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THE INFLUENCE OF THE CLIMATIC FACTORS ON THE DEVELOPMENT AND YIELD CAPACITY OF SOME APPLE VARIETIES CULTIVATED IN HIGH DENSITY ORCHARD SYSTEM

Ioan PLATON, Zsolt JAKAB-ILYEFALVI

[1]Fruit Research and Development Station Bistrita, No. 3, Drumul Dumitrei Nou street, 400127, Bistrita, Bistrita-Nasaud, Romania, Tel: 0263-217895, Fax: 0263-214752; scdpbn@yahoo.com, zsolt.jakab@yahoo.com

Corresponding author email: *zsolt.jakab@yahoo.com*

Abstract

Researches have been effectuated in a high density apple orchard (2500 trees/ha) established in the year 2001 with apple varieties resistant or tolerant to scab (Venturia inaequalis), Florina, Generos, Auriu de Bistrita grafted on rootstocks M9 and M 26.Growth and yield capacity of trees was influenced in the period 2001 and 2011 beside the fruit growing technology also by the evolution of climatic factors. The effects of drought has influenced the fruit production quantitatively and qualitatively through an increase of medium and little sized fruits in the years 2002 (118.5 mm rainfall deficit when compared with 677 mm/ year normal atmospheric precipitation quantity), 2003 (rainfall deficit 244.2 mm) and 2011 rainfall deficit 181.5 mm). In the 11 years of studies there have been registered hail droppings, in the year 2004, phenomena which has contributed to the quality depreciation of the fruit production. Also in the year 2007 in the period of blossom there have been registered low temperatures (-2.8˚C) which have been contributed to the reduction of the fruit production. The growth and yield capacity of the fruits in the eleven years have been influenced by the age of fruit trees, by the rootstock-scion combination, training system and not least by the evolution of the climatic factors.

Key words: *apple, climate, drought, hail, temperatures*

INTRODUCTION

In the scientific world it is well known the fact that the climatic changes are the effect of global warming. According to the estimations of the weather forecasts, there have been presented in the frame of the 4th report of the International Committee for Climatic Changes in the year 2007, the whole Europe and implicit Romania will be confronted in future with a process of global warming, characterized by increasing of temperatures with -0.5 - 1.5 ^{o}C for the period 2020 – 2029 and with -2 – 5 ^{o}C for the period 2029 – 2099. In the period 2090-2099 Romania will confront with pronounced drought during the time of summer.

Researches from many countries, in the frame of climatic research methodology have the approached aspects regarding climatic changes effects on growth and development of some fruit tree species (Chmielewski and Rotzer et al., 2002; Olensen 2002;Sunley et al.2006, Chitu et al., 2010; Sumedrea et al, 2009). Climatic changes occurred also in Romania, they have determined meteorological phenomena, which are manifesting with augmented amplitude and intense frequency (severe drought, intense flooding, tornados, hail). Researchers are well aware of the danger which are produced by the climatic changes and the effect of these on agriculture products and even on the existence of populations with high impact risk (flooding, drought). The scientific world at global level and implicitly in our country is asking if there is something to do to temper or stop the negative effects of climatic changes. In this situation the acute question is: what helps more, the planting of trees or the adopting of modern innovative technologies in the fight against the negative effects of the global changes. The answer is just one. Both of the directions can contribute to the obtaining of viable solutions which could be used toward the negative effect of climatic changes. In this

context the fruit growing from Romania in the last 10 years has been confronted with fluctuations in the realization of the targeted fruit productions, due to the effect of negative climatic factors. The problem is that if fruit growers need to adapt the fruit growing technologies to the different climatic conditions of present days it is a challenge how to realize this and face this situation. It is about problems of great economical effects, because the fruit growing activity represents an important sector of the agriculture and the effects of drought are reflected directly on the dimensions of fruits, on the quality of fruits, contributing in a great deal to the destination of the fruit processing industry where acquisition prices are of low level.

