PISTACHIO – A NEW POSSIBILITY

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Introduction

Fruit production in the Republic of Macedonia is mainly concentrated in areas about 300 to 800 m above sea level, mostly in the western part of the country. Due to different altitudes, there are various microclimate areas with special weather conditions suitable for fruit production. Over 150,000 t of fruit are produced on an area of about 15,000 ha on some 7.6 million fruit trees, about half of which are apple trees (Agency for Foreign Investment of the Republic of Macedonia, 2007).

One of the hardest declining is recorded in pear production which suffered serious losses in the early 90's of the XX-th century, as a result of the appearance of Fire blight *(Erwinia amylovora (Burrill) Winslow et al.)* which devastated pear production in the eastern part of the Republic of Macedonia, thus forcing fruit growers to seek other production possibilities. Looking for a way out producers turned to other fruits thus changing the fruit production structure by expanding fruits that were not previously present in certain regions (Mitrev, 1994; Mitrev, 1995).

One of the fruits that draws the attention of fruit growers in the Republic of Macedonia for sure is pistachio, as this fruit has the potential to sustain all the challenges of different climate types. This fruit is quite unknown to the broad audience but experiences from countries such as Turkey give reason to a conclusion that it could prove itself worthy of trial to be introduced. It is a nut fruit which is grown with great success in areas with sub-tropic and moderate-continental climate type. The Republic of Macedonia fits in both climate types and the possibilities for successful large scale introduction are proven with the existence of the autochthonous variety *Pistacia terebintus* L. that has been proven to be very resistant to low temperatures and could be used as a root-stock (Petkov, 2002).

Due to the low content of fat and high content of proteins, carbon-hydrates, minerals, vitamins and other bio-active materials pistachio is one of the finest and most delicious nut-fruit with high nutritional and dietary

value. Pistachio's nut contains 47-56% fat, 17.4-24% proteins, 4-19% carbohydrates, 4-6.5% cellulose, 2.5-3% ash, and significant amounts of vitamins A, B_1 (Petkov, 2002).

In spite of the fact that pistachio as a fruit is known for millennia its globalization was initiated in the '60's of the XX century. Such interest is due to the enormous demand on the market and its stable price. Although it can be found on all continents, majority of orchards are located in the Near East and Mid Asia. In 2000 there were 371,714 ha under pistachio with the annual production of 430,313 t. Top countries holding majority of the world production are Iran, Turkey, USA, Tunisia and Syria respectively (Petkov, 2002).

Status presens

The average size of farming agricultural households producing fruit is 2.9 ha of the nation's arable land and it has a declining trend from 21,500 ha in 1992 to 16,000 ha in 2003. Two thirds of the fruit producers are part-time farmers. Between June and October, around 85% of the fruit producers market their products, corresponding to the lowest market prices (AgBiz Program, 2009; Petkov, 2002; Ministry of Agriculture, Forestry and Water Economy of Republic of Macedonia, 2004; Ministry of Agriculture, Forestry and Water Economy of The Republic of Macedonia, 2005).

Yields in qualitative and quantitative terms are low due to the use of old machinery, uncertified propagating material and insufficient use of agricultural inputs and irrigation. Fruit farmers are poorly organized. A survey conducted among producers in 2005, wholesalers and retail traders and agricultural associations showed that the fruit farming sector is inadequately supported in financial and technical terms (research/extension), as there is lack of packing, sorting and manipulation, storage and processing capacities, and lack of relevant information on market standards for quality for both domestic and foreign markets (AgBiz Program, 2009).

In 2005, fruit export (including dried and semi processed) reached €18.4 million (mainly apples 30%, table grape 22%, wine grape 19% and semi-processed fruit 8%), while fruit import was € 15.6 million (85% tropical fruits and citrus). Net exports were € 2.8 million. The largest part of the fruit export is with the neighboring countries (AgBiz Program, 2009).

Table 1. Crop area (ha) (State Statistic Office, Republic of Macedonia, Statistical Data Base, 20.12.2010).

