PRODUCERS' REACTION TO CLIMATE CHANGE IN PARTICULAR FAMILY FARMS

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Abstract

Climatic influences have had effects on agricultural production for ancient ages. The mankind has always tried to adapt to the rapidly changing and sometimes hectic effects of weather which has very huge and important effect on the quality and quantity of production. Today, climate change impacts are one of the most serious problems for Hungarian fruit growers. The year of 2007 was a particularly difficult time for Hungarian fruit growers, especially in North Great Plan region. Serious and repeated frosts occurred at blooming time in this region, which caused almost 100% of fruit loss. Frost caused an "off-year" in the orchards. The purposes of our research were to study the effects of irregular frost on nutritional status and enrich farmers' knowledge to understand the risks and consequences of climate change. Nutritional investigations pointed out that the crop loss puts at risk the current season's fruit, and also because of the perennial nature of fruits, it influences the productivity of fruits for several seasons in the future. The concrete nutritional test results have made the producers aware that in future they will be successful if their knowledge is improved. Enriching farmers' knowledge and understanding of the risks and consequences of climate change is the most promising strategy to better assist them. Regarding protection against extreme weather events, in addition to technological and technical elements, the level of importance assumed by family farmers for the above-mentioned protection techniques are also worth of studying. This ongoing research beginning in 2009 mainly focuses on studying the opinions of fruit growers making up the target group for this analysis. The questionnaire survey primarily intends to study their knowledge on the definition of climate change as reactivity to unfavourable weather events occurring in the growing.

Key words: *family farms, climate change, protection, yield security, human factor*

1. INTRODUCTION

Environmental sustainability is a current issue in global agenda. Healthier food produced in a sustainable manner at affordable price is a necessity in the contemporaneous society.

The awareness of the growing impact of environmental stress has led to worldwide efforts in adapting agricultural production to adverse environmental conditions, focusing on mitigating quantitative yield losses (Godfray et al., 2010). Far less attention has been devoted to the impact of abiotic environmental stresses on crop quality (Wang - Frei, 2011).

Nowadays, the strong trends in climate change already evident, the likelihood of further changes occurring, and the increasing scale of potential climate impacts give urgency to addressing agricultural adaptation more coherently.

Extreme climatic events are predicted to increase in intensity, frequency, and geographic extent as a consequence of global climate change.

It is no doubt that climate change is a reality and the pressure over water reserves will increase in next years, as well over high water consuming activities. Agricultural practices are among the biggest water consuming activities, considering that, alternatives to reduce water use in agricultural practices is of special interest in the present moment.

It is no doubt that frequency of unexpected climatic events and their growing rate result more and more problems for fruit growers all over world. It is very hard task to estimate the fruit failure which follows from climatic extremes. But its rate is growing continuously year by year. Nowadays, we have to know the dark side of the weather events because it is causing more and more problems and significant hazards to many horticultural regions all over the world.

Naturally, plants are frequently exposed to many stresses such as drought, low temperature, salt, flooding, heat, oxidative stress and heavy metal toxicity, while growing in nature. But limiting resources, as stress factors during plant development have strong effects on fruit postharvest quality, mainly in terms of sensorial attributes (texture, colour, aroma, and taste) and composition (nutrients and bioactive compounds), and also in terms of gene expression, enzyme activity, yield, and storage behaviour because the stress situations reduce plant growth by affecting various physiological and biochemical processes, such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters.

Therefore the climate conditions and the proper orchard management practises are the main key factors in the production of high and qualitative yields of fruits (Bramlage, 1993).

In general, to grow crops, especially fruits successfully in the future, growers will need to adapt to the limited resources and the tested technologies of fruit growing according to these climatic events as modifier factors (Nagy et al., 2010).

Nowadays, in Hungary, many growers in some regions will need to adapt their orchards to cope with days of extreme climatic event, including frost in spring, drought in summer and water deficiency in autumn.

Climate change poses a major challenge to Hungarian agriculture because of the critical dependence of the agricultural system on climate and because of the complex role agriculture plays in rural and national social and economic systems.

