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FRUIT GROWING TECHNOLOGIES TO MITIGATE THE NEGATIVE IMPACT OF CLIMATIC CHANGES FROM THE SOUTHERN PART OF ROMANIA

Dorin SUMEDREA, Emil CHITU, Viorica CHITU, Mihaela SUMEDREA, Florin Cristian MARIN, Nicolae TĂNĂSESCU

Research Institute for Fruit Growing Pitesti, Romania, Marului Str, Maracineni, Arges, cod 117450, OP 1, CP 73, *Tel: +40-248-278066; Fax: +40-248-278477;* office@icdp-pitesti.ro

Corresponding author email: dsumedrea@yahoo.com

Abstract

The actual relief and pedo-climatic diversity of Romania offer favorable conditions to grow a large panel of fruit species, but the climatic changes bring into the actuality new criteria for durable zoning of fruit species and adequate fruit growing technologies as well. 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. This work goal is to present the influence of fertigation on growth and fruit yield from a high density apple orchards, in the fourth year from orchard establishment. The fruit productions obtained in the third year from orchard establishment ranging between 34.3 - 44.4 t ha^{-1}*, depending on the cultivars. The decrease order of vigour of the studied cultivars, estimated by the average increase of trunk cross-section area (TCSA), was: Jonagored (4.39 cm^2 of TCSA), Fuji Kiku 8 (3.43 cm^2 of TCSA), Golden clona B (3.09 cm^2 of TCSA).*

Key words: *fertigation, climatic changes, high density apple orchard.*

INTRODUCTION

The effects of the Global Climate Changes, the increased frequency of the dry years and not very uniform distribution of the precipitations during the vegetation period, lead to the increasing of the semiaridity climatic character and its extent also in the hilly zones of the Southern part of Romania. Mateescu *et al.,* 2009, estimated that, in Pitesti, Romania, according to projections made by regional climate model RegCM3/SRES A1B, annual average air temperature will increase by 1.5°C from 2020 to 2050 compared to the current conditions. The biggest increases are expected in the warm period of the year respectively during April-August period (1.6°C in May, 2.6°C in June, 2.8°C in July and 1.0°C in August). Annual amounts of rainfalls will decrease by an average of 91.1 mm, the largest decreases being projected, again, in the summer period. In the Maracineni area, between 1969 and 2010, there was a statistically assured trend of weather warming, of sunshine hours and rainfalls deficit increasing and of the annual rainfalls decreasing [2]. The months having the highest abnormal weather were June, July and August. The largest slope of temperature and Penman-Monteith potential evapo-transpiration increase has been registered, however, in August. Under these conditions, even if in climatic areas favorable for growing fruit trees, the rainfall deficit in summer months is increasing, growing fruit trees in high density

systems require more efficient methods of irrigation and fertilization [1].

Many authors have argued that a highly accurate application, both for water and fertilizers, can be achieved by simultaneous administration by fertigation. Thus we obtain the advantage of simultaneous supply of mineral elements in accordance with the trees needs [5, 7]. The foliar application of fertilizer associated with fert-irrigations, insure in great measure the fruit trees needs for supplies, the soil fertilization is reducing and the fertilizers consumption as well [3].

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 of the external supply with nutrients [6]. 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 by the roots developed in the soil volume supplied with water by irrigation. Present paper goal is to present some essential elements of apple fertigation fruit growing systems, 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.

MATERIAL AND METHOD

The researches were carried out in a high density apple orchard, established at RIFG Pitesti - Romania in the spring of 2007. The trial with the trees planted at 3.25 x 1.00 m (3,077 trees ha^{-1}), was a bifactorial one and included 18 treatments (3 x 6) with 5 trees in repetition plot, following the subdivided plots design. The experimental factors taking into the study included: A factor, the cultivar: 'Jonagored', 'Fuji Kiku' Cl. 8 and 'Golden Delicious' clone B cultivars, grafted on M9 T 337 rootstock; B factor, the nutrients doses applied together with irrigation water, with six graduations: b1 - untreated control, and treated with the following annual fertilizer rates (kg ha^{-1}): b2 - $N_{(20)}:P_2O_{5-(10)}:K_2O_{(30)}:MgO_{(10)}$, b3 -$N_{(40)}:P_2O_{5-(20)}:K_2O_{(60)}:MgO_{(20)}$, b4 - $N_{(60)}:P_2O_{5-(30)}:K_2O_{(90)}:MgO_{(30)}$, b5 - $N_{(80)}:P_2O_{5-(40)}:K_2O_{(120)}:MgO_{(40)}$, b6 - $N_{(100)}:P_2O_{5-(50)}:K_2O_{(150)}:MgO_{(50)}$.