The meteorological forecasts for the next years are indicating an increase of the frequency of drought years for which we are asking: the climatic factors what impact will have on fruit yielding, especially effects of drought in Romania on quantitative and qualitative level in the conditions in which fruit orchards with localized drip irrigation are less and are representing low surfaces. In this situation the technologies need to be reorganized and adapted to the cultivation of fruit trees from Romania in the context of appearing of the negative climatic changes, denoting the proper rootstock- scion combination, mechanical soil cultivation techniques which need to contribute to the maintaining of water in soil and the promotion of these systems capable to face the effects of negative climatic changes.

MATERIALS AND METHODS

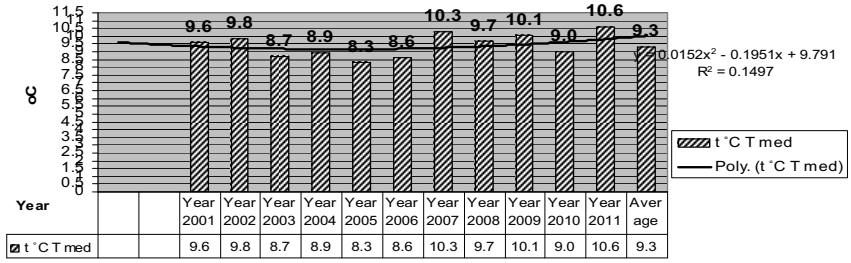
In the multi-annual experience during 2001-2011 there have been taken into study th following apple varieties Florina, Generos, Auriu de Bistrita resistant or tolerant to scab (Venturia inaequalis), and grafted on rootstocks M9 and MM 106. Main climatic indicators have been registered at the agrometeorological weather station "Agroexpert" localized at the Fruit Research and Development Station Bistrita during the time period 2001-2011.

The analyzing of climatic data targeted the scientific indicators, durable and relevant criteria for the characterization of the area in perspective of climatic global changes. The climatic factors are influencing and directly conditioning the vegetative and fruiting phenophases of the fruit species. The determinant factor for the apple culture is the thermal resource for the development if vegetative and fruiting organs. The main analyzed factors were annual average temperature of air, maximum and minimum temperatures of air, rainfall and relative humidity. There have been effectuated a series of biometrical analyses regarding the yield obtained per tree, per hectare. The finality of the researches was concretized in the elaboration of a real technical-economical report between the reference resources which have a direct consequence on the production and fruit quality.

RESULTS AND DISCUSSIONS

In the Table 1 and Fig. 1 it is presented the average climatic descriptors in the last 10 years during 2001-2011. From the analyses of these factors results that the average annual temperature on 10 years was 9.4 ^{o}C being observed an increasing of the temperature level by 1.5 ^{o}C when comparing with multi-annual average of 7.9 ^{o}C for Bistrita region calculated for the time span of 1961-1990 (Table 1).

Fig 1. Annual average temperature registered at the agrometeorological weather station at SCDP Bistrita during the period 2001 – 2011



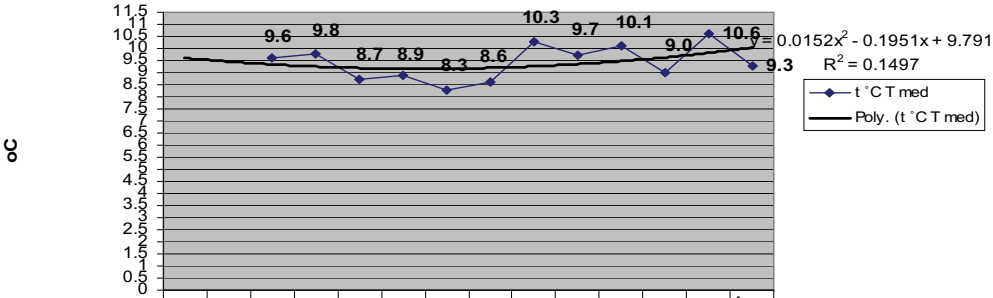
Year			Year 2001	Year 2002	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007	Year 2008	Year 2009	Year 2010	Year 2011	Aver age
t °C T med			9.6	9.8	8.7	8.9	8.3	8.6	10.3	9.7	10.1	9.0	10.6	9.3

In the analyzed period during 2001-2011 the average annual temperature on 10 years had an increasing tendency with high temperatures values in 2007 (10.3 ^{o}C) and 2009 (10.1 ^{o}C) (Fig. 1). The first period of the analyzed time span presented values between 8.3-9.8 ^{o}C (2001-2007) and there was observed a relatively constant warming in the beginning (9.6 -9,8 ^{o}C) with an inflection of could effect in 2005 (8.3 ^{o}C) (Fig 2).