The cumulative impacts of climate change will ultimately depend on changing global market conditions as well as responses to local climate stressors, including farmers adjusting planting patterns in response to altered fruit yields and fruit species and producers investing in drought-tolerant varieties. Adaptive actions in the areas of consumption, production, education, and research involve seizing opportunities to avoid economic damages and decline in food quality, minimize threats posed by climate stress, and in some cases increase profitability.

Much of the economic literature suggests that in the short term, producers will continue to adapt to weather changes (Antle et al., 2004). In the longer term, however, existing adaptive technologies will likely not be sufficient to buffer the impacts of climate change without significant impacts to producers, consumers, or both.

New strategies for building long-term resilience include both new technologies and new institutions to facilitate appropriate, informed producer response to a changing climate. Furthermore, there are both public and private costs to adjusting agricultural production and infrastructure in a manner that enables adaptation (Malcolm et al., 2012).

In Hungary, where the climatic conditions were very excellent for fruit growing in the past, nowadays the fruit growers have to face the increasing number of extreme climatic events and their increasing unfavourable effects (Nagy- Szegedi, 2017).

The frequency and the extent of unfavourable weather events in the last two decades are significantly increased in Hungary (Várallyay, 2005; Láng et al., 2007; Pálfai, 2007). This trend is particularly detrimental to fruit growers.

Due to this the following effects are probable in Hungarian fruit sector (Soltész et al., 2006):

- the frequency and intensity of droughts are increasing in the near future,
- water demand of trees is increased by the increasing transpiration and due to the decreasing precipitation,
- there is a growing demand for irrigation and the quality of irrigated water can be impaired,
- yield safety is reduced,
- shift of the borderline of fruit growing zones.

The year of 2007 was very critical for Hungarian fruit growers especially who lived in Eastern-Hungary. Serious and repeated frost damaged was observed at blooming period (1st of May and 2nd of May (T=-6--9°C)) in this region, which caused almost 100% of fruit loss. These frost events resulted in an "off-year" in the many orchards. It was the first time for some of them to meet the negative impacts of extreme weather events caused by climate change.

Due to scientific uncertainties, it is complicated to analyze the potential impacts of global climate change. And this is also the case as from the empirical results of social scientific studies, only the nature of relations various social groups have today to nature, physical environmental problems and the (mainly believed) impacts of the global climate change can be concluded. Taken society as a whole, exploring future interests is not only difficult as people are aware they should abandon their interests of today for their future interests but also as this future interest is rather difficult to enforce (Szirmai , 2009). Farmers involved in fructiculture, on the contrary to this general phenomenon, perceive that the implementation of this 'future interest' will determine yield security and by this, their profitableness as during production, they closely apprehend the negative impacts of extreme weather phenomena.

Therefore, in this paper we focus on the unfavourable nutritional and social effects of this real serious climatic event. This critical situation led many growers to recognise the real impacts of climatic extremes. After the climatic anomaly a comprehensive questionnaire study was conducted to find out how far fruit growers are aware of the effects of climate change and how to defend against its impacts.

2. MATERIALS AND METHODS

2.1. Description of the climatic anomaly

On the 1st of May 2007, and the 2nd of May from late in the evening until the dawn for several hours the air temperature was below 0.0 ºC recorded by the near soil probes, registered at the meteorological station of Újfehértó Fruit Research Station (about 20 km from the studied plantation). The frost effect was perceptible for several hours, which allowed freezing symptoms to be seen in the higher parts of the plantation (Figure 1, 2 and 3).

After the frost event, the nutrition practice was not changed. The irregular yields that were created were not corrected in the test area either by manual or chemical fruit control.

In the rows, blocks were formed from ten trees. Plantation management was carried out in accordance with integrated norms. Soil and plant analytical studies were performed to determine the supply of nutrients.

