INVESTIGATIONS ON THE DEVELOPMENT OF SOME PHYSIOLOGICAL PROCESSES DURING APPLE TREE GROWTH AND FRUCTIFICATION

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The apple tree plantation and environmental conditions represent a single unit, within which the mutual interdependence and conditioning are compulsory laws, with a greater influence from environment toward the vegetal organisms. The change of environmental conditions determines changes in the metabolism, within the growth and development processes, having positive or negative influences on plant health and vitality. In this scientific paper, our goal was to study some aspects concerning the ecophysiological response of Jonagold and Golden spur varieties to the climatic conditions of year 2008. Therefore, we have studied the dynamics of the leaf pigment content during the phenological phases of shoot growth, fruit growth and ripeness and dormancy beginning for one-year shoots and branches. The eco-physiological response of the two apple tree varieties was estimated according to the determination of the content of photosynthetic and flavonoid leaf pigments. The pigment content from leaves was analysed spectrophotometrically, being estimated through the light absorption capacity by the pigment acetone extract (1%) in visible spectrum and in near UV. The comparative study of the content of leaf pigments in the leaves of the vegetative and flower shoot may evaluate the various mechanisms

***Key words**: physiological processe, apple tree plantation, pigment content*

We know that Earth is being confronted to global warming, which determines the appearance of some extreme weather phenomena [1]. Besides the catastrophic ecological consequences, the variability of climatic conditions has a negative influence on the normal development of the vegetation cycle of cultivated plants. Air and soil dryness causes the disturbance of some physiological and biochemical processes that may have important repercussions on ultrastructure and physiological processes from cells [7].

Leaf wilting diminishes the photosynthetic activity. The negative effects of draught are shown by diminishing stomata opening, transpiration and photosynthesis, respectively, the diminution in CO_2 supply [6]. Draught reduces the photosynthetic intensity from mesophyll cells and translocation of assimilates [3].

Fruit growing plantation and environmental conditions represent a single unit, within which the mutual interdependence and conditioning are compulsory laws, with a greater influence from environment toward the vegetal organisms [2]. The change of environmental conditions determines modifications in metabolism and in the development of growth and development processes, with positive or negative influences on plant quality and vitality [4].

Water stress affects differently apple tree leaves and fruits; at early phenological phases, transpiration and photosynthesis are affected, efficiency of water use increases, while senescence and fruit falling are stimulated [8]. At late phenological phases, they found tolerance to low water potential of soil and diminution in the efficiency of water use [5].

MATERIAL AND METHOD

Investigations were conducted on two apple tree varieties, Golden spur and Jonagold, cultivated at the Farm of Teaching Station from the University of Agricultural Sciences and Veterinary Medicine of Iaşi, during the growth season of year 2008.

Analysis of climatic conditions. Temperature and rainfall were recorded by decade during spring-autumn and values of mean temperatures and sum of monthly rainfall were reported to mean multiannual values.

Analysis of leaf pigment content. Analyses of leaf pigments were carried out in the following phenological phases: *shoot growth, fruit growth, beginning of fruit ripeness, full ripeness in fruits and wood maturation.* Analyses were carried out on leaves from one-year branches and on vegetative and floriferous shoots.

The ecophysiological response of the two apple tree varieties was estimated according to the determination of the content in photosynthetic and flavonoid pigments. The pigment content from leaves was analysed spectrophotometrically, being estimated through light absorption capacity by the pigment acetone extract (1%) in visible spectrum and in near UV.

The *a* 663-664 nm chlorophyll may estimate the intensity of photosynthesis in the reaction centre, while *a* 431-432 nm chlorophyll and *b* 453 nm chlorophyll may evaluate light absorption capacity in photosynthetic systems: the flavonoid pigments with absorption in near UV (321-322 nm) may evaluate the plant response to various climatic stress factors. The comparative analysis of the leaf pigment content from leaves of the vegetative and floriferous shoot may evaluate the different mechanisms of controlling growth, fructification and stress resistance.

