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FRUIT GROWING TECHNOLOGIES - PRESENT AND PERSPECTIVES

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Abstract. Romanian fruit growing, under financed in the last years, owns predominant old plantings, with low profit, and the establishment of modern new orchards is chaotic and insignificant, regardless on the most favorable soil and climatic areas and on local tradition in fruit growing. To enter and perform on the fruit market, the Romanian fruit growers need to establish new plantation types, using valuable nursery material, adapted to consumer's preferences. They need to apply in the new orchards, intensive fruit growing technologies, to provide constantly superior and high quality fruit yields. Orchards must produce earlier and sustained in order to generate an earlier return on investment and improve profitability. At Research Institute for Fruit Growing Pitesti Maracineni (RIFG), according the variety, the fruit productions obtained in experimental high density apple orchard of 3,077 trees x ha^{-1} (3.25 m x 1.0 m), were 19.3 up to 30.0 t x ha^{-1} in the second year after planting and in the third year from 29.7 to 38.5 t x ha^{-1}. This work goal is to present and recommend some orchard training systems, their appropriate technology and to highlights some results obtained at some apple cultivars in these types of orchards.

Key words: high density, apple orchard.

1. Introduction

In fruit growing, especially at European level, the intensive fruit production system tend to generalization, together with continuous supply all over the vegetation season of all positive interactions between the natural growing factors and physical, chemical and biological vegetation factors, well balanced and allocated at optimum levels as quantity and quality, by application of the advanced technological measures which also protect the orchards against the risk factors.

All these technological measures are applied in high density orchards, established with valuable biologic material, consisting in high productive cultivars, grafted on low vigor vegetative rootstocks, in order to obtain very high fruit yields on the surface unit and a superior economical efficiency.

The actual relief and pedo-climatic diversity of Romania offer favorable conditions to grow a large panel of fruit species, but the Global Climatic Changes bring into the actuality new criteria for durable zoning of fruit species and adequate fruit growing technologies as well [2].

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In this context, choosing the appropriate cultivar-rootstock combination, the needed technology for soil maintenance and fertilization and trees management, the choose of the most effective orchard phytoprotection program represent the major preoccupations for every fruit grower [3, 6, 8, 9].

As regard the fruit trees nutrition, Marangoni et all., 2001, shows that foliar feedings associated with fert-irrigations (nowadays used on a large scale in world fruit growing), insure in great measure the fruit trees needs for supplies, the soil fertilization is reducing and the fertilizers consumption as well.

The great densities of fruit trees on the surface unit, using low vigor vegetative rootstocks determines the diminution of the soil volume available for each fruit tree and determine the accentuation of the competition for nutrients and water, an exhaust of the soil explored by the roots and a higher trees dependence on the external supply with nutrients. On the other hand, if is applied constantly, the localized irrigation provide into the plants a sustained sap circuit, with the capacities to uptake the minerals especially for the roots developed in the soil volume supplied with water by irrigation [1, 7].

Present paper goal is to present some essential elements of fruit growing systems, modern technologies for apple and to support by the our researches results, the necessity to guide the Romanian fruit growers toward these technologies and orchard types which join in a happy manner the economical efficiency with the environment protection.

2. Material and method

In the spring of 2007, complex experience were set up in a super intensive orchard type, with planting distances 3.25 x 1.0 m (3,077 trees/ha). The experience was a polyfactorial one and included 36 variants (3 x 6 x 2) with 5 trees in replicate plot, disposed according to sub-divided plot method.

The experimental factors studied included:

A factor **- The Cultivar**: the biological material was represented by 'Jonagored', 'Fuji Kiku Clone 8' and 'Golden Delicious Clone B', grafted on ‘M9 T 337’;

B factor **- Fertilizers Dose**, applied concomitant with the irrigation water had 6 graduation:
b1 - untreated control, and annually fertilized with the following nutrients amounts:
b2 - N_{20}:$P2O5_{10}$:$K2O_{30}$:MgO_{10},
b3 - N_{40}:$P2O5_{20}$:$K2O_{60}$:MgO_{20},
b4 - N_{60}:$P2O5_{30}$:$K2O_{90}$:MgO_{30},
b5 - N_{80}:$P2O5_{40}$:$K2O_{120}$:MgO_{40},
b6 - N_{100}:$P2O5_{50}$:$K2O_{150}$:MgO_{50};

C *factor* - The pest and diseases management system - The aim was the comparative analysis of 2 pest and diseases management systems, 'standard' and 'integrate' using plant protection products with low impact on the environment and the users.

