

## EFECTELE IRIGĂRII LOCALIZATE ASUPRA CANTITĂȚII ȘI CALITĂȚII PRODUȚIEI UNOR SOIURI DE CAIS ÎN CONDIȚIILE DIN DOBROGEA EFFECTS OF LOCALIZED IRRIGATION ON FRUIT YIELD AND ITS QUALITY FOR SOME APRICOT VARIETIES UNDER THE CONDITIONS OF DOBROGEA

Mihail Iancu<sup>1</sup>, Leinar Septar<sup>2</sup>

<sup>1</sup>Research Institute for Fruit Growing Pitesti, Romania

<sup>2</sup>Research Station for Fruit Growing Constanta

### Abstract

Dobrogea, with its fertile soils and higher temperatures is one of the most favorable areas for apricot culture in Romania. However, in this area, high production and quality can only be achieved by applying irrigation. The present paper presents the effects of applying four irrigation treatments, i.e. drip irrigation and micro sprinkler, on fruit yield and some indicators regarding fruit quality on both Tudor and NJA 42 varieties. The research was conducted in 2003-2005 on the territory of Research Station for Fruit Growing Constanta, on a calcareous chernozem soil type. On average, when studying NJA 42 tree cultivar, the fruit yield was significantly higher by 32% versus the Tudor cultivar in those three years and five different soil water regimes. Within the two varieties, application of located irrigation through the four treatments determined a significant increase in fruit yield by 32-37%. Fruit yield differences between the two varieties were determined by the different numbers of fruit per tree, and differences in yield between the irrigated and non irrigated variants were determined by the different average fruit mass. On average, on the five different levels of soil water regimes in the case of the Tudor variety higher values of sugar content by 90% and dry matter by 49% versus NJA 42 variety were obtained. On average for the two varieties, in the non irrigated variant the sugar content was higher by 27% and the dry matter by 11% compared to the irrigated variants. For each cubic metre of water applied by the two treatments of drip irrigation, an increase in fruit yield of 11.06 kilograms/m<sup>3</sup> was recorded. In exchange, over the two micro sprinkler irrigation treatments, an increase in fruit yield of 5.18 kilograms/m<sup>3</sup> was obtained. These findings show, primarily, the importance of irrigation on the increase in fruit yield, and secondly, a higher water use efficiency with drip irrigation versus micro sprinkler irrigation.

**Cuvinte cheie:** irigare localizată, producția de fructe, eficiența irigației,

**Keywords:** localized irrigation, apricot yield, efficiency of irrigation

### 1. Introduction

Dobrogea, with its fertile soils and higher temperatures is one of the most favorable areas for apricot culture in Romania. However, in this area, high production and quality can only be achieved by applying irrigation. To quantify the effects of irrigation application on yield to apple, pear and peach species, under the conditions of Dobrogea (Ionescu and Tomuleț, 1967, Ionescu 1979, Popa, 1987), traditional irrigation methods (furrow, sprinkler) with large irrigation water amounts were used. Given the critical needs to save irrigation water in both our country and worldwide, in this paper we present the effects of applying localized irrigation methods (drip, micro-sprinkler) on yield and its quality for "Tudor" and "NJA 42" apricot varieties.

### 2. Material and methods

The research was conducted in 2003-2005 on the territory of Research Station for Fruit Growing Constanta. On the depth of 0-100 cm, the soil that was tested (calcareous chernozem) presented a total porosity of 57%, and a value of 15.3% (g/g) for the available soil moisture interval. These properties characterized the soil as a deep one, well aerated and with high water retention capacity. From a chemical composition point of view on the same depth of 0-100 cm, the soil presented a medium humus content (2.61%), total nitrogen (0.1 mg /100 g soil) and mobile phosphorus 0.157 mg/100 g soil, thus showing a high-fertility soil category. On average over those 3 years of experimentation, the value of the annual precipitation sum was higher by 52% versus the annual average over 25 years. Trees were planted in the year 1994, at the distance of 4.5 x 4.0 m, and were grafted on wild apricot.