	2000	2001	2002	2003	2004	2005
Apples	7379	7456	7283	8110	8051	7200
Plums	3206	3655	3063	6141	6133	2610
Peaches	1411	1249	1320	1329	984	949
Apricots	597	433	424	368	350	345
Pears	1071	1099	1080	1039	1040	830
Cherries	360	360	358	345	354	300
Sour cherries	2270	2503	2518	2478	2492	1535

The Table 1 clearly identifies the constant fall in the area under orchards on national level. Only apple orchards tend to keep some kind of stability as the rest of the fruit records only downward trends.

In the last several years different factors determined the production abilities; among many of them is the effect of climate change. In 2008 under the auspices of the Global Environmental Facility and UNDP a Second National Communication on Climate Change was issued. A number of academics and other relevant authorities worked to determine what the Republic of Macedonia would be facing in the second and third decade of the XXI century.

Many studies were carried out in order to provide answers to numerous questions which were bothering Macedonian farmers, beginning from ordinary disease appearance to such complex issues as climate change effect, on which none of the farmers can have any influence to improve production conditions. This paper deals with the effect of climate change on the whole territory of the Republic of Macedonia (Ministry of Environment and Physical Planning of Republic of Macedonia, 2008).

Weather conditions - National characteristics

Weather conditions are one of the most influential factors in agriculture since there is no way to limit or prevent their influence over any plant. Hence, proper research activities are essential in order to determine whether any new crop (pistachio included) could adapt to the standing conditions. Pistachio is a fruit which does not have great water demand, so looking at the wider picture it is clear that it could serve as a new opportunity in the areas with precipitation between 400 – 500 mm, and that is the area that suffered most from the loss of pear orchard during early 90's of the XX century. The precipitation distribution is quite unfavorable for most of it comes in the months of February, March, May and November, providing very little rainfall in the summer months (Mitrev, Zlatkovski , 2010).

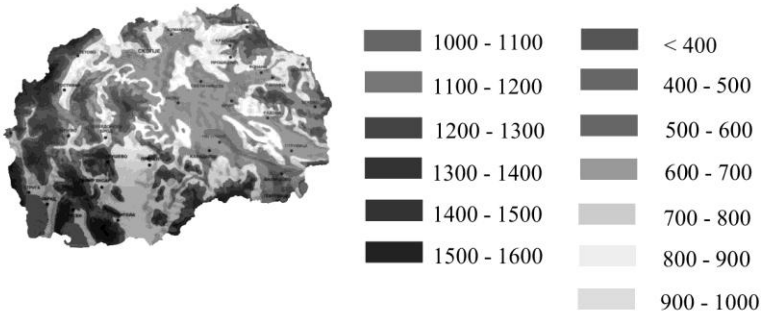

Figure 1. Precipitation layout (mm) in the Republic of Macedonia.

The picture clearly suggests the areas suitable for pistachio growing as this crop is quite susceptible to hard and moist retaining soil types, since there is significant level of jeopardy that the root system will suffer from soil borne pathogens such are *Verticillium sp., Alternaria sp., Phytophtora sp., Armillaria sp*. etc. (Petkov, 2002).

The other determination factor is the temperature and as presented in Figure 2, the majority of the territory of the Republic of Macedonia is exposed to higher average temperatures (above 14°C). This is quite important because as a heliophyte pistachio demands long, dry and hot summers. Insufficient light leads to nut disability to reach optimum size and that prevents the endocarp to detach (it does not break) (Petkov, 2002).

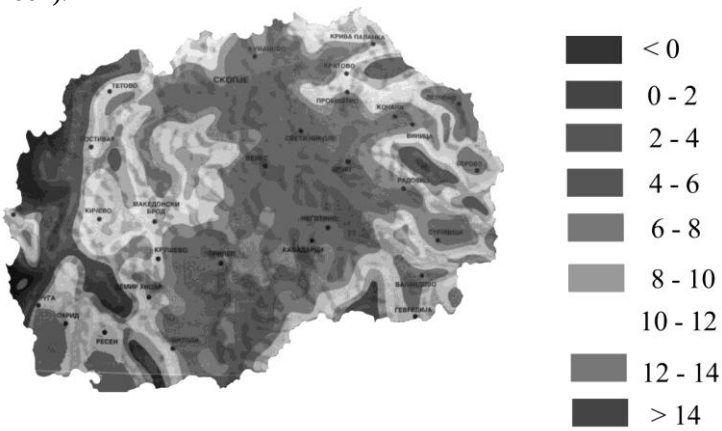

Figure 2. Average annual temperatures (°C) in the Republic of Macedonia.

