The background.

Plastic film can be used to aid crop production in many ways. Polyethylene and other materials can be formulated to control or utilize more effectively the heat and light energy from the sun, and also heat energy radiated from the soil. These forms of energy are part of the electromagnetic spectrum and differ only in their wavelength. By using different polymers and additives, it is possible for films to transmit, absorb or reflect different wavelengths preferentially. It is possible, therefore, to create a wide variety of microclimates by using different types of film, either as covers over crops or as mulch on the soil surface.

The ideal properties of the films used for these very different growing systems in temperate regions are essentially the same. These are[1]:

a. A film lifespan suitable for the end use. This will vary from a few months for direct covers to three or four years for greenhouses.

b. Suitable visible light energy transmissions with a wavelength range from 400 nm to 700 nm.

c. Good transmission of solar heat energy (near infrared wavelength range 700 to 2,100 nm).

d. Low transmission of black body radiated heat energy (wavelength in mid infrared range from 7,000 to 14,000 nm).

Polyethylene (usually 150-180 micron) is the main plastic used for greenhouses and low tunnels. Other materials, such as PVC, EVA and glass-reinforced polyester sheeting, are also used, but in relatively small amounts. Low density polyethylene (LDPE) has a number of advantages, including cheapness, availability in large sheets, high light transmission and light weight, but it has also important disadvantages. It is short-lived (2-3 years at most) and has poor heat retention, allowing some 60-80% of radiant heat (mid infrared) to pass through.

As one of the main requirements of plastic films is low transmission of radiant heat, this is a major defect, as any heat generated under the film by the action of sunlight on plants or soil will be rapidly lost through the film at night. The heat-retention properties of polyethylene can be greatly improved by the incorporation of a suitable filler to produce infrared polyethylene (IR PE)[2].

[1] Robinson & Brae. Developments in plastic structures and materials for horticultural crops. www.fftc.agnet.org

[2] Robinson & Brae. Developments in plastic structures and materials for horticultural crops. www.fftc.agnet.org

Of a number of materials tested, including calcium carbonate, talc and china clay, calcined clay was the most effective, giving the strongest absorption in the mid to far infrared. This thermal barrier film retained over 70% energy and gave the greatest heat retention. It also increased the yields of a number of crops and extended the growing period (Hancock 1988)[3]. Although films with inorganic fillers retain a greater proportion of radiated heat at night, they have the disadvantage of reducing visible light transmission and heat energy gain during the day. This has tended to limit their use in areas where winter light levels are low.

The shortcomings of single layer films are now being overcome as a result of the extension of co extrusion technology into wide film manufacture, supported by the continuing development of special purpose polymers and additives. Co-extrusion enables the desired properties of different polymers to be combined, and can be used to compensate for their negative effects. In this way, a final polymer can be made with all the desired properties at an acceptable price. For example, the co-extrusion of EVA as a middle layer with polyethylene as the two outside layers can overcome the weaknesses of both materials. Thus coextruded films can be made with good light transmission plus heat retention properties, and with little deformation under wind or snow loadings[4].

Demonstration set up and results.

Growing watermelon in low tunnels is a widespread practice among Albanian farmers. Actually, the large majority of growers are using simple polyethylene films. Mostly they accept the advantage of use of thermal plastic films, but often hesitate to use them by arguing that it is economically questionable. Indeed, the cost of thermo plastic coverings is 3.5 - 4 times higher per ha compared to simple polyethylene films. Though the thermoplastics might be used for two successive years (by reducing the investment cost by two) the higher initial investment cost is the reason of theirs limited use. Through several specific demonstrations AAC was aiming to check out the efficiency of using thermal plastics in terms of quantity and quality of production as well as in terms of financial efficiency, and therefore to encourage its use in support of competitiveness of watermelon value chain.

There were three demonstration plots settled, respectively in; Fier (Kurjan), Lushnje (Divjake) and Saranda (Xarre). Good farmers were selected based on a share cost agreement. Each plot a 0,5 ha open field watermelon, labor and input costs were provided by farmers, while AAC has contributed with the cost of thermo plastic of 0.5 ha, for each demonstration.

The expected outcomes of the proposed technology included;

[3] Hancock, M. 1988. Mineral additives for thermal barrier plastic film. Proceedings, Conference on `Plastics in the Nineties'. 1988. British Agricultural and Horticultural Plastics Association.

[4] Robinson & Brae. Developments in plastic structures and materials for horticultural crops. www.fftc.agnet.org

1. Increase in productivity.
2. Increase in revenues and profit
3. Expanded market opportunity due to earlier production.

The planned parameters to be measured included;

- temperature inside the tunnels,
- days to first flowering,
- days to first harvest,
- days to first harvest,
- marketable yield and the respective prices.