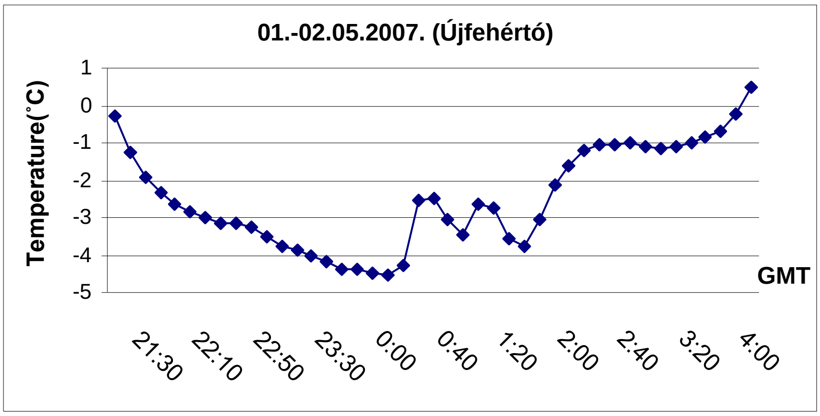

Figure 1. Earth-close temperature values (Újfehértó, 01.-02.05.2007.)

Source: author's research

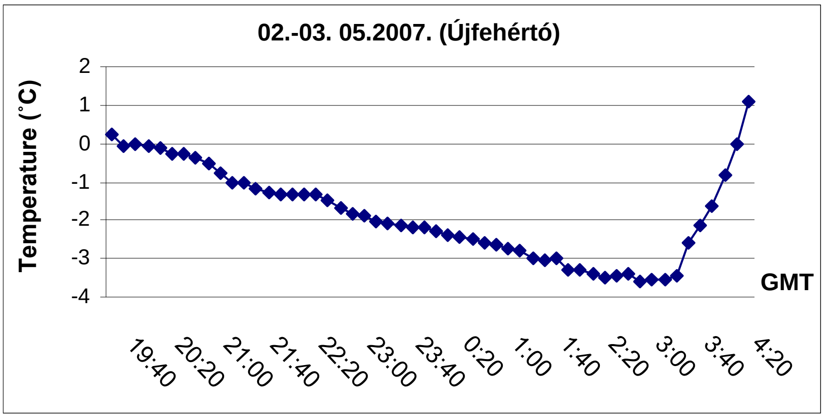

Figure 2. Earth-close temperature values (Újfehértó, 02.-03.05.2007.)

Source: author's research

Figure 3. Frost-damaged flowers

Source: author's research

2.2. Soil and plant analysis

Our original aims were quite different: nutritional trials were set up to study the nutrient uptake of trees but the frost event in 2007 created a new situation. Therefore we changed our original research aims and started studying the nutritional effect of frost.

Our nutritional investigation were carried out from 2006 to 2010, in the frost affected apple orchard (*Malus domestica* Borkh.) of TEDEJ Rt., Tedej (47º55'N, 21º256'E), in Eastern Hungary. The orchard was located on lowland chernozem soil. It was established in the autumn of 1999, using scions grafted on MM106 rootstocks at a spacing of 3.8 x 1.1 m. The orchard was irrigated.

Soil samples were taken at three levels (0-20 cm; 20-40 cm and 40-60 cm) of each cultivar by using manual soil augers. For the characterisation of the soil the most important soil parameters were determined. Sampling was performed at the beginning of the vegetation period in April, 2006. The soil samples were air dried outdoors in a 1-1.5 cm layer, then the soil was sifted through a sieve of 2 mm holes size, homogenized and stored in plastic boxes until the examination. For extracting the available phosphorus and potassium content of soils, ammonium-lactate extractant (so called AL soluble) was used. AL soluble phosphorus was quantified colorimetrically with phospomolybdovanadate method (reference), using a spectrophotometer (Metertech VIS SP-850 Plus; Metertech Inc., Taipei, Taiwan). The amount of potassium was quantified by flame atom emission spectrophotometry method using an

Unicam SP90B Series 2 Atomic Absorption/Emission Spectrophotometer (PYE Unicam, England). Mineralized nitrogen contents and pH of soil samples were quantified according to Houba et al., 1986. The K_A, carbonate and humus content of soil were determinated according to Hungarian standards (MSZ 20135:1999).

For plant analysis the following apple cultivars were selected: ‘Idared’, ‘Topaz’, ‘Gala Must’ and ’Summerred’.

Healthy, fully developed leaves were collected from the mid-third portion of current season extension shoots. Leaf samples were collected 100 days after full bloom, from 50 uniform trees from 2006 to 2010, respectively to study the nutrient uptake by trees of different cultivars (see Table 2-4).