Analyzing Fig. 2 it is shown that the dynamics of warming process has an intense increase tendency starting with 2007 (10.3 ^{o}C), 2008 (9.7 ^{o}C), 2009 (10.1 ^{o}C), 2010 (9.0 ^{o}C), 2011 (10.6 $^{\circ}$C) , in conclusion four years of severe warm effect being observable.

Maximum temperatures influence shows a clear tendency of temperature increasing process especially in the final time periof of 2001-2011, years in which the maximum air temperature registered values over 13.9 $^{\circ}$C the calculated average maximum temperature for time period 1961-1990 were 2001, 2002, 2003, 2007, 2008, 2009, 2010 (Fig. 3). Unusual high absolute maximum temperatures were recorded as well in years 2007 (36.0 ^{o}C), 2009 (34.3 ^{o}C), 2010 (33.8 ^{o}C) (Fig. 4). Dynamics of absolute maximum temperatures is shown in Fig. 5.

Fig 2. Dynamics of the average temperatures registered at the agrometeorological weather station at SCDP Bistrita during the period 2001 – 2011



Anul			Year 2001	Year 2002	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007	Year 2008	Year 2009	Year 2010	Year 2011	Aver age temp
t °C T med			9.6	9.8	8.7	8.9	8.3	8.6	10.3	9.7	10.1	9.0	10.6	9.3

Table 1. Climatic factors registered at the agrometeorological weather station at Fruit Research Development Station Bistrita in the period 2001-2011

Year	Average temperature of air [°C]		Temperature Difference [°C]	Maimum temperature of air [°C]		Temperature Difference [°C]	Minimum temperature of air [°C]		Temperatur e Difference [°C]	Sum of rainfall amount [mm]		Temperature Difference [mm]
	Value of the analysed year	Reference value	Value of the analysed year – Reference value	Value of the analysed year	Reference value	Value of the analysed year – Reference value	Value of the ana-lysed year	Refe-rence value	Value of the analysed year – Reference value	Value of the analysed year	Refere nce value	Value of the analysed year – Reference value
Year 2001	9.6	7.9	1.7	14.4	13.9	0.5	5.3	2.8	2.5	826.1	677	149.1
Year 2002	9.8	7.9	1.9	14.6	13.9	0.7	5.5	2.8	2.7	558.5	677	-118.5
Year 2003	8.7	7.9	0.8	14.4	13.9	0.5	3.9	2.8	1.1	432.8	677	-244.2
Year 2004	8.9	7.9	1	13.4	13.9	-0.5	3.9	2.8	1.1	690.7	677	13.7
Year 2005	8.3	7.9	0.4	13.4	13.9	-0.5	3.7	2.8	0.9	909.9	677	232.9
Year 2006	8.6	7.9	0.7	13.6	13.9	-0.3	4.1	2.8	1.3	914.4	677	237.4
Year 2007	10.3	7.9	2.4	15.2	13.9	1.3	5	2.8	2.2	1044.2	677	367.2
Year 2008	9.7	7.9	1.8	15	13.9	1.1	4.8	2.8	2	809	677	132
Year 2009	10.1	7.9	2.2	15.9	13.9	2	4.8	2.8	2	706.7	677	29.7
Year 2010	9.0	7.9	1.1	15.7	13.9	1.8	2.3	2.8	-0.5	954.2	677	277.2
Year 2011	10.6	7.9	2.7	16	13.9	2.1	4	2.8	1.2	495.5	677	-181.5
Average values	9.4	7.9	1.5	14.7	13.9	0.8	4.3	2.8	1.5	758.4	677.0	81.4