At first glance we assume that the main benefit from the use of thermal films is the effect on the air temperature of the greenhouse/tunnel, which is the criterion most frequently measured in order to determine whether the film is doing its job.

The truth lies elsewhere, without underestimating the importance of nocturnal greenhouse air temperature. Of prime importance is the maintenance of optimal temperatures of the plants we are growing in a greenhouse/tunnel. If the air is warm at night it will impart some of its energy to the plants which it envelopes. In other words, plants in a greenhouse covered with a thermal film which is absorbing heat radiation and is relatively warm will (theoretically, at least) be warmer than they would be where they exposed to the sky above with no plastic (or glass) cover or with a non-thermal cover[5]. Another important , perhaps the most important, benefit is the fact that condensation of moisture in the greenhouse/tunnel will occur on the plant surface only as a "last resort" after the moisture has condensed on other, colder surfaces

Row covers, or plastic low tunnels, protect crops from frost and create favorable conditions for plants to achieve early production. But meantime there are data illustrates both the opportunities and hazards of low tunnels: unless the grower is prepared to vent them daily, maximum temperatures inside can injure plant growth[6].

These facts were clear for farmers involved in demonstration activities. They reported about significant temperature differences inside tunnels covered with simple polyethylene versus tunnels covered with thermo plastic[7]. According to their observations, air temperature of thermo plastic tunnels during the night was about 2 Celsius degree compared to simple plastic tunnels. A totally different picture was observed during sunny days. The air temperature

[5]Ashkenazi Y. Benefits to the grower from the use uf modern "sophisticated" plastic greenhouse covers. www.ginegar.com .

[6] Ch. Wien. Use of low tunnels to improve plant growth in high tunnels.

[7] Gjergji Todi. Personal communication.

inside thermo plastic tunnels was up to 10 Celsius degree less, compared with simple polyethylene tunnels. Due to that temperature differences the growth rate of thermo plastic tunnel's plants was higher, plants were more vigor, and fruit setting was earlier and more uniform. All this advantages at the end resulted to up to one week earlier harvests and higher yields[8].

Farmer's impression and observations are supported by data collected from AAC staff of Lushnja office. They reported significant differences regarding flowering (5 to 10 days) and first harvest (4 to 6 days). Higher early and total yield (up to 100 kv/ha) was also recorded each demonstration site (Table 1). According to farmers interviewed the increase in early production due to thermo plastic range from 150 kv/ha to 300 kv/ha.

Table 1. Flowering time, fruit setting and watermelon early production of simple polyethylene and thermoplastic tunnels.

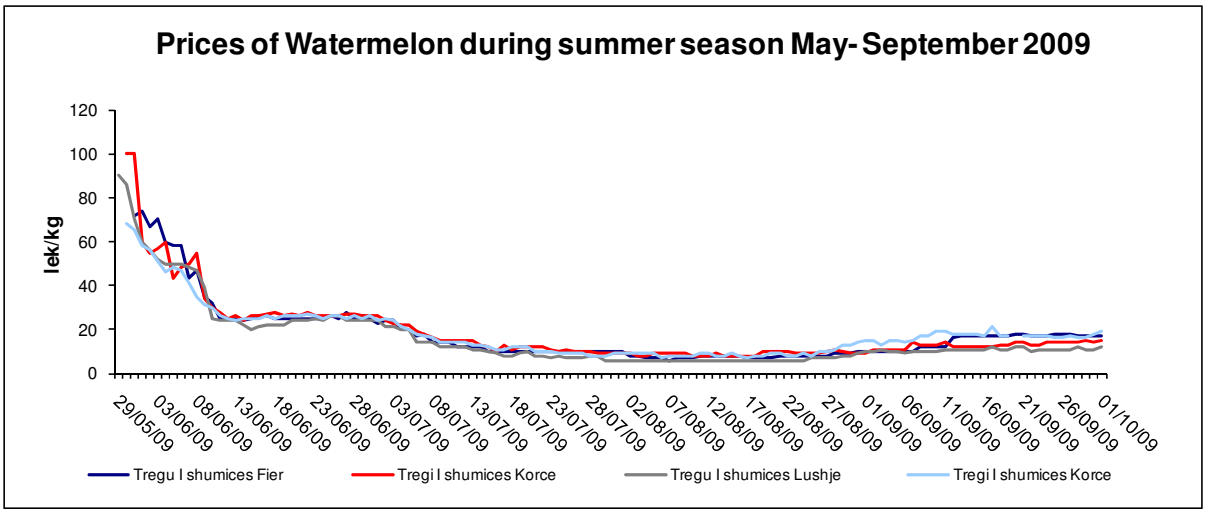
Data/site	Lushnje (Divjake)		Fier (Kurjan)		Sarande (Xarre)	
	Simple polyethylene	Thermo plastic	Simple polyethylene	Thermo plastic	Simple polyethylene	Thermo plastic
Planting	March 14	March 14	March 15	March 15	March 8	March 15
Flowering	April 26	April 20	May 4	April 29	April 25	April 15
Harvesting	June 5	May 31	June 21	June 15	June 14	June 10
Yield (kv/ha)	650	700	450	470	450	550