According to Petkov (2002), this factor presents no threat to pistachio introduction since many research activities prove this crop as quite

resistant to this factor. Furthermore, having a late blooming period it is very favorable in the areas that tend to have late spring frost, often causing damages to apricot, peaches and almonds.

The rate of split nuts of some varieties is quite important. The bigger the percentage of unsplit rate, the more unfavorable the variety is, since there is a necessity for additional resources to open the unsplit nuts (Table 2). Generally, Iranian varieties have higher splitting rate (Ak, 1998)

Table 2. Rates of split nuts (%) (Ak, 1998).

Varieties	Years			Average
	1992	1993	1994	
Kirmizi	57.98	31.37	42.10	43.82[b]
Siirt	79.49	64.69	55.29	66.49[a]
Ohadi	76.56	41.96	22.52	47.01[b]
Bilgen	75.01	36.93	13.72	41.89[b]
Vahidi	38.46	55.53	3.22	32.40[c]
Mumtaz	82.79	57.95	32.22	57.65[a]
Average	68.38[a]	48.07[b]	28.18[c]	48.21

LSD5% (variety): 0.17; LSD5% (year): 0.12; LSD5% (variety x year): 0.29;

Abcd: values marked with different letters are significantly different

Next on the level of importance for pistachio fruit are fruit weight, fat and protein content. Such research was carried out on the nuts grown in the collection garden of the Institute in Gaziantep. Eight of them were Turkish (Kirmizi, Uzun, Halebi, Siirt, Çakmak, Ketengömlegi, Degirmi, Sultani) and five of them were Iranian (Ohadi, Vahidi, Mümtaz, Haci Serifi, Sefidi) (Karaca, Nizamoglu, 1994).

The analyses were based on the results of 1984, 1985, 1987. The nuts of Iranian pistachio trees were bigger than Turkish nuts. Approximate weight of the 100 Iranian pistachio nuts was 162.03 g. while Turkish types were about 129.72 g. splitting percentages of Turkish types were 67.14 % and the Iranian nuts were about 78.70 %. Karaca and Nizamoglu (1994) reported approximate fat of Turkish and Iranian nuts were about 57.68 % and 55.43 %, respectively. The protein content of Turkish type was 22.08 % and for Iranian type it was 22.69 %. There was not an important difference in protein content between Iranian and Turkish nuts.

Vulnerability and adaptation to climate change

The scenario used to determine possible outcomes is based onthe status in the year 2006, performed on a comparative analysis of two thirty-year series, i.e.1961-1990 and 1971-2000. The first analysis pointed out that the

period 1971-2000 was annually warmer than the period 1961-1990 in almost all climate areas in the country, while mean monthly temperatures varied during the year. Winter and summer months were warmer in comparison to the period 1961-1990. Despite this, autumn and summer months were colder compared to the previous thirty-year period. The highest values of mean annual deviations of the air temperature in the Republic of Macedonia appear in the region with sub-Mediterranean climate (Valandovo 0.7 °C, Gevgelija 0.5 °C, and Nov Dojran 0.2 °C). Climate change projections of the main climate elements (temperature and precipitation) have been made up to the year 2100 (Table 3), i.e. for the periods 1996-2025, 2021-2050, 2050-2075, and 2071-2100 in comparison with 1961- 1990.

According to the results presented in Table 3, the average increase of temperature is between 1.0°C by 2025, 1.9°C by 2050, 2.9°C by 2075, and 3.8°C by 2100, while the average decrease of precipitation ranges from 3% in 2025, -5% in 2050, -8% in 2075, to -13% in 2100 in comparison tothe reference period.