The experimental plot was placed on a plane terrain, located on the second terrace of the Arges River, the soil being brown eumesobasic, slightly podzolic şi pseudogleic one. As regards the texture, in the experimental plot soil was a sandy loam one, with a good aeration and water holding capacity. The soil reaction was slight acid (pH=5.8 - 6.8). Generally, the humus content was under 3%, indicating a low supply in nitrogen of the soil. The mobile phosphorus ranged between 8-10 ppm, showing a medium supplied soil. Analysis of the soil degree of bases saturation indicated that the soil had a low to medium natural fertility. The nitrogen index value was under 2%, revealing a low supplied soil with nitrogen. The orchard soil training system was a combination of grasses cover between the trees rows and herbicides in stripes of 1.0-1.2 m wide, along the trees rows.

The influence of the experimental factors was quantified using the following set of biological indicators registered in the fourth year from orchard establishment: trunk cross section area (TCSA, cm^2), annual increase of TCSA, mean number of flower buds per tree, mean number of harvested fruits per tree, fruits mean weight at harvest time (g), and fruits mean yield (t ha^{-1}). The high amount of the experimental data was stored and processed by the analysis of variance, using the specialized program SPSS 14.0 with its bifactorial ANOVA calculation model and by correlations method (Pearson's coefficients).

RESULTS AND DISCUSSIONS

1. Meteorological parameters evolution during the last 42 years and their influence on fruit growing We are going to present some tendencies of the climate in 1969-2011 period, with consequences on the fruit growing activity. The polynomial curves of fifth degree trends, allow us to affirm that in this period a clear tendency (statistically insured) was directed toward weather warming (figure 1). All determination coefficients (r^2) for the regression curves are statistically insured, from 1998 to present the temperature probabilities being almost in all cases greater than 50%.

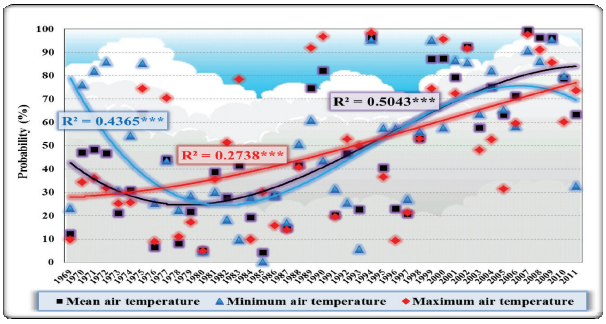

Fig. 1. Probability to register annual average values of the mean, maximum and minimum temperatures, equals or lower than the ones accomplished during 1969 - 2011 at Maracineni-Arges.

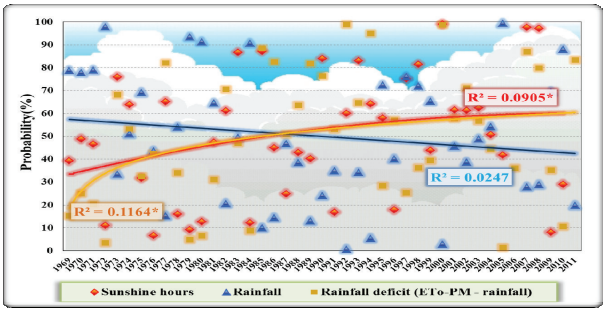

Fig. 2. Probabilities to register during 1969 - 2011 the annual sums of sunshine hours, rainfall amounts and rainfall deficit, equals or lower than the ones registered during the study period.

The same tendency of increasing the annual sums according the time was evidenced also in the case of sunshine hours (figure 2, R^2=0.0905*) and in the case of the rainfall deficit (R^2=0.1164*), but for the precipitations, the general tendency was to decrease (R^2=0.0247). As regard the intensity of correlation, between the monthly mean values of meteorological parameters and time included in the study (simples correlation coefficients - 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 onset of vegetation of the fruit trees [2].

Table 1. Correlations intensity between the monthly mean values of some meteorological parameters and time (simples r correlations coefficients, 1969-2009) Chitu et al., 2010

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 yield 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.