The experimental device is located on a plane ground situated on the second terrace of the Argeş River, the soil being brown eumezobasic, low podzolic and pseudogeic ones. As regard the experimental device soil texture is sandy-clay one with a good aeration and water holding capacity. Orchard ground management was with grass covered between the trees rows and cleared with herbicides on a 1.0 - 1.2 m wide strip, along the trees rows.

Daily meteo parameters (medium, high and low air temperature, daily air temperature amplitude, sun shine length, the rainfalls and pluviometric deficit - represented by the difference between the reference potential evapo-transpiration calculated with Penman-Monteith equations and rainfalls) were determined and stored at the RIFG Piteşti-Mărăcineni weather station located in the neighborhood of the experimental fields.

3. Results and discussions

3.1.Fruit growing systems evolution in Romania

Şefan N. and colab. (1983) referring to autochthonous intensivized orchards states that, although in the experiences carried out by the Romanian fruit growing research the performances were similar with the ones obtained abroad, „the driving" under the production conditions of the technologies established by the research activity, was realized with different performances according to the zones and production units.

The same authors opiates that among the major factors determining the productive potential diminution of these plantations type were: the orchards setup on improper grounds, incorrect execution or lack of canopy forming works, abandon of the summer prunings, insufficiency of resources, poor technical equipment of the farms, inadequate organization, use of a non-specific assortment and frequent use of some to vigorous cultivars/rootstocks combinations which entered into productive period to late and lead finally to over crowded orchards.

After 1990, due to the changes appeared by the application of the land property and administration laws (from Law 18/1991 up to Low. 247/2004), the fruit growing registered a significant regress, materialized by orchards surfaces diminution, fruit production reduction, also gradually decrease of the nurseries material stock and planting works.

In the next images are presented some representative aspects of the apple orchards existing in Romania, established 25-30 years ago. Generally the MM 106 rootstock was used, in combination with many cultivars; the canopy shapes used, types „palmete" with horizontal or oblique branches, determined the shadow persistence and poor differentiation of the fructiferous branches and buds in the inferior part of the tree canopies.

The planting distances used were sometimes unbalanced with trees vigor (3.5m – 3.6m / 1.5 – 2.0 m) and the trees high were limited at 2.0 m – 2.2 m by drastically and cost effectives annual pruning and periodic shorten of trees axes.

Figure 1. Apple orchard of 25 years old, trained as „palmete with horizontal branches"

Figure 2. Apple orchard of 25 years old, trained with double rows

Figure 3. Apple orchard of 25 years old, with the trees planted in zigzag.

Such kind of plantations had limited productive and economical performances, also because of the disequilibrium between the growth and yielding processes,

generated by the necessity of more severe prunings (great consumers of high quality labor force), but also due the lack of irrigation water, supplied in required amounts at the right moment.

In the latest years, in the same kind of plantations, sporadic was used the „spindle" type canopy („slender spindle" and „spindle bush"), which offer the possibility of more efficient use of the production space, a better aeration and illumination of the fructiferous branches (figure 4) and offer a higher fruits production and quality, superior to the older plantations.

Figure 4. Apple orchard 5 years old, planted at 4/2 m,
with canopy trained as „spindle" (RIFG Pitesti, Mărăcineni)

In the experiences organized and carried out at RIFG Piteşti the differentiation between fruit growing systems was done taking into account the following indicators: ground use degree expressed by density (trees/ha) or by planting density, the biological material used (species and cultivar/rootstock combinations), trees grumping mode, canopy shape, the fructiferous wall height and thickness, orchard exploitation period, yield amount and quality on surface unit, all of them studied in dynamic, during the exploitation period, the investition value, the human labor force consumption, the production costs and the investition recovery period.

3.2. Meteorological parameters evolution during the last 40 years and their influence on fruit growing

The effects of the Global Climate Warming, the increased frequency of the dry years and not very uniform distribution of the precipitations during the vegetation period, lead to the accentuation of the semiaridity climatic character and its extent also in the hilly zones of the Romania. In this context, we shall present some tendencies of the climate in 1969-2009 period, with consequences on the fruit growing activity.

The polynomial curves of fifth degree trend allow us to affirm that in this period a clear tendency (statistically insured) was directed toward weather warming (figure 5). All determination coefficients for the regression curves are statistically insured, from 1996 to present, the phenomena probability rising up to 50%.