Table 3. Projected changes of average daily air temperature (°C) and precipitation for the Republic of Macedonia based on direct GCM output interpolated into geographic location 21.5°E and 41.5°N with regard to the period 1990 (Ministry of Environment and Physical Planning of Republic of Macedonia, 2008).

	Changes of temperature (°C)				Changes of precipitation (%)			
	ANNUAL				ANNUAL			
Sensitivity	2025	2050	2075	2100	2025	2050	2075	2100
Low	0.9	1.6	2.2	2.7	-1	-2	-4	-5
Mean	1	1.9	2.9	3.8	-3	-5	-8	-13
High	1.1	2.1	3.6	5.4	-6	-7	-12	-21

It is expected that the largest increase of air temperature in the Republic of Macedonia is expected in the summer season, associated with a strong decrease in precipitation as presented in Tables 4 and 5.

Table 4. Projected changes in average daily air temperature (°C) based on direct GCM output (Ministry of Environment and Physical Planning of Republic of Macedonia, 2008).

Average temperature change (°C)																
	winter				spring				summer				autumn			
	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100
Low	0.7	1.4	1.8	2.2	0.7	1.3	1.8	2.2	1.2	2.2	3.2	3.7	0.8	1.5	2.2	2.6
Mean	0.8	1.7	2.3	3.0	0.8	1.5	2.2	3.2	1.4	2.5	4.1	5.4	0.9	1.7	2.8	3.7
High	0.9	1.9	2.9	4.2	0.9	1.8	2.9	4.6	1.7	2.9	5.1	7.6	1.1	2.0	3.6	5.3

Table 5. Projected changes in precipitation (%) based on direct GCM output (Ministry of Environment and Physical Planning of the Republic of Macedonia, 2008).

Precipitation change (%)																
	winter				spring				summer				autumn			
	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100
Low	1	5	3	4	-3	-2	-7	-5	2	-16	-21	-21	2	-2	0	-5
Mean	0	1	2	-1	-5	-6	-10	-13	-7	-17	-27	-37	-1	-4	-9	-13
High	-2	-1	1	-3	-7	-10	-13	-22	-24	-18	-33	-53	-3	-7	-17	-23

For the eastern part of Macedonia with prevailing continental climate an impact of a slight increase in precipitation by 6%, is expected in winter, but a decrease in all other seasons, most intensive (-20%) in summer. In summer as well as in autumn, an increase in daily air temperature is expected, reaching the maximum value of 5.2°C in summer 2100.

Analysis of the impact in agriculture

General conclusion by the given data leads to the finding that there will be significant decrease in yield, especially in vulnerable areas. By 2050, Shtip as a city located in one of the most vulnerable areas and where winter wheat is a major crop, is estimated to suffer yield loss of up to 17% and grape yield in the region of Kavadarci by 2050 is estimated to reach 50%. The projections are made with the assumptions that crops will be grown without the possibility to irrigate (Ministry of Environment and Physical Planning of Republic of Macedonia, 2008).

In order to avoid greater negative effects it is suggested to implement several adaptation measures, such asintroducing water-saving irrigation measures, soil and water preservation, new agricultural practices, introduction of less-water demanding crops (Ministry of Environment and Physical Planning of Republic of Macedonia, 2008).

Due to climate change soil erosion is also expected to be accelerated. The most vulnerable regions of cultivated soil are: Central Povardarie, especially the area of the confluence of the rivers Crna and Bregalnica with Vardar and South Povardarie (Ministry of Environment and Physical Planning of Republic of Macedonia, 2008).

Results and discussion

Facing evident change in climate, recording a drop in areas planted with orchards, which results with reduced production volume hence increasing trading deficit, it is very important to set a course to intercept the forthcoming changes and challenges.

Agriculture is determined by many factors and one of the most influential is the natural one, hence the importance of carefully analyzing every scenario that might appear in order to build-up a successful business.

As unpredictable as the market trends can be, and already manifesting climate changes in many areas accompanied with a downward trend in orchard area, it is a moment to set a direction in which Macedonian fruit growers will identify their future activities. Knowing that fruit growing is a long-term investment often with high demand for initial capital values, it is of great importance to provide reliable information.