Leaf samples were dried in a well-ventilated drying oven for 6 hrs at 70 ° C to reduce the nitrogen loss and then the whole sampled material was finely grinded, homogenized and stored in a dry, cool place in a paper bag for examination. Nitrogen content of plant samples was determined from homogenized samples directly using the dry combustion method according to Nagy, 2000, using an Elementar Vario EL analyser (Elementar Analysensysteme GmbH, Hanau, Germany). Plant phosphorus and potassium were qualified as described for soil samples.

2.3. Questionnaire survey

Beside the nutritional investigation - due to this real and dramatic climatic event, a questionnaire survey is done to explore how climate change appears in the everyday thinking of Hungarian fruit growers, observations and activities of people living from agriculture: how they perceive the problem, how they react, what knowledge they have, and how they localise climate change in their own local context, influenced by personal factors.

Therefore, in this study, a questionnaire survey frequently applied in social scientific research was also used. This method bears a number of advantages as being relatively rapid, suitable for providing descriptive statistical studies on large assemblies and from the data obtained from the results of such surveys, secondary analyses can be simply conducted (Babbie,2001). Secondary analyses were carried out following simple statistical studies evaluating and quantifying the basic features of the study sample. The growers, who filled the questionnaire, were selected random simple sample.

The descriptive statistical method applied was frequency test during which the variables’ relative and cumulative distributions within a given topic were analysed and represented. For multiple answers, the analysis was conducted by applying frequency and crosstabs in accordance with the previously defined groups and sets of multiple answers.

Association between variables of nominal in type advancing our study of hypothesis was described by association measures. During the analysis, data were arranged to crosstabs, validity of causality associations assumed based on the arrangement of frequencies were proven by applying definitely a chi-square test. The level of significance was set on the conventional value ($p \leq 0.05$). This study primarily intends to examine knowledge on the concept of climate change and reactivity to unfavourable weather phenomena occurring in nature among farmers. In addition to these, the research also aimed at obtaining qualitative and quantitative information required for the development of consultancy and research guidelines. In the study’s first period, 70 farmers were involved in the survey. The answers received were indicative and informative however proved to be inadequate to make final conclusions.

The questionnaire, in addition to calibrating questions, intended to survey the knowledge of farmers in relation to the topics below:

- sources of information, type of information (new protection technological elements, techniques of protection, technological solutions advancing damage mitigation)
- frequency and type of damage (exposition), possibilities for damage mitigation (types of funding, rate of own contribution)
- how can be the role of human capital

3. RESULTS

3.1. Results of nutritional investigation

Soil analysis

Soil test was made to establish the nutrient supply ability of the soil of studied area which relation in tree conditions. Moreover, it is widely known that weak nutritional status of trees resulted higher sensitivity to frozen or other climatic extremes. Results of soil analysis are represented in Table 1. Conventional Hungarian soil testing procedures were used to establish N, P and K supply of soil of plantation (MSZ 20135:1999). The pH of soil was near the neutral value. The physical category of soil was clay loam. The water management and the water retention ability of the soil are very good so it has significant water capacity.

The soil P and K was medium, while the soil N was suitable for growing according to Hungarian standards.

Besides conventional soil testing procedures, 0.01M $CaCl_2$ was used to give further information about the easily soluble and available mineral N contents of soil (Houba et al., 1986.) The values of easily soluble N form correspond to the type of examined soil and decreased by depth.

	Depth			
Parameters	0-20	20-40	40-60	*0-60*
pH ($CaCl_2$)	7.43	7.36	7.54	*7.44*
H%	2.95	2.83	2.58	*2.79*
K_A*				*45*
$CaCO_3$%	8.3	8.5	12.5	*9.77*
	mg/kg			
$CaCl_2$-N_{min}	14.10	9.05	5.44	***9.53***
AL-P	164.11	89.12	42.7	*98.64*
AL-K	263.93	160.69	88.65	*171.09*

Table 1. Results of soil analysis (Tedej, Hungary, 2006)

Source: author's research

* - Plasticity index according to Arany is a soil parameter connection with the water holding capacity and the clay content of soil, using in Hungary

Leaf analysis

In the present study, the test results obtained from four apple varieties are presented (Table 2-5).

