of the total greenhose area, is still limited. No doubt that the future lies in systems that minimise their impact on the environment; closed systems where the nutrient solution is retained within the system and ground water pollution is reduced to a minimum (Tüzel et al., 2004).

Soil solarisation: This technique has assumed increasing importance as a consequence of the restrictions in the use of the methyl bromide and more in general to the necessity to reduce the use of chemicals for the control of soil born diseases. In consideration of the variety of factors that concur to determine the effectiveness of the solarisation treatment and consequently to the incerte efficacy of the treatment the treatment can not be considered resolutive; therefore the technique still finds an employment limited, also in consideration of the long interruption of the productive activity that its adoption involves. Perspectives more interesting seem to offer with reference to the use of the soil solariation and in combination with other technical means (e.g. chemical treatments, biofumigation, etc.) or biological (e.s. resistant cultivars).

Fumigants different from methyl bromide: Different chemicals (1-3-dichloropropene, dazomet, metam sodium aldicarb, cadufos, fenamiphos, fostiazate, prophos and oxamyl) are used as altervative to MeBr (Greco and Vito, 2004).

- ***Improvement of water and nutrient use efficiency (through fertigation, tensiometers, etc):*** The high degree of intensification that characterizes the productive systems in protected cultivation often involves the massive employment of production means in amounts higher than the real crop requirement. The directed consequence is the considerable environmental impact deriving from the intense exploitation of the natural resources and the release of chemicals, fungicides, insecticides and fertilizers mainly. Not considering the effects on the agro-ecosystem for which, at least on the normative plan currently there are not tightening ties, the more punctual quantification of the crop requirements could concur to reduce the production costs through a more efficient use of means of production (es. water, fertilizers, etc). The margins for the attainment of this last result appear enough considering that a more correct quantification of the requirements is today possible with the availability of instruments and innovative methodologies (e.g.: uptake estimation, captors, etc); besides more efficient modalities of application are available (e.g.: fertirrigation, etc.).

- ***Pest and disease control with the use of antagonist organism:*** The researches in biological control agents have been conducted over thirty years. Although their proportion in the greenhouse crops may be higher, biocontrol agents still represent a specialised niche market. However, biocontrol products currently represent less than 1% of the total world market of crop protection products (Benuzzi et al., 2004).

- ***Extension of the production cycles (to reduce rest period, thus increasing yield per year):*** The discontinuity of the production calendars represents one of the features of the protected cultivations in Mediterranean climate; the necessity of an interruption of the productive activity is consequence of the elevated temperatures of the summary months or the succession in the course of the same year more cultivation cycles. To the aim to realize a more regular production, beyond that to raise the system effectiveness through an increase of the yields, the widening of the cultivation cycles is more and more considered in order to carry out growing cycles lasting up to 10 months. Such strategy if from a part offers obvious advantages, from the other it places the necessity to have available protection structures of suitable dimensions and however suitable to assure favourable climatic conditions to the cultivation also in correspondence of the periods marked out by suboptimal thermal levels. The widening of the offer calendars goes however considered holding account that the obtaining of the production expectably will come true in periods in the course of which the competition from part of the coming from product from other areas is more meaningful.

- ***Process and product certification (e.g.: GlobalGAP):*** "Quality" is the new prerequisite for any current and future market strategy. Product needs to offer high quality and safety that meets the international standards. Also the traceabilitiy of the produce is becoming a necessary must for the production, in order to provide the consumer with the required security about the way of producing. Growers have to produce their high quality products in an environment conscious, labour safe and hygienic way and within socially accepted labour conditions to meet the customer's demands (van Uffelen et al., 2000).

CONCLUSION

The protected cultivation in the Mediterranean area has assumed such an importance to make them irreplaceable both under economically and socially points of view. The evolution of the cultivations protect in the Mediterranean area has been manifested not only by a continuous and huge increment of the area devoted, but also with a progressive adaptation of the production process in function of the scenes that in the time have been gone delineating.

The aspects that sure will condition the development of greenhouse industry in the area concern the increasing international competition, the production costs which are particularly high in some countries and the increasing attention of the consumers in relation to the quality of the product and the sustainability of production process. In this picture the priority concerns the individuation of possible strategies suitable to improve the efficiency of protected cultivation. The correspondents process innovations that seem more suitable to the aforesaid development will have however to be validated in connection with the context of reference and to their possible integration. To such scope the adoption of a systematic approach based on the involvement of different "actors" will allow the increase of sustainability of the Mediterranean protected cultivations.

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