Fig 3. Annual maximum temperature registered at the agrometeorological weather station at SCDP Bistrita during the period 2001 – 2011

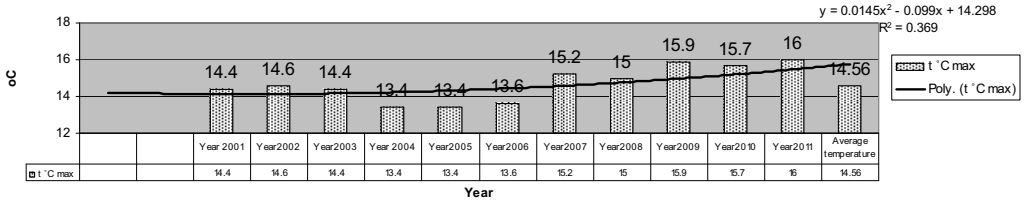


Fig 4. Annual absolute maximum temperature registered at the agrometeorological weather station at SCDP Bistrita during the period 2001 – 2011

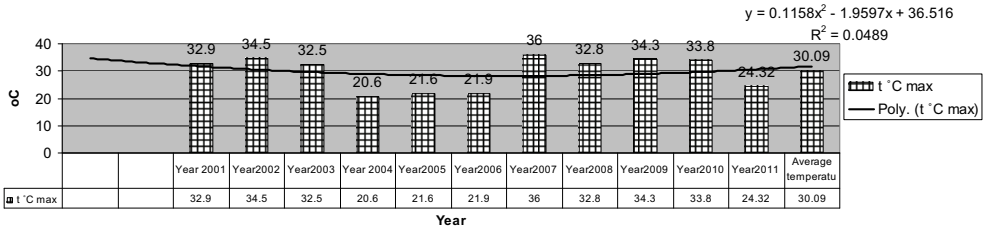


Fig 5. Dynamics of annual absolute minimum temperature registered at the agrometeorological weather station at SCDP Bistrita during the perioad 2001 – 2011

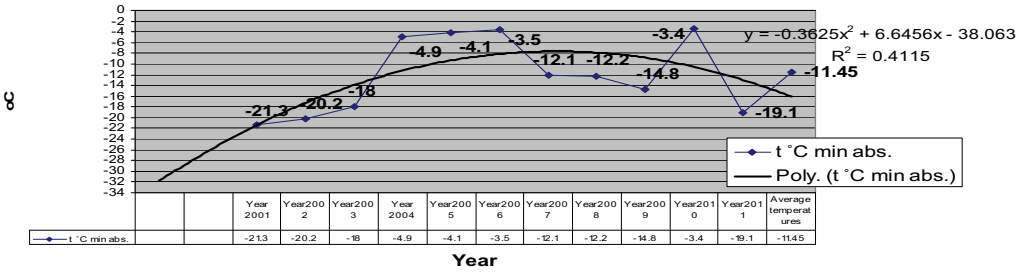
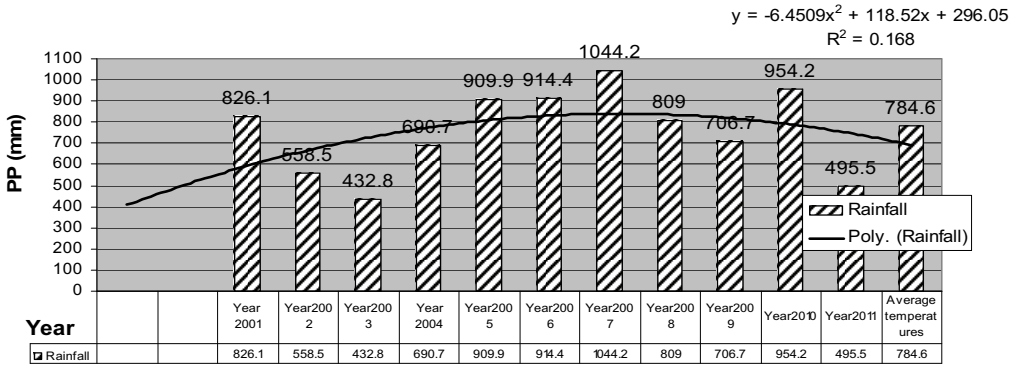