The N content of the leaves of the examined varieties showed a favorable supply in 2006, and after the frost, the leaf N values were lower. As a result of the decrease, the N-supply of the varieties came from the favorable to the low nutritional category.

The data of the year of the frost was significantly lower than the data of the previous and the following years. The rate of decrease was varied by cultivars but the average of it was about 19%. From 2008, the N content of the leaves became good again thanks to the planned nutritional management.

In the third year following the frost event, the N content of the leaf increased in all cultivars and mostly exceeded the pre-frost value.

	2006	2007	2008	2009	2010
Varieties	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Idared	2.10	1.73	2.11	2.04	2.14
Topáz	2.44	1.73	2.19	2.11	2.17
Gála Must	2.14	1.97	2.34	2.14	2.20
Summerred	2.19	1.70	2.36	2.10	2.22
Average	***2.22***	***1.78***	***2.25***	***2.10***	***2.18***
SzD $_{5\%}$ ***(within year)***	***0.11***	***0.08***	***0.07***	***0.06***	***0.07***
SzD $_{5\%}$ ***(without years)***	***0.08***				

Table 2. Leaf N content of examined apple varieties (Tedej, 2006-2010)

Source: author's research

The significant difference within the year was smaller than the yearly value, in most cases. This suggests that in addition to the varieties, the years had a significant impact.

The P content of the leaves of the examined varieties was favorable in 2006 (Table 3). After the frozen, a significant increasement was observed in the P content of the leaf. The rate of growth was scattered between 19 and 111%. Probably it is due to the different involvement of the examined varieties. In the next few years, the P content of the leaves declined significantly, later stagnated and did not reach the values of the year 2006. Since 2008, phosphorus supply has been in low supply category.

	2006	2007	2008	2009	2010
Varieties	**P (%)**	**P (%)**	**P (%)**	**P (%)**	**P (%)**
Idared	0.18	0.28	0.10	0.11	0.12
Topáz	0.16	0.19	0.15	0.12	0.14
Gála Must	0.18	0.23	0.15	0.14	0.12
Summerred	0.18	0.38	0.13	0.17	0.13
Average	***0.18***	***0.27***	***0.13***	***0.14***	***0.10***
SzD $_{5\%}$ ***(within year)***	***0.02***	***0.09***	***0.04***	***0.04***	***0.03***
SzD $_{5\%}$ ***(without years)***	***0.06***				

Table 3. Leaf P content of examined apple varieties (Tedej, 2006-2010)

Source: author's research

The P content of the leaves became more and more balanced, but the P content of the leaves did not reach the favorable supply category even after four years.

The K contents of the examined apple varieties are shown in Table 3. The K content of the leaves of the examined varieties was favorable for the Glala Must and Summerred varieties, it was low at Idared, but it was insufficient at the Topaz in 2006.

	2006	**2007**	**2008**	**2009**	**2010**
Varieties	**K (%)**	**K (%)**	**K (%)**	**K (%)**	**K (%)**
Idared	1.11	1.40	1.04	1.11	1.10
Topáz	0.74	1.26	1.04	1.01	0.98
Gála Must	1.39	1.68	1.47	1.33	1.37
Summerred	1.39	1.84	1.31	1.27	1.25
Average	***1.16***	***1.55***	***1.22***	***1.18***	***1.18***
$SzD_{5\%}$ (within year)	***0.21***	***0.22***	***0.17***	***0.14***	***0.11***
$SzD_{5\%}$ (without years)	***0.13***				

Table 4. Leaf K content of examined apple varieties (Tedej, 2006-2010**)**

Source: author's research

The K content of the leaves of the examined varieties similarly to that described for phosphorus, increased in the year following the frost and then declined for years. After the frost event a significant increase was observed in the K-content of the leaf for all varieties. Growth rates are scattered between 21 and 70%. In the next few years, the K content of the leaves declined significantly, later stagnated and only approached the values of the year 2006. The Potassium has been in low supply category since 2008.

Our results pointed out that in 2007 the leaf N was lower, while the leaf P and K was higher in most cultivars than they were in 2006. It can be explained by the absence of fruits which caused a smaller accumulation of N (Sadowski et al,. 1995). The vegetative growing rate of trees was higher in 2007 than in the previous and the next year. This is attributed to greater vegetative growth and the unbalanced vegetative-generative processes.