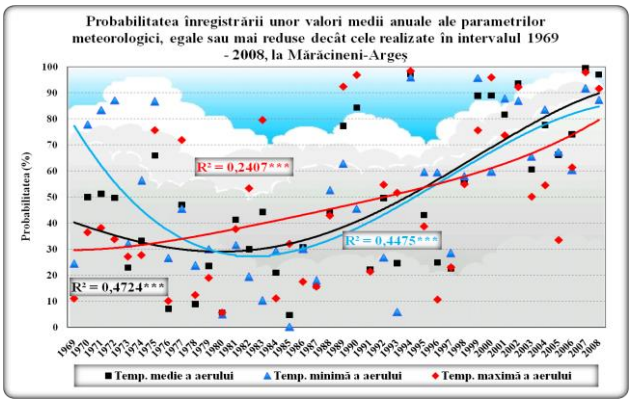

Figure 5. Probability to register some annual average values of the mean, high and low temperatures of the years, equals or lower than the ones accomplished during 1969 - 2008 at Mărăcineni-Argeş.

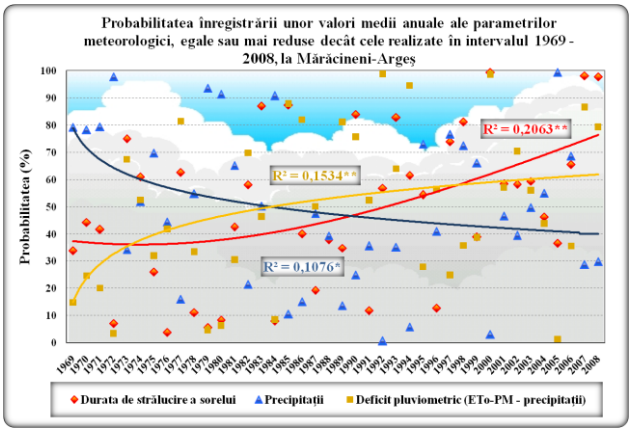

Figure 6. Probabilities to register during 1969 - 2008 the annual sums of sun shine length period, precipitation amounts and pluviometric deficit, equals or lower than the ones registered during the study period.

The same tendency of values increase according the time was evidenced also in the case of sunshine length period (figure 6, R^2=0.2063**) and in the case of the annual medium pluviometric deficit (R^2=0.1534**), but for the precipitations, the general tendency was to decrease (R^2=0.1076).

As regard the intensity of correlation, between the monthly mean values of some meteorological parameters and some years included in the study (simples r, 1969-2009), the table 1 reveal that among the year months that influence the trees entrance into vegetation, February was the month with the most significant

changes; the higher temperature, day-night amplitude and sunshine length period, manifested a rise up tendency, which can determine in the future an earlier entrance into the vegetation of the fruit trees.

Table 1. Correlations intensity between the monthly average values of some meteorological parameters and the years of study (simples r correlations coefficients, 1969-2009)

Month	Mean air temperature	Maximum air temperature	Minimum air temperature	Mean diurnal thermic amplitude	Sunshine length period	Atmospheric precipitations
I					0.332*	
II		0.331*		0.426**	0.464**	
III				0.331*		0.303*
VI	0.436**	0.396**	0.307*		0.319*	
VII	0.607***	0.586***	0.373*	0.301*		
VIII	0.559***	0.398**	0.520***			
IX					-0.351*	
X	0.545***		0.473**			

The results regarding the fruit production obtained in the experimental intensive apple orchard, in relation with the experimental factors, in the second and third year after orchard establishment are presented from now on.

3.3. The effect of experimental treatments on fruit growing processes starting with the second year after orchard establishment

The fruit productions registered in the experimental plot are very high for an orchard in the second year: 19.3 - 30 t/ha according the cultivar (Figure 7).

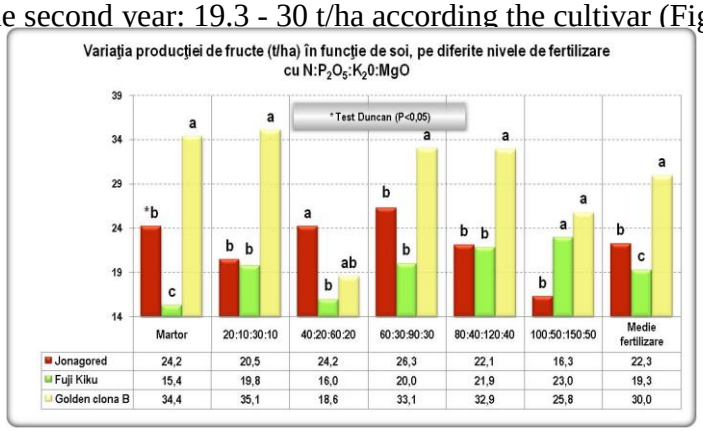

Figure 7. Fruits production variation (t/ha) according to cultivar, in relation with different levels of fertilization with $N:P_2O_5:K_20:MgO$

With small exceptions (fertilization level with $N:P_2O_5:K_20:MgO$ - 40:20:60:20), for all fertilizer graduations, the cultivar 'Golden clone B' yielded the highest production 30 t/ha, followed by 'Jonagored' cultivar with 22.3 t/ha and

respectively 'Fuji Kiku Clone 8' with 19.3 t/ha (Fig. 7), the differences being statistically insured.