2. Effect of the experimental treatments on the growth and fructification processes in the fourth year after orchard establishment

Increase of trunk cross section area (*TCSA*)

In the fourth year of application, on average of the 6 levels of fertilization, induced a descendent of the vigor on the cultivars taken in the study, revealed in the trunk cross section area (TCSA) increase (Fig. 3), with different values from each cultivar for a statistical insurance of 5%: 'Jonagored' (4.39 cm^2 TCSA increase), 'Fuji Kiku Clone 8' (3.43 cm^2 TCSA increase T), 'Golden Delicious Clona B' (3.09 cm^2 TCSA increase). In general, at all graduations of fertilization level, the 'Jonagored' cultivar had the highest vigor and 'Golden Delicious Clone B', had the lowest vigor (Fig 3).

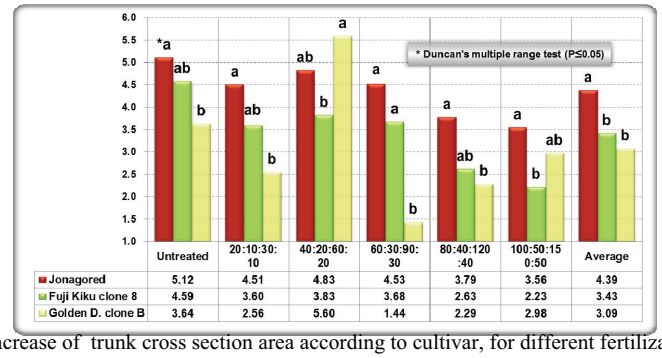

Fig. 3. Increase of trunk cross section area according to cultivar, for different fertilization levels

Assessment the influence of fertilization variants on the trunk cross section area (TCSA) annual increase (Fig. 4), reveal that, on cultivars average, the highest vigor and statistically assured was surprising registered in the untreated control variant and in the variant N:P2O5:K20:MgO with the elements ratio 40:20:60:20 (4.45 cm^2 and respectively 4.75 cm^2 TCSA increase), compared with the other fertilization variants with TCSA increase of 2.9-3.56 cm^2.

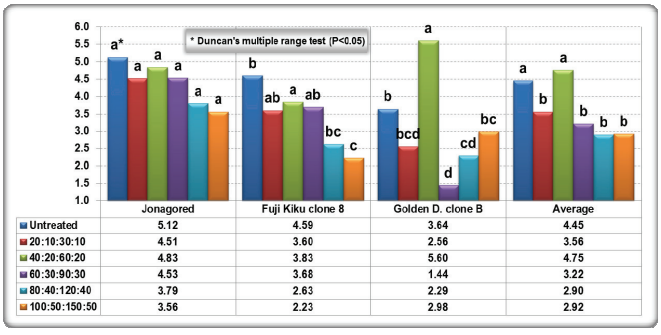

Fig. 4. Increase of trunk cross section area according to fertilization level, for different cultivars

Number of flower buds per tree

Although inside each fertilization variant there are statistically assured differences regarding the number of the flower buds per tree, on the average of the graduations of fertilization variants, the cultivars did not induced statistically assured differences (Fig. 5). In this sense, there are small differences regarding the flower buds number among the cultivars, the sorted descendent order being: 'Golden Delicious Clone B', with 57.9 flower buds, 'Fuji Kiku Clone 8' with 57.9 flower buds, and 46.5 flower buds at 'Jonagored' cultivar.

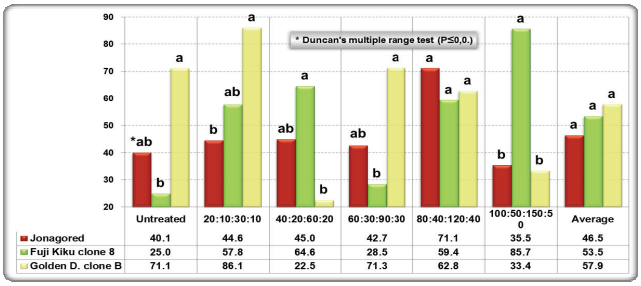

Fig. 5. Number of flower buds per tree according to cultivar, for different fertilization levels

On the cultivar average, the fertilization treatments did not induced statistically assured differences regarding the number of flower buds per tree (Fig. 6), their number ranging between 44.1 and 64.4 flower buds per tree.