The following experimental scheme was organized:

A factor – Variety, with graduations: a1 = NJA 42, a2 = Tudor;

B factor – Method of irrigation, with the following graduations: b1 = non-irrigated (control), b2 = drip irrigation using a Tack dripper type, b3 = drip irrigation with “Tipaz” type dripping; b4 = micro sprinkler irrigation with a discharge (q) of 12.0 l/h, b5 = micro sprinkler irrigation with q = 27.0 l/h.

Variants were placed according to the subplot method in three replicates. Both drip irrigation variants, b2 and b3, were 1.0 m spaced on watering pipes, and the micro sprinklers were spaced on irrigation pipes at a distance of 3.0 m in b4 and 6.0 m in b5.

During 2003, five irrigation applications were done on b2, b3 and b4 variants, whereas four irrigation applications in b5. In 2004, three irrigation applications were carried out in b2, b3 and b4 variants and only two in b5. Finally, in 2005 we applied, only, one single irrigation in b2 and b3 variants, because in July 131.8 mm of rainfall were recorded, thus making inappropriate any further application of irrigation.

In each of the three years of research, the average water quantities applied for a wetting event were about 180 m<sup>3</sup>/ha for the two variants of drip irrigation, 300 m<sup>3</sup>/ha for b4 variant and 600 m<sup>3</sup>/ha for b5 variant.

To determine the fruit yield and its components (i.e. the number of fruits per tree and the average weight per tree) and to calculate the indicators regarding yield quality, we used the current methods practiced in Romanian research for fruit growing.

### 3. Results and discussions:

#### 3.1. The influence of irrigation on fruit yield and its components in the two apricot varieties

On average for the three years and five variants investigated with regard to the soil water regime, fruit yield was significantly higher by 32% within the NJA 42 variety versus the Tudor variety. Over the same period and averaged on the two varieties, fruit production was significantly higher by 32-37% in the four variants of irrigation versus the control variant. Between the four variants of irrigation no significant differences were obtained (Table 1). Analyzing the influence of irrigation application on fruit yield within each variety it has been noted that, on average for the three years, fruit yield in the four irrigation variants was significantly higher by 36% in the NJA 42 variety, and by 33 % in the Tudor variety, versus to the control, non-irrigated one (Table 2). This shows a higher irrigation water use capacity for NJA 42 varieties compared to the Tudor variety.

Over the period of experimentation, the number of fruit per tree was significantly higher by 66% in NJA 42 variety versus Tudor variety. On average for both varieties and four irrigation variants, the number of fruit per tree was higher by 4.5% versus the control (Table 1). Within each variety, analyzing the influence of irrigation on the number of fruit / tree, it has been noted that on average for the experimental period, the number of fruit / tree on the four irrigation variants was higher by 19% in NJA 42 variety versus the control. This represented 86% of the 100% obtained in the non-irrigation, control variant for Tudor.

Regarding the influence of irrigation, on average fruit weight, data of Table 1 shows that, on average, over the three years of experimentation and five irrigation regimes, the fruit weight was significantly higher by 27% in Tudor variety, versus NJA 42 variety. On average over both varieties and four variants of irrigation, the average fruit weight was significantly higher by 34% versus non-irrigated variant. Under the same conditions, the average fruit weight in b4 variant was significantly lower than in the other three irrigated variants (Table 1).

Analyzing the influence of irrigation on average fruit weight within each variety, the results (Table 2) show that differences between the irrigated variants compared to the non irrigated variant were more noticeable for the Tudor variety versus NJA 42.

Interesting data were obtained regarding the influence of localized irrigation on the productivity index. Thus, the data (Table 1) show that on average on the five variants of soil water regimes, the productivity index was significantly higher by 32% for NJA 42 variety versus Tudor variety. On average on both varieties and three years of testing, the value of the productivity index was not significantly different between the five variants of soil water regimes.

Analyzing the influence of localized irrigation versus the non-irrigated one, on the productivity index within each variety (Table 2), it has been noted that for the NJA 42 variety, there was a significantly lower productivity index value in the b4 micro sprinkler irrigation variant versus the other treatments of soil water regime.