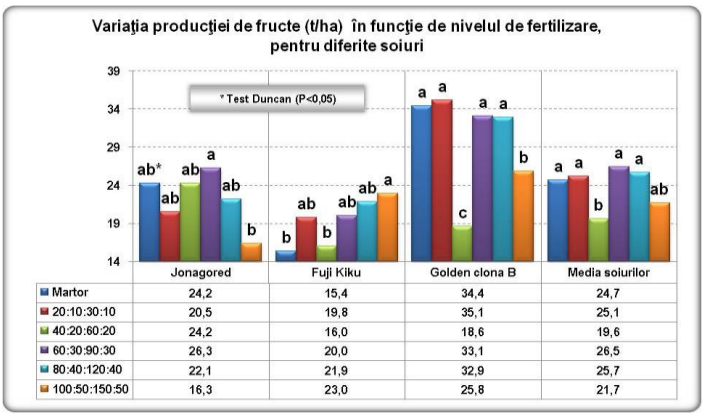

Figure 8. Fruits production variation (t/ha) according to fertilization level, for different cultivars

By assessment of the fruits production variation (t/ha) according to fertilization level, for different cultivars (fig. 8), we can observe that, production levels induced by different quantities of fertilizers are similar from the statistic point of view (21.7 – 26.5 t/ha), with the exception of the fertilization level $N:P_2O_5$:K20:MgO - 40:20:60:20, on which was registered a production of 19.6 t/ha.

3.4. Effect of the experimental variants on the fructification processes in the third year after orchard establishment

Although did not produced the highest number of fruits per tree, 'Jonagored' together with 'Golden Clone B' cultivars provided the highest fruits productions (36.7 and respectively 38.6 t/ha), which differ significantly from the production obtained with the cultivar Fuji Kiku Clone 8 (29.7 t/ha), assessed as regard the means of fertilization levels (Figures 9).

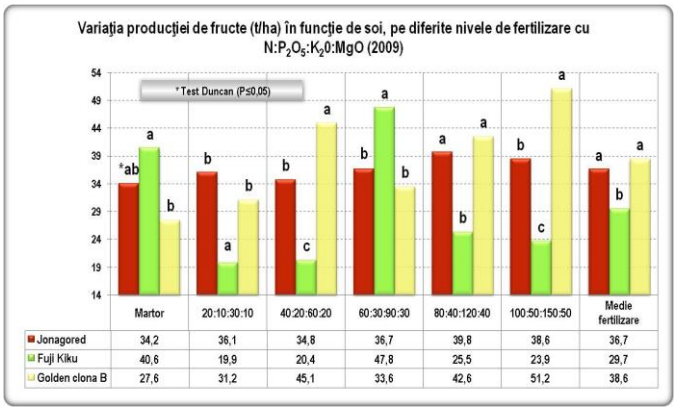

Figure 9. Fruits production variation (t/ha), according to cultivar and fertilization levels.

As regard the fertilizers influence, was noticed that starting with the third year after orchard establishment, the production tend to rise up with the increase of fertilizers amounts, especially nitrogen and potassium (the proportion of these elements rise even more than phosphorus and magnesium in V4-V6 variants), and the production levels arrives at 36.0 – 39.4 t/ha, for cultivars and phytoprotection variants averages (Figure 10).

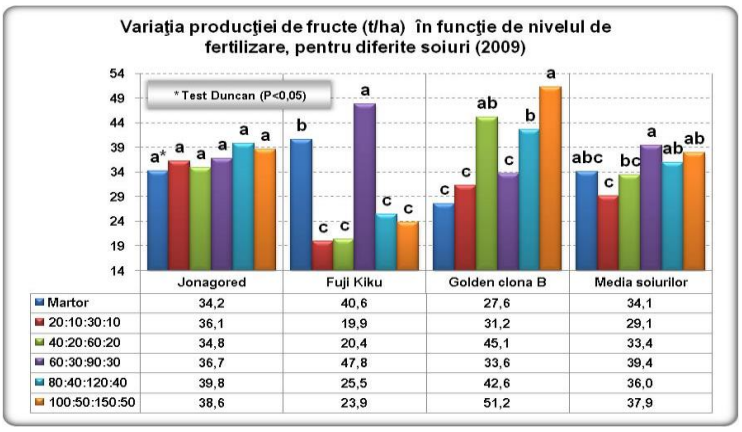

Figure 10. Fruits production variation (t/ha), according to fertilization level (Third year after orchard establishment).