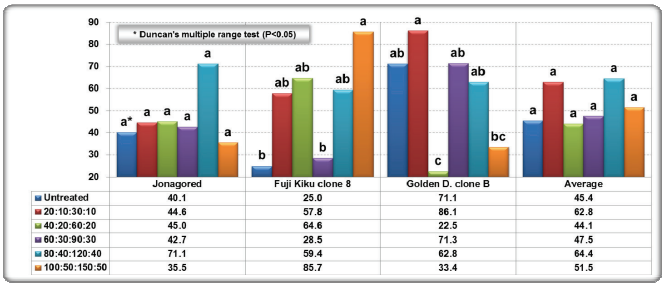

Fig. 6. Number of flower buds per tree according to fertilization level, for different cultivars

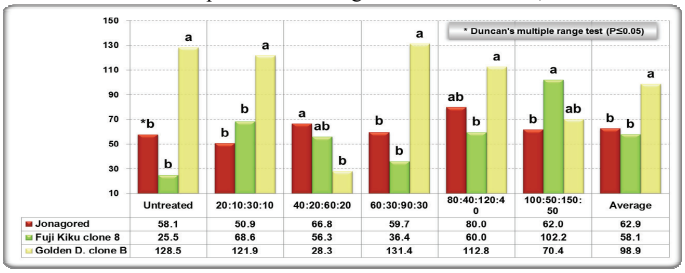

Fig. 7. Number of fruits per tree according to cultivar, for different fertilization levels

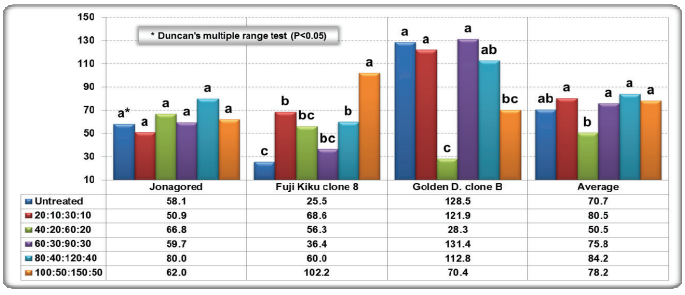

Fig. 8. Number of fruits according to fertilization level, for different cultivars

Number of fruits per tree

With small exceptions inside each fertilization level, the cultivar with the highest number of fruits per tree was 'Golden Delicious clone B', which presented 28.3-131.4 fruits / tree according the fertilization variant (Fig. 7).

On average of the fertilization levels 'Golden Delicious Clone B' cultivar presented the highest fruit number (98.9 fruits /tree), value which differ significantly from the statistically point of view from 'Jonagored' and 'Fuji Kiku' which produced 62.9 and respectively 58.1 fruits /tree (Fig. 7).

The fertilization variants with the highest nitrogen amounts (V4-V6) induced the highest fruits number per tree (Fig. 8), on the cultivars average being registered 75.8 - 84.2 fruits /tree, similar values being observed also in the variant 20:10:30:10, with the lowest nitrogen amount (80.5 fruits/tree).

Fruit yield

In the fourth year of fertilization, on the average of fertilization treatments level, the cultivar 'Golden Delicious Clone B presented the highest production (44.4 t/ha), which significantly differ from the one obtained at the cultivars 'Fuji Kiku Clone 8' and 'Jonagored' (34.3 and 35.2 t/ha respectively).

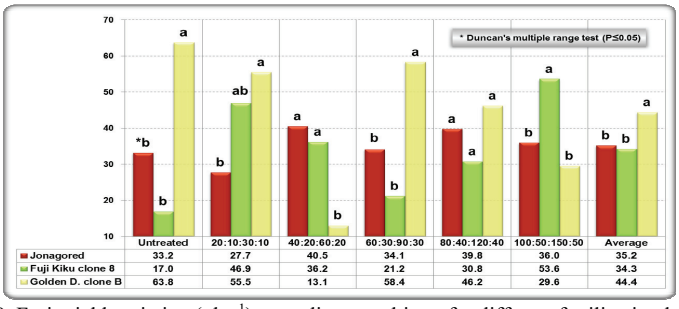

Fig. 9. Fruit yield variation (t ha^{-1}) according to cultivar, for different fertilization levels

It can be observed a light production increase tendency together with the fertilizers amounts increase, especially nitrogen and potassium (the proportion among these elements is increasing much more than phosphorus and magnesium in variants V4-V6), the obtained productions ranging between 37.9-39.7 t/ha, except the fertilization variant 20:10:30:10 in which was obtained the highest production 43.4 t/ha (Fig. 10).