Our results confirmed earlier findings that there is close relationship between fruit load and nutrient level of leaf (Hansen, 1980) and between irregularity of yield and nutrients status of trees (Lalatta, 1980; Buwalda and Lenz, 1992; Sadowski et al,. 1995).

The nearly 100% frost damage induced periodic crops and alternatives to the trees. Flowers are fallen, the yield is destroyed and as a result, the vegetative-generative balance of the trees shifted. The lack of fruits resulted in vegetative overweight in the trees, which also manifested in leaf size growth and nutrient concentration changes. The nutrient supplies were near the optimum in the plantation before the frost. In the year of frost damage, the nutrient ratios overturned due to frost-induced fruit failure. The shift in vegetative-generative balance of trees can be studied well with leaf diagnostic tests.

3.2. Results of questionnaire survey

Regarding the technique of protection, in addition to the distribution of the given possibilities, the frequency each category mentioned is also worth of studying (Figure 4). Here, conventional technological elements gained predominance in both categories of cultivation. (70 percent of the respondents pursue integrated farming whereas 30% applies conventional technologies. At present, no bio-farms are included in the sample.). The share of fruit species can be relevant at correlation tests at present however, taking the relatively low number of samples and the fact that this research is still being carried out this question was not analysed.

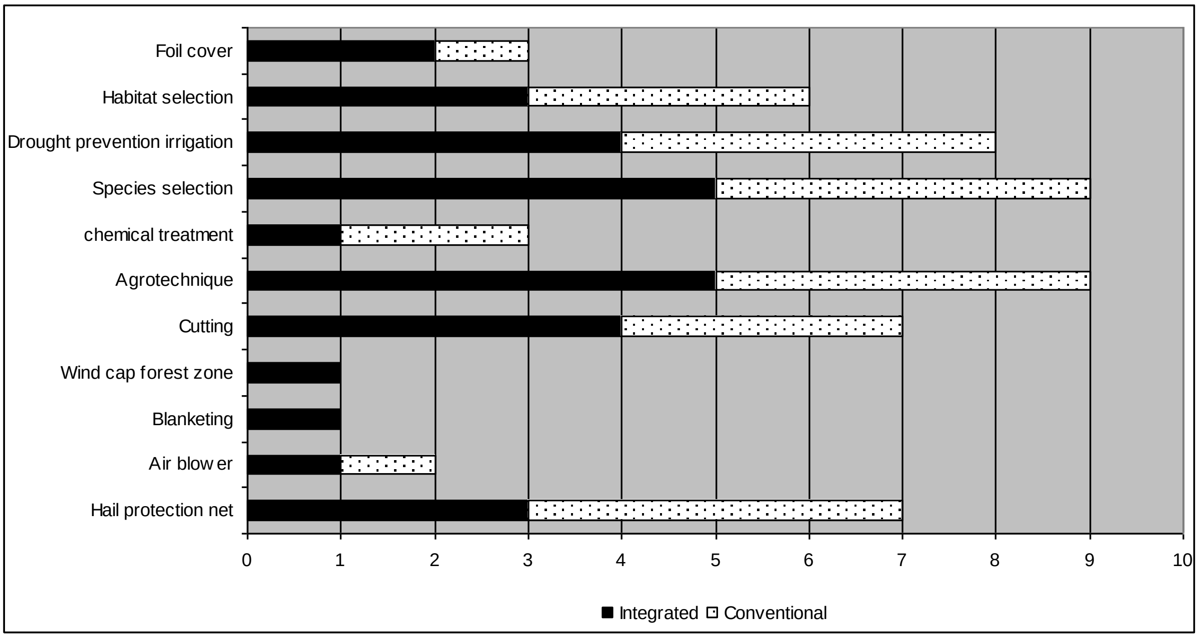

Figure 4. The share of protection technologies applied for preventing damage for various methods of cultivation, in function (%) of the valid answers, 2010

p=0.000, p≤0.05

n=70

Source: Demeter D, Visegrad Journal on Bioeconomy and Sustainable Development, vol 2/2014., p.75

Results can greatly contribute to the elaboration of climate change related adaptation technologies for the sector as well as foresee the success of implementation in practice. The results of this survey can primarily advance a more active contribution of farmers regarding the prevention and mitigation of production damages occurring in relation to the climate change. To this, processing of the entire questionnaire following the closure of research and explaining certain sections proved to be problematic and controversial. The way and type of source of information having obtained fruit farmers become capable of mitigating and preventing the above mentioned weather-caused damages can also be a subject to further studies (Demeter, 2014).