For exemplification, in the figure 11 are presented images taken in the experimental intensive apple orchard established at RIFG Piteşti - Mărăcineni, where the presented production results were obtained.

Figure 11. Intensive apple orchard in the third year after orchard establishment (‘Golden Clone B’ - left and ‘ Jonagored cultivar’ - right)

3.5. Technical and economical indicators for the actual and the perspectives technology

From here we are presenting some synthetic technical and economical parameters that can defines from the economical point of view the applied growing technologies in the table 2 for apple species. In the tables are comparatively

presented the indicators for the actual technology used in the Romanian fruit growing and the indicators for the perspectives technology recommended for a performance fruit growing.

Table 2: Technical and economical indicators for apple species

Crt. Nr.	Specification	M.U.	Quantity or value	
			Actual technology	Perspectives technology
1	Designed capacity	ha	1	1
2	Density	trees/ha	1,250	3,333
3	Total value of the investment	lei	61,134	136,545
4	Exploitation period	years	20	15
5	Annual rate of the amortisment	lei/ha	3,057	9,103
6	Annual expenses for exploitation	lei/ha	13,447	21,930
7	Fruits production planified at the entrance into full bearing period	tons	20	55
8	Average cost price	lei/t	825	564
9	Marketable production	tons	20	55
10	Average price per unit for valorification	lei/t	1,155	1,175
11	Marketable production value	lei	23,100	64,625
12	Annual profit	lei	6,596	33,592
13	**Investment turnover period**	**years**	**9/12***	**4/6***

* For investment turnover two values are given; first value represent the investment turnover period from entering into the full bearing of the orchard, and the second value represent the investment turnover period, from the moment of orchard establishment.

In presented tables it can be noticed that, the investment turnover period is smaller in the case of the perspectives technology application, although the total investments value is higher for these fruit growing technologies.

In this moment, the Romanian fruit growing is on the roads cross and can choose: to remain at the present low technical and economical performances level, or to apply the modern technologies of fruits production, in order to make profit and to gain new markets.

For the future reduction of the cultivated surfaces concomitant with crops intensivization create favorable conditions to diminish unfavorable effects of climatic changes with low costs: fert-irrigation systems, protection systems against frost hail and insolation.

With the large increase in air temperature, in number of hours of sunshine and lower rainfall in the summer months, irrigation techniques will have to evolve within the meaning of efficient exploitation of water resources - is known that drip or micro-sprinklers irrigation techniques distribute water more economically than sprinklers or furrow irrigation.

By increasing the range of vegetative rootstocks it was possible to achieve high density orchards, not only for pome species but also for stone fruit species: the range of apple rootstocks tend to reduce to the type M9 and his clones; for pear is spreading the grafting on various types of low vigor quince rootstocks; the Saint Joulien rootstock is more and more used for plum and Gisela series rootstocks for sweet cherry.

In the high density plantations is necessary to increase solar energy use efficiency by choosing the appropriate type of crown (slender spindle, vertical axis, "V" system, etc.), simplification of crown training technology, removing unproductive areas around the axis, generalization of "green" pruning.

The massive transition to high density orchards requires the generalization of fertigation and support systems settled even before planting. The support function of the branches of low and medium density plantations will be taken by a support system consisting of espalier, wire and bamboo, like individual support (first year production can be 5-10 t ha^{-1}, particularly in pome species).

Conclusions

From the climatic point of view, under the local conditions from Piteşti-Mărăcineni, a clear tendency of weather warming (statistically insured) was noticed, with an increase of sun shine period length and an evident rainfall deficit than 10 years ago, compared with the multiannual values registered at the local weather station;

At RIFG Piteşti-Mărăcineni, in high density apple orchards, application of the intensive fruit growing technology lead to apples productions of 19.3 – 30.0 t/ha, in the second year after orchard establishment and 29.7 t/ha – 38.6 t/ha in the third year after orchard establishment, according with the grown cultivar;

In the intensive orchards, a large amount of investments are needed to apply modern fruit growing technologies, but the obtained fruits productions lead to investments turnover period shortening with five years, both for apple and plum species.

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