RESULTS AND DISCUSSIONS

The evolution of climatic factors under conditions of year 2008, in the Copou- Iaşi area, was analysed each month, being established the monthly mean and the sum concerning air temperature and rainfall, as well as the deviation to the multiannual mean. The study in dynamics on mean monthly temperatures showed that in the first three analysed months, the mean recorded temperature was between -1.3^{0}C in January and +7.1^{0}C in March, determining deviations to the multiannual mean, comprised between +1.4^{0}C and +3.6^{0}C. These values had a positive influence on plant unhardened process and bud burst (*tab. 1* and *fig. 1*).

Table 1

Temperatures of year 2008 (^{0}C)

Months	I	II	III	IV	V	VI	VII	VIII	IX	X
Mean monthly temperature (^{o}C)	-1.3	2.4	7.1	11.2	15.8	20.6	21.4	22	15.1	11.7
Mean multiannual temperature (^{o}C)	-2.7	-0.9	3.5	10.3	16.1	19.5	20.8	20.0	15.6	9.9
Deviation	1.4	3.3	3.6	0.9	-0.3	1.1	0.6	2.0	-0.5	1.8

The rainfall amount during the studied interval was characterized by a deficit of –12.8 mm and -20.2 mm in January and February, while in March, a surplus of +4.6 mm was found, without affecting the beginning of bud growth (*tab. 2* and *fig. 1*).

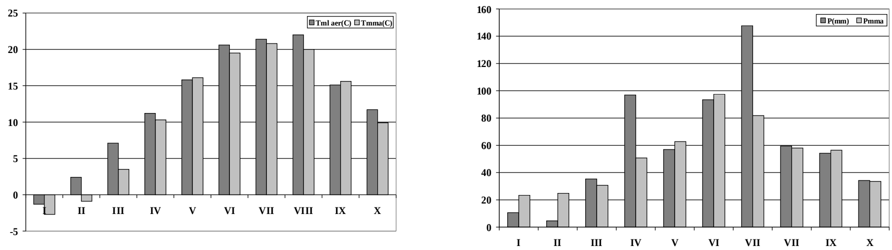


Figura 1 **Evolution of climatic conditions in 2008**

Table 2

Values of rainfall recorded in 2008 (mm)

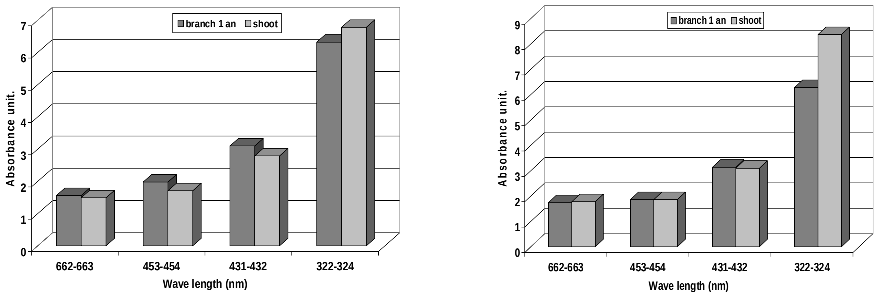
Months	I	II	III	IV	V	VI	VII	VIII	IX	X
Monthly sum	10.6	4.6	35.3	96.9	56.9	93.4	147.7	59.4	54.2	34.2
Mean multiannual sum	23.4	24.8	30.7	50.7	62.7	97.6	81.8	58.0	56.4	33.5
Deviation	-12.8	-20.2	4.6	46.2	-5.8	-4.2	65.9	1.4	-2.2	-0.7

In April, the mean monthly temperature was of 11.2^{0}C, the deviation to the multiannual mean being of only 0.9^{0}C, while in May, a negative deviation of only 0.3^{0}C was recorded, the monthly mean being of 15.8^{0}C. With a mean monthly temperature of 20.6^{0}C and a surplus of 1.1^{0}C to the normal temperature, the studied period proved to be favourable for the appearance of flower buttons and flowering.

From the water regime point of view, that period has recorded a significant surplus of +46.2 mm in April, followed by a deficit comprised between -4.2 mm in June and -5.8 mm in May that affected flower opening. The mean temperatures during July and September were characterized by close values to the multiannual mean (deviations varied between +0.6^{0}C and – 0.5^{0}C), only in August a temperature surplus of +2^{0}C being recorded.