Pistachio is a typical xerophyte and its most favorable conditions are those similar to arid, semi-desert and desert conditions of Near and Middle East. Nedev et al. (1983) and Popov (1979) stated that pistachio roots were found at a depth of 1.2 m in the first year of planting, while the depth of pistachio roots at matured trees had reached 20 m. It is a fruit that demands long, hot and dry summers but short and moderately cold winters. Kaska et al. (1990) point out that in South Anatolia there is a sufficient number of high summer temperatures and that there are 98-110 days with an average daily temperature above 30°C. In areas where the average daily temperature is below 22°C, pistachio fruits do not mature, the nut does not fill the shell, the percentage of opened fruits is low and the mesocarp detaches from the endocarp with difficulties.

On the other hand, the need of pistachio for temperatures below 7°C represents a burden for successful introduction to the south. According to the need for a number of hours with temperatures below 7°C IPGRI (1997) divided pistachio varieties into three groups:

- Low need (under 600°C)
- Medium need (600-1200°C)
- High need (above 1200°C).

Knowing that almond and pistachio originate from the same area (Mediterranean) their resistance to low temperatures is almost the same. The difference is almond's earlier blooming period which makes that fruit more susceptible to spring frosts as opposed to pistachio which blooms much later. Furthermore, pistachio has a stable winter dorm period and possible frequent changes of temperatures in the atmosphere will not cause premature bud growth hence preventing any damage by spring frosts as would be the case with almond (Petkov, 2002)

The weather in the regions suitable for pistachio growing in the Republic of Macedonia varies from moderate continental to sub-Mediterranean. Most northern city Kumanovo has annual average temperature of 11.8°C, Skopje 12°C, Vinitsa 12.9°C, Shtip 13.2°C, Veles 13.3°C, followed by Kochani 14.1°C, Valandovo, Gjevgjelija and Dojran with 14.2°C, respectively. For pistachio it is of great importance to have a high value of annual temperature sum because in insufficient values the plant cannot complete the physiological process with a possibility to enter winter unprepared. Highest temperature sums are recorded in the South Povardarie region, in the cities Valandovo with annual temperature sum of 5210°C, Gjevgjelija 5201°C up to the northern city of Kumanovo with sum of 4310°C. In order for the fruit to ripen it is essential to have a sum

of active temperature above 10°C, hence it should be avoided for planting in regions where summers are not warm enough because fruits will not ripen. Cities with highest active temperatures are Gjevgjelija 4446°C, Valandovo 4448°C, Dojran 4403°C, Kavadarci 4293°C and Kumanovo 3662°C respectively. Even though pistachio survives in quite arid areas, it reacts quite positively to rainfall (Petkov, 2002; Mitrev, Zlatkovski, 2010).

Further fruit production in the Republic of Macedonia could consider introducing pistachio in its strategies for development. If predictions of the National communication on climate change are to be true, further drop in yields in major growing areas will become a serious threat, especially to cherry, sour cherry, apple and grape growing practices.

Data on weather, soil and existence of pistachio varieties point that the growing this crop is quite possible, but a lot is yet to be done. Since there is no plant propagation facility in the Republic of Macedonia and no National list of approved varieties, it is essential to performcareful research activities in order to set most adequate varieties in most suitable regions. On the other hand, since areas in which pistachio would be established do not have possibilities for irrigation, or such possibility would require significant investment, setting proper planting dimension is of great importance.

The next issue would be the establishment of new orchards. Proper choice of rootstock is of great importance, as there are different varieties resistant or susceptible to drought. Knowing various practices such as planting rootstocks and later grafting use of 2-year old plantlets, it is quite important to set adequate planting dimensions in order to use intercrops for planting different crops which could support farms economic balance (Petkov, 2002).

Conclusions

It is evident that even at this phase there are favorable conditions for growing pistachio in several of the regions in the Republic of Macedonia. Temperature sum is at the required level, precipitation level is enough to sustain plant's water needs and soil conditions are on the satisfactory side as well.