From the results of survey it was evident that the use of variety was the most important part of agrotechnique. From the survey responses, it is apparent that the farmers prefer the competitiveness in connection the variety usage. The variety usage is determined by the sales opportunities (42%), consumer demands (18%) and of course the land facilities (18%). The production traditions and labor input are less important. It is pointed out that the wide variety usage and variety enhancement have a special attention in preparing for climate change. Therefore it was also investigated in the survey thoroughly. The appearance of the favorable trend of variety enhancement was in the last decade. Among the reasons for the variety expansion is the most important the improvement of competitiveness which was followed by the replacement of the older plantations and the mitigation of the effects of unfavorable climate events. To explore the reasons of the variety expansion correlation studies were conducted. According to the correlation studies, there is no statistically verifiable correlation between the age of the fruit growers and the factors influencing the use of the variety (p=0.22). Similarly, there is no connection between the duration of fruit growing and the use of the variety (p=0.21). In the study, we have outlined the reasons for the lack of modern varieties. The lack of capital and the lack of information about varieties are most frequently mentioned by the surveyed fruit growers. Most of fruit growers said that “There is no variety corresponding to the site conditions” and “I do not know what it would bring”. Thus, the lack of modern varieties is mostly due to lack of capital and information among the respondents. Those, who are using more cultivars than the average users, do not use modern varieties.

They do not even think about it, they do not want to further expand the range of varieties. Moreover, those who are using lesser cultivars want to use more modern varieties in the future. Currently, however, only a few fruit growers (15%) use modern varieties. In the future it would be suspected that the rate of modern varieties will be increased. In the plantations where modern varieties are used or planning the usage of them the main reasons of they using are the better market possibilities and the higher prices. The adaptation to climate change has not emerged among the answers.

Our results show the importance of education and the extension of knowledge of growers which lead to use proper long term adaptive technologies and varieties to face the challenges of climate change.

We agree Jankó et al., 2017 who stated that for those who live from the land, the transformation of climatic patterns and local problem perception are apparent, and therefore if problems are perceived, responses to such changes, i.e. adaptation, necessary happens faster.

4. CONCLUSIONS

2007 was a critical year for Hungarian fruit growers, especially who lived and produced in East-Hungary. Mid-spring frost as a real and dramatic climatic anomaly might result almost 100% fruit loss and pointed out the sensitivity of Hungarian climate. In the last ten years the intensity, frequency and geographic extension of extreme climatic events continuously increased in Hungary. Therefore, the most accurate predictions of extreme weather events, the assessment of the damage caused, the field and laboratory testing of the frost and drought tolerance of trees are common and urgent tasks for the growers, researchers and decision makers.

Our results pointed out that the weather factors fundamentally affect both the nutrient supply of the soil and the nutrient uptake of the trees. Their impact on the nutrient content, yield and quality of trees is very complicated and complex, which is further complicated by unexpected weather events. These climatic anomalies are basically affecting the nutritional supply and management strategies of orchards. Therefore, the adaptive conception of nutrient supply should be elaborated to orchards in the future to avoid the adverse effects of climatic anomalies. There is increasing urgency for a stronger focus on adapting agriculture to future climate change.

But the elaboration of adaptive nutrient supply conception is not enough to assured success because multidisciplinary problems require multidisciplinary solutions. Therefore, in this paper we show the importance of education and the extension of knowledge of growers which lead to use proper long term adaptive technologies and varieties to face the challenges of climate change. So, climate advisories/services for farmers are indeed necessary.

It is widely known that the farmers’ learning is based on mostly empirical observations and direct experiences. Therefore, assisting them to interpret what is happening in their fields by referring to their recent practices and outcomes, past learning, and their fellow farmers’ strategies and crop performances, is a reliable and good way to enrich their knowledge.

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