July was characterized by the highest water surplus (+65.9 mm), but during the next interval (August – September), the rainfall amount was close to the multiannual mean, representing the best conditions for achieving fruit growth and ripeness. The mean pigment content from the shoot leaves and one-year branch was analysed in dynamics, during the growth season, according to the phenological phase.

The obtained results have shown that in July, during the intense shoot growth, the content of photosynthetic pigments (chlorophyll *a* 662-663 nm, chlorophyll *b* 453-454 nm and chlorophyll *a* 431-432 nm) recorded identical values in Jonagold Variety and slightly higher in the leaves of one-year branch in Golden spur variety (*fig. 2*).



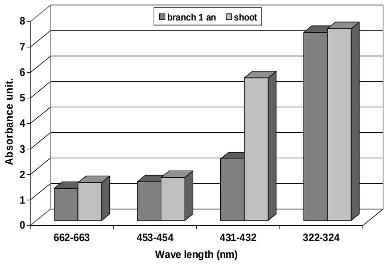
Golden spur **Jonagold**

Figure 2 **Mean content of leaf pigments in July**

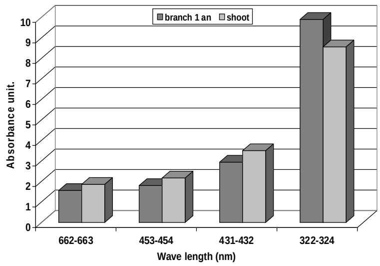
The content of flavonoid pigments that provided resistance to unfavourable factors has recorded higher values in the shoot leaves, compared to the values of one-year branch, especially in Jonagold variety. Therefore, at this phenological phase, the intensity of photosynthesis in the two apple tree varieties, represented both by the capacity of assimilates synthesis and by light absorption, is a species feature, while the content of flavonoid pigments that provided resistance to stress factors, are synthesized at greater amount in the young leaves of the shoot, with more evident values in Golden spur variety.

In August, at the phenological phase of fruit growth, the obtained results have shown a change in the ratios between the quantities of leaf pigments in the shoot leaves and one-year branch. Although the shoot did not cease its growth in length, most of its leaves became mature, recording a higher content of photosynthetic pigments, chlorophyll *a* 662-663 nm, chlorophyll *b* 453-454 nm and chlorophyll *a* 431-432 nm, compared to the leaves from one-year branch.

The clearest differences between the two leaf types were noticed in the values of the content of chlorophyll *a* 431-432 nm in Golden spur variety, where the reduced shoot growth, which is a feature of the variety, is compensated by a higher light absorption in shoot leaves (*fig. 3*).



Golden spur



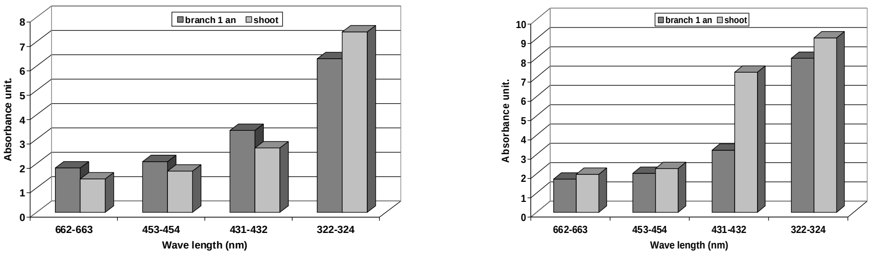
Jonagold

Figure 3 **Mean content of leaf pigments in August**

The content of flavonoid pigments has recorded an equalization tendency in the leaves of both studied varieties. The comparative analysis between the two varieties has shown higher values of this content in Jonagold variety, which can be correlated to the high resistance to scab. At this phenological phase, they found the equalization in the content of leaf pigments from shoot and one-year branch. This behaviour provides a photosynthetic intensity and a high resistance capacity to climatic (drought) and biological stress and the normal development of the physiological processes that took place in that period, like fruit growth and ripeness, but also the floral differentiation providing the fruit yield for the next year.