The use of thermo plastic covering low tunnels is well justified from the financial point of view (Table 2). By assuming an increase of total production of about 10%, from 660 kv/ha in common grafted watermelon production to 726 kv/ha in grafted and thermo plastic production), obtained due to an increase of 130 kv/ha of early production, the increase of market revenues and farmer's profit was very significant. As it could be seen from table 2, an increase of about 1600 euro/ha was calculated in farmer's profit due to thermo plastics.

While the increase of total yield is moderate (about 10%), the much higher profit in this case was obtained mostly due to higher market price of early production. As it can be seen from the graph below[9] the changes in market prices of early watermelon are huge at the beginning of harvesting season. Probably a single day might cause a large difference in farmer's incomes, making the issue of earliness a first priority of watermelon production technology.

[8] Jorgji Krruti. Personal communication.

[9] Denalda Kuzumi. AAC data base. Personal communication.



There is an additional advantage of thermo plastic films one must consider. Due to higher night temperatures, the risk of late frosts might be avoided, thus increasing the safety of farmers business. This advantage was confirmed by the case of March 12, where due to the sudden frost tens of hectares from simple polyethylene covered watermelons were totally destroyed in Lushnja and Berat, but none from thermo plastic covered watermelons[10].

Discussion and recommendations.

The use thermo plastic films versus simple polyethylene coverings are of great interest in watermelon production. By providing higher temperatures during the night, but lower in sunny days thermo plastic films provides a higher growth rate and faster development of plants, resulting to 5-7 day early harvesting and 15-30 ton/ha more early production. Thanks to much higher prices at the beginning of harvest season farmers profit per ha might increase up to 1600 euro per ha. Meantime, due to its better insulation properties thermo plastics might save plants on cold/late frost nights, making the farmer's business safer.

The high initial cost is the main obstacle for massive use of thermo plastic films. Compared to common simple polyethylene films, their initial cost is up to 4 times higher. Anyway, contrary to common plastics, thermal ones might be used for 2 or 3 successive years, distributing the corresponding cost in two or more year. The additional benefit is a significant reduction of plastic films wastes due to agricultural activities which are becoming a serious environmental threat in highly intensive agricultural areas in Albania.

[10] AAC Lushnja office. 2009. Mbulimi me plasmas termik i bimeve. Extension leaflet.

The use of thermo plastic covering low tunnels is well justified from the financial point of view. Practically, an increase of about 1600 euro/ha was calculated in farmer's profit due to thermo plastics, which was achieved due to higher market price of early production.

Based on the relatively high initial investment cost, the use of thermo plastic films might be promoted by subsidizing the additional cost of simple polyethylene films (500 euro/ha) or by providing farmers with credits with no interest to purchase thermo plastic films. Support provided – either grant for ha or subsidized interest rate – is justified on the ground of several perspectives: supporting farmers establish an innovative "model"; the model will result in higher profits and lower risk – both factors that are supposed to have a multiplication effect, recompensing farmers for environmental benefits created, and increasing chances for export to niche markets. Chances for export would substantially increase if support to farmers is provided through exporters using contract farming.

	Table 2. Summary of crop expenditures and incomes (euro)				
Incomes					
		Planted area (sq.m)	10000	Simple polyethylene	Thermo plastics
Yield (kv)				**660**	**726**
Average price (ALL/kv)				**1850**	**2027**
Sell's incomes					
	Watermelon			9768	11774
		Total sells		**9768**	**11774**
Direct costs					
	Mashinery costs			187	187
	Labor			1455	1557
	Seedlings			1400	1400
	Fertilizers			960	960
	Pesticide			120	120
	Bee hife rent			0	0
	Electric power			800	800
	Plastic films			**520**	**800**
	Total of direct costs			**5442**	**5823**
Indirect and administrative costs					
	Depriciation			142	142
	Maintenance			0	0
	Administrative costs			100	100
	Non planned costs			263	282
	Total of indirect costs			**505**	**524**
Incomes without interests and taxes				**3821**	**5427**
	Bank interests costs			**0**	0
	Taxes			**0**	0
	Credit loans			**0**	0
		Total expenditures		**5947**	**6348**
Net incomes				**3821**	**5427**