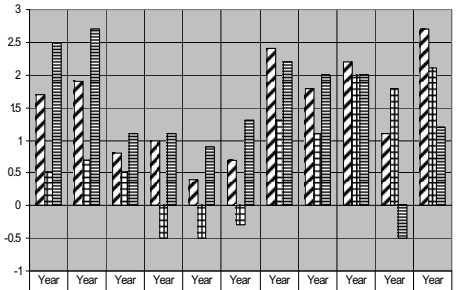
Fig 6 . Rainfall recorded at the agrometeorological weather station at SCDP Bistrita during the period 2001 – 2011



In the analyzed time period average minimum temperatures have increased, the recorded minimum temperature 4.3 ˚C increased when compared with the multiannual value of 2.8 ^{o}C calculated for the reference period 1961-1990, the difference being 1.5 ^{o}C. In the 10 years studied the winter periods were generally mild , with low level snow fall.

Rainfall level analysis (Fig 6) during the time period 2001-2011 revealed the fact that the amount of rainfall was in the frame of 432.8 mm-1044 mm, with a minimum in 2003 and a maximum in 2007. Analyzing Fig. 9 it is shown that there were several years with serious water deficits especially in the years 2002 (-118.5 mm), 2003 (-244.2) and 2011 (-181.5) (Fig. 8, 9). The tendency of water deficit is accentuated in the first and last part of the time period 2001-2011, rainfall graph line shows an increased deficit in 2002, 2003 and 2009.

Fig. 7 Temperature differences between the refrence values and the recorded value



	Year 2001	Year 2002	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007	Year 2008	Year 2009	Year 2010	Year 2011
Average temperature of air oC Differences Recorded value-Refrence value	1.7	1.9	0.8	1	0.4	0.7	2.4	1.8	2.2	1.1	2.7
Maximum temperature of air oC Differences Recorded value-Refrence value	0.5	0.7	0.5	-0.5	-0.5	-0.3	1.3	1.1	2	1.8	2.1
Minimum temperature of air oC Differences Recorded value-Refrence value	2.5	2.7	1.1	1.1	0.9	1.3	2.2	2	2	-0.5	1.2

Fig 8. Differences between the refrence value and the recorded rainfall level at SCDP Bistrita

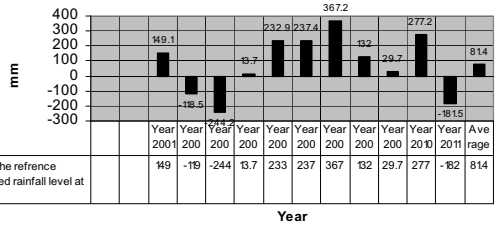
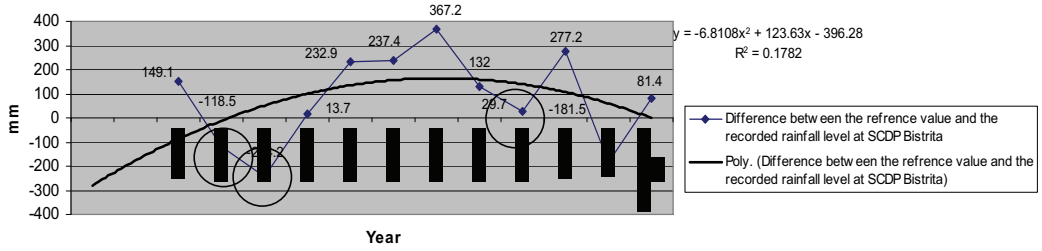


Fig 9 - Rainfall difference between the refrence value and the recorded rainfall level at SCDP Bistrita