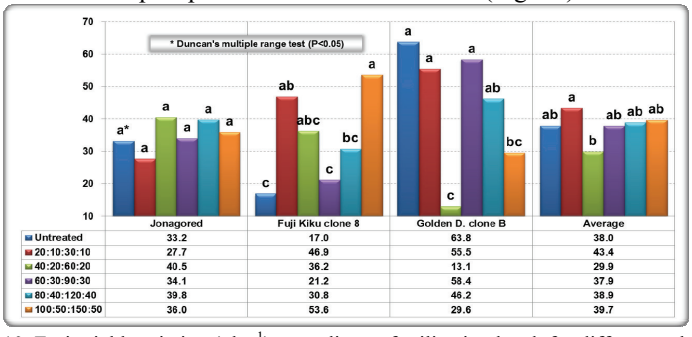

Fig. 10. Fruit yield variation (t ha^{-1}) according to fertilization level, for different cultivars

Fruit weight

In the fourth year of experimentation, on the average of the fertilization level, the cultivar 'Golden Delicious Clone B' formed the highest number of fruits per tree and in consequence the lowest fruit weight (151 g), the value which differ significantly from the statistically point of view to the cultivars 'Jonagored' and 'Fuji Kiku' wich registered average fruit weights of 201 g and respectively 206 g (Fig. 11). In general, the average fruit weight is inverse proportional

with the number of fruits per tree: 'Fuji Kiku Clone 8' 206 g, 'Jonagored' 201 g, respectively 151 g and 'Golden Delicious Clone B'.

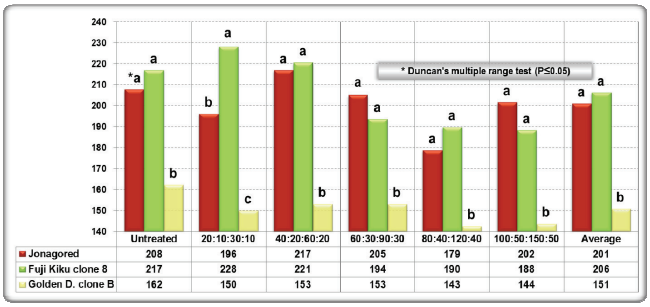

Fig. 11. Average fruit weight according to cultivar, for different fertilization levels

The fertilization level did not induced great differences regarding the average fruit weight. On cultivars average, no tendencies were registered which drive us to strong conclusions, this indicator variations being in relatively small limits 170.0 - 197.0 g, pretty similar to the ones registered in the previous year (Fig. 12).

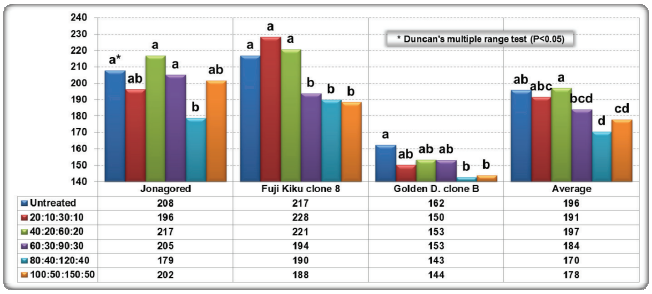

Fig. 12. Average fruit weight according to fertilization level, for different cultivars

CONCLUSIONS

From the climatic point of view, under the local conditions from Pitesti-Maracineni, a clear tendency of weather warming was noticed, with an increase of sunshine hours and an evident rainfall deficit than 10 years ago, compared with the multiannual values registered at the local weather station.

In the fourth year of experimental factors application, on the 6 level of fertilization average, the cultivars induced a descendent growing vigor expresses by the increase of trunk cross section area (TCSA increase): 'Jonagored' (4.39 cm^2), Fuji Kiku 8 (3.43 cm^2), Golden Delicious Clone B 3.09 cm^2).

Although inside each fertilization variant exist statistically assured differences regarding the number of flower buds per trees, on the average of fertilization variants graduations, the cultivar did not produced statistically assured differences.

On the fertilization level average, the 'Golden Delicious Clone B' cultivar presented the highest fruit number per tree (98.9 fruits / tree), the value being significantly different from the statistical point of view from 'Jonagored' and 'Fuji Kiku Clone 8' which registered 62.9 and respectively 58.1 fruits / tree.

In the fourth year of experimentation, on the fertilization variants average, Golden Delicious Clone B cultivar induced the highest production (44.4 t/ha), which differ significantly to the one formed by the cultivars 'Fuji Kiku' and 'Jonagored' (34.3 and respectively 35.2 t/ha).

On the cultivars average, the yield tends to be higher by increasing the quantity of fertilizers, the fruits productions ranging between 29.9 - 43.4 t / ha.

The average fruit weight was inversely with the fruit number per tree: 206 g on 'Fuji Kiku Clone 8'; 201 g on 'Jonagored' and respectively 151 g on 'Golden Delicious Clone B'.

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