Still, there are several important things that require attention, to set a proper order of activities:

- Establishing scientific relations with institutions that have a tradition in similar activities for staff and knowledge exchange
- Research of soil conditions (micro, macro nutrient, organic matter etc.)
- Establishment of a committee which would agree on a National variety list

- Support to institutions that would initiate propagation production in the Republic of Macedonia
- Due to frequent spring frost losses on almond, pistachio could be considered a crop to replace orchards which are set for renovation
- Educate advisory staff on pistachio's requirements, as the advisory service is the one that has the capacity to respond to farmers needs at lowest cost
- Set trial orchards, where training and research processes will take place.

(e) Pistachio – New Opportunity

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Appendix

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Table 2. Rates of split nuts (%) (Ak, 1998).

Varieties	Years			Average
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Low	0.9	1.6	2.2	2.7	-1	-2	-4	-5
Mean	1	1.9	2.9	3.8	-3	-5	-8	-13
High	1.1	2.1	3.6	5.4	-6	-7	-12	-21

Table 4. Projected changes in average daily air temperature (°C) based on direct GCM output (Ministry of Environment and Physical Planning of the Republic of Macedonia, 2008).

Average temperature change (°C)																
	winter				spring				summer				autumn			
	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100
Low	0.7	1.4	1.8	2.2	0.7	1.3	1.8	2.2	1.2	2.2	3.2	3.7	0.8	1.5	2.2	2.6
Mean	0.8	1.7	2.3	3.0	0.8	1.5	2.2	3.2	1.4	2.5	4.1	5.4	0.9	1.7	2.8	3.7
High	0.9	1.9	2.9	4.2	0.9	1.8	2.9	4.6	1.7	2.9	5.1	7.6	1.1	2.0	3.6	5.3

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	winter				spring				summer				autumn			
	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100	2025	2050	2075	2100
Low	1	5	3	4	-3	-2	-7	-5	2	-16	-21	-21	2	-2	0	-5
Mean	0	1	2	-1	-5	-6	-10	-13	-7	-17	-27	-37	-1	-4	-9	-13
High	-2	-1	1	-3	-7	-10	-13	-22	-24	-18	-33	-53	-3	-7	-17	-23

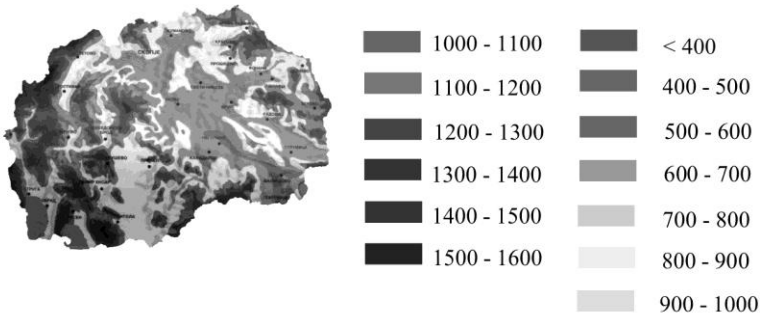
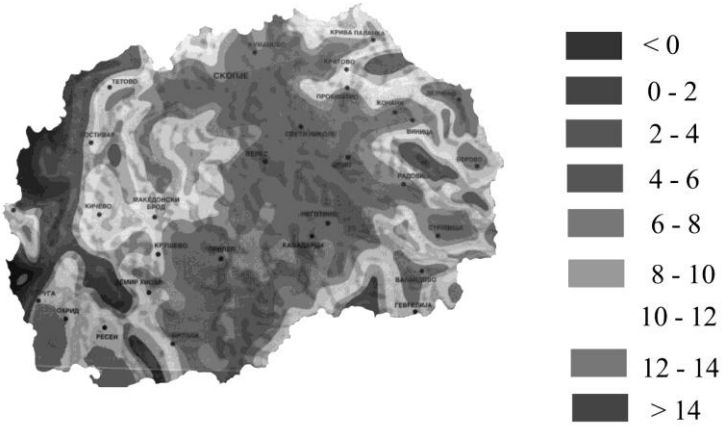


Figure 1. Precipitation layout (mm) in the Republic of Macedonia



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