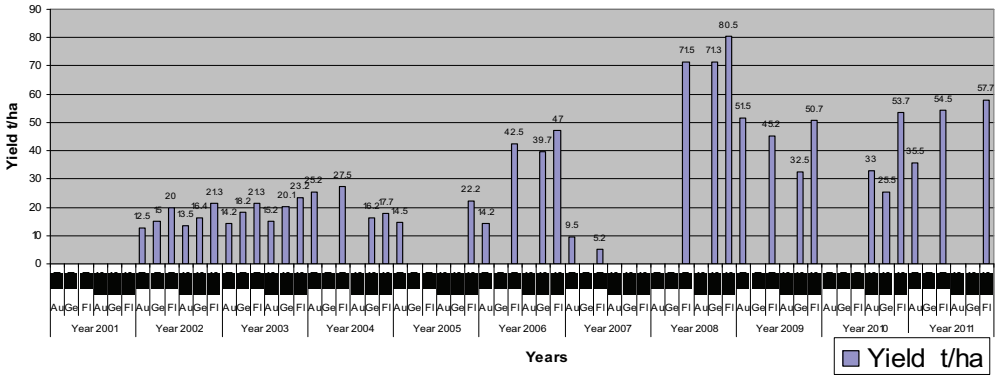


Increased air temperatures recorded during 2002, 2003, 2009 have influenced the phenomena of increased evapotranspiration from soil, which negatively influenced the normal physiological processes of the fruit tree metabolism. The accentuated drought was characterized during the summer period June-August which negatively influenced the development of fruits with direct effect on the quantitative and quality characteristics.

Technologies recommended in the drought period were localized drip irrigation where it could be effectuated (high density apple orchard of 2.0 ha), fruit tree nursery (rootstock seedlings plot and second year grafted seedlings plots). In other orchard plots

there have been recommended effectuation of soil cultivation techniques (ploughing along the fruit tree rows) for the interruption of water capillarity in the soil in order to maintain the water in the soil.

Fig.10 Yield capacity of some aple varieties cultivated in high density system during 2001-2011 at SCDP Bistrita



Fruit productions at the rootstock combinations taken into study in the 10 experimental years have fluctuated according to age of trees, bearing capacity kg / tree, training system and not ultimately de variation of climatic factors. Data presented in Fig.11 shows that the yields have increased year by year, with the exception of 2007 when in the first period of the month may in the period of blooming there have been registered -2.8 oC and the flowers were affected by frost. Improved yield capacity have been registered at the beginning of the 6th year after planting when there have been obtained at a density of 2500 tress/ha 42.5 to/ha at cultivar Florina grafted on M29 and 47 to/ha at the same variety grafted on M26.After the 7th year of planting until the 10th year after planting the recorded fruit yields have increased. There have been observed high rated capacities at Florina/M26 (80.5 t/ha) and Florina/M9 (71.5 t/ha). In the years with high yield capacity the climatic factors were favorable from the point of view of thermal and rainfall meteorological indicators (Fig. 2). At other rootstock-variety combinations Generos and Auriu de Bistrita grafted on rootstocks M9 and M26 the fruit yields had a fluctuation tendency. In the favorable years the fruit productions have achieved the values of 33.0 to/ha-51,5 to/ha at Auriu de Bistrita and 25.5 to/ha (2010) and 71.3 to/ha (2008) at cultivar Generos.

CONCLUSIONS

Growth and yield capacity of trees was influenced in the period 2001 and 2011 beside the fruit growing technology also by the evolution of climatic factors. The effects of drought has influenced the fruit production quantitatively and qualitatively through an increase of medium and little sized fruits in the years 2002 (118.5 mm rainfall deficit when compared with 677 mm/ year normal rainfall quantity), 2003 (rainfall deficit 244.2 mm) and 2011 (atmospheric rainfall deficit 181.5 mm). In the 11 years of studies there have been registered hail droppings, in the year 2004, phenomena which has contributed to the quality depreciation of the fruit production. Also in the year 2007 in the period of blossom there have been registered low temperatures (-2.8 ^{o}C) which have been contributed to the reduction of the fruit production. The growth and yield capacity of the fruits in the eleven years have been influenced by the age of fruit trees, by the rootstock-scion combination, training system and not least by the evolution of the climatic factors.

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