In September, the beginning of fruit ripeness and wood maturation took place, providing resistance of branches and buds to wintering. At this phenological phase, the behaviour of the two varieties differs as concerns the photosynthetic pigments; the content of chlorophyll *a* 663-664 nm, chlorophyll *b* 453-454 nm and, especially, chlorophyll *a* 431-432 nm is higher in the shoot leaves in Jonagold variety, while in Golden spur, these values were lower. The content of flavonoid pigments has shown an identical behaviour in both studied varieties, with higher values in the shoot leaves (*fig. 4*).

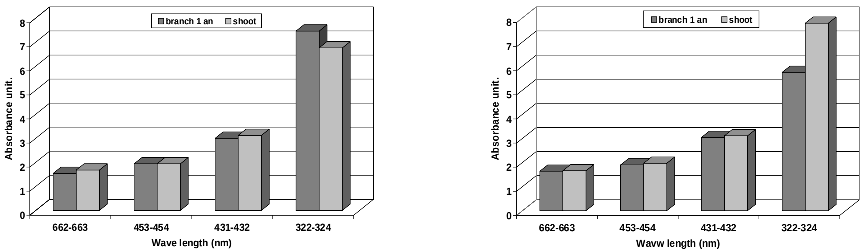
We noticed, thus, the correlation between the content of photosynthetic pigments with shoot growth vigour, which was greater in Jonagold variety and the presence of shoot leaves in the biosynthesis of flavonoid pigments that provided the preparation for wintering.



Golden spur **Jonagold**

Figure 4 **Mean content of leaf pigments in September**

In October, at the phenological phase of fruit ripeness and beginning of bud dormancy, the content of photosynthetic pigments was equalized in the leaves of both branch types, but in Jonagold variety, the shoot leaves were characterized by a higher content in flavonoid pigments, having role in providing resistance to wintering (*fig. 5*).

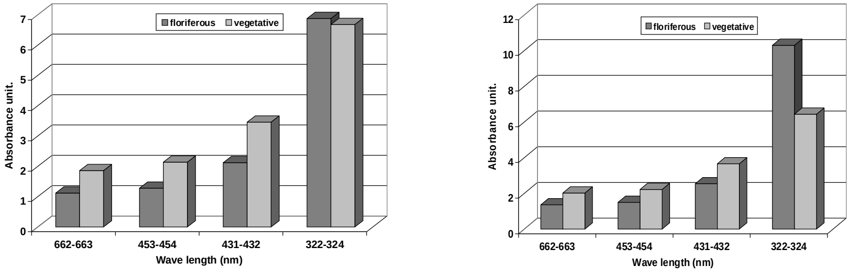


Golden spur **Jonagold**

Figure 5 **Mean content of leaf pigments in October**

The comparative analysis of the leaf pigment content from leaves of the vegetative and floriferous shoot was done according to phenological phases, for estimating the presence of different origin leaves at the fructification process.

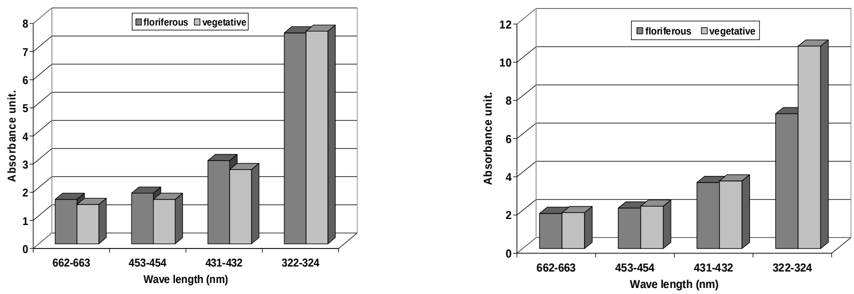
Determinations carried out in July have shown that in both studied varieties, the content of photosynthetic pigments was the highest in the leaves of the vegetative shoot, compared to the ones of the floriferous shoot. Therefore, at the phenological phase of intense shoot growth, the intensity of photosynthesis and light absorption capacity were higher in the vegetative shoot, showing the metabolic effect determined by this process. The biosynthesis of flavonoid pigments is more reduced in the vegetative shoot, especially in Jonagold variety, which may be explained by the lower degree of leaf maturation. The comparison between the two varieties has shown higher values in Jonagold variety, especially in the leaves of the floriferous shoot (*fig.6.*).



Golden spur **Jonagold**

Figure 6 **Mean content of leaf pigments in July**

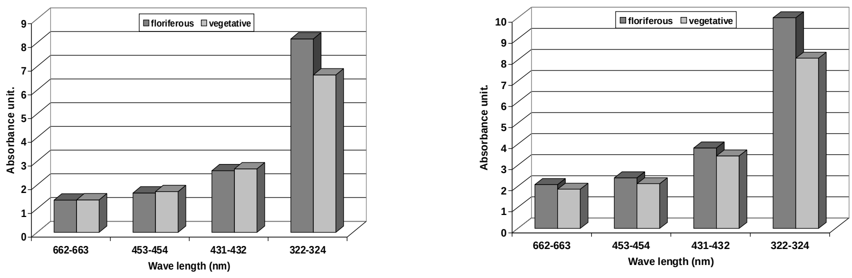
In August, at the phenological phase of fruit growth, we found an equalizing tendency of the photosynthetic pigment content from the leaves of both shoot types (*fig. 7*). A high intensification of the flavonoid pigment content was recorded in the leaves of the vegetative shoot in Jonagold variety.



Golden spur **Jonagold**

Figure 7 **Mean content of leaf pigments in August**

In September, at the phenological phase of fruit ripeness, we found the same tendency of equalizing the photosynthetic pigment content in the leaves of the two shoot types, showing the uniformity of the photosynthetic process as concerns light absorption and achievement of biosynthetic reactions. The biosynthesis of flavonoid pigments was more intense in the leaves of the floriferous shoot in both studied varieties. This may be explained by directing the leaf metabolic effect to the biosynthesis of substances with role to protect the fructification organs against the climatic and biological stress that may appear at this phenological phase (*fig. 8*).

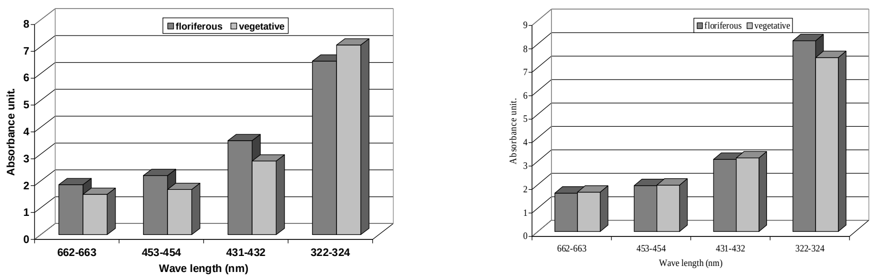


Golden spur **Jonagold**

Figure 8 **Mean content of leaf pigments in September**

In October, at the phenological stages of fruit ripeness and wood maturation, the ratio is maintained as concerns the photosynthetic pigments from Golden spur variety, while in Jonagold, there is an equity ratio between the intensity of photosynthesis and light absorption by leaves (*fig. 9*).

As concerns the flavonoid pigments, the two varieties show a different behaviour, the content being higher in the leaves of the vegetative shoot from Golden spur variety, compared to Jonagold variety, where there is a reversed ratio. The same higher values are kept in Jonagold variety, showing a higher resistance to wintering of the shoot that will become branch in Jonagold variety.



Golden spur **JonagolD**

Figure 9 **Mean content of leaf pigments in October**

CONCLUSIONS

1. The evolution analysis of climatic conditions during spring-autumn of year 2008 has shown that they were favourable from temperature and water point of view for the tested apple tree varieties.

2. The mean content of photosynthetic pigments from the leaves of shoot and one-year branch has, generally, relatively close values to both studied varieties, confirming the species traits.

3. The differences between varieties are shown by the intensification of light adsorption capacity in Golden spur variety in August, as compensation effect of more reduced growth vigour and in Jonagold variety in September, for supporting the high and prolonged growth vigour.

4. The content of flavonoid pigments has the highest values, especially in the leaves of the floriferous shoot from Jonagold variety, results that may be correlated to the good resistance of this variety to stress, recommending it to be cultivated in the area.

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