#### 3.2. The influence of variety and localized irrigation on some indicators regarding fruit yield quality

On average over the three years of experimentation and five different soil water regimes, the fruit dry matter content was significantly higher by 49% and the sugar content by 90% for the Tudor variety versus the NJA 42 variety. Averaged for both varieties, the fruit dry matter content was significantly higher by 11%, and the sugar content by 27% (Table 1) in the control variant versus the four irrigated variants.

Analyzing the influence of irrigation application on indices outlined above for each variety (Table 2), it was found that the differences were more apparent within the Tudor variety. Thus, in case of Tudor the

fruit dry matter content was significantly higher by 14% and the sugar content by 29% in non-irrigated variant versus the four irrigated variants.

### **3.3. Correlations between the soil water reserve on different periods and some indicators regarding fruit yield and its quality for both apricot varieties studied**

The annual fruit yield was very closely correlated, positively with soil water reserves on the deep of 1 m, from May and June in the case of NJA 42 variety, and for the months of May, June and July in the Tudor variety (Table 3). For the Tudor variety, water reserves from June and July were correlated with the average fruit weight (Table 4).

The two chemical components analyzed (dry matter content and sugar content) were very closely correlated with water reserves during May for NJA 42 variety, and from May and June on the Tudor variety (Table 5). Between the annual trunk growth and fruit yield, higher and significant correlations were obtained for NJA 42, as well as lower intensity for Tudor variety (Table 6).

### **3.4. The influence of irrigation on the economic efficiency of apricot culture**

The data in Fig. 1 shows that in the four irrigation variants and the two varieties, the yield increase per cubic metre of irrigation water versus non irrigation variant were higher in 2003 compared to 2004 by 35%. On average over the two years and two varieties, for 1 cubic metre of water applied by the two methods of drip irrigation, a yield increase of 11.05 kg fruit was obtained, whereas for the two methods of micro sprinkler irrigation, the yield increase per 1 cubic metre of water applied was 5.18 kg.

Following the above presented and due to the differentiation attributed to the other technical and economical factors (especially higher price recovery for the earlier matured NJA 42 variety), the economic efficiency in both cultivated varieties and all irrigation variants was very different. Thus, the data in Table 7 show that for the four variants of irrigation, in the case of NJA 42 variety versus Tudor variety, the profit rate was higher by 107%, and the number of man-days per tone of fruit was to 6.7 versus 7.7. Also, on average for the two varieties and two methods of drip irrigation, the profit rate was higher by 8% and the number of man-days per tone of fruit was 6.78 versus 7.20, compared to the two methods of micro sprinkler irrigation.

The data in Tables 1 and 2 showed that the higher fruit yields following the application of irrigation were due mainly to the fruit weight and less to the increase in the number of fruit per tree. Stronger influences of irrigation application on the growth of fruit weight rather than on the increase in the number of fruit per tree, specifically under the temperate zone, have been presented by Iancu et al., 2009. These results can be explained by the fact that under the temperate zone conditions at the beginning of the growing season, when the vegetative growth is usually most intense, the soil water reserves are higher as a consequence of winter accumulation. With time, increasing in fruit size becomes a dominant process. At the same time, soil water reserves decrease more rapidly mainly due to changes in the ratio of potential evapotranspiration and precipitation. That is why the application of irrigation in this period determined an increase in fruit size. In arid areas, however, where reserves of soil water from rainfall are much lower throughout the growing season near the tree, the decrease in fruit yield under non irrigation conditions can be determined mainly by the lower number of fruit per tree (Perez et al., 2008).

Differentiation between the two varieties in terms of fruit yield was mainly due to the greater number of fruit per tree for NJA 42 variety versus Tudor variety. The data presented by Septar and Iancu (2009) showed that the increase in volume of tree canopy and the quantity of wood removed during pruning was higher for NJA 42 variety versus Tudor variety. Similarly, data in Table 1 presented in this paper showed that the index of productivity was higher for NJA 42 variety compared to Tudor. These two findings show that the greater number of fruit per tree in the case of NJA 42 variety compared to Tudor variety was due not only to the higher values of both growth characteristics from above, but also due to other elements.

Correlations presented in Tables 3 and 5 showed a strong relationship between the indices of fruit yield and quality on the one hand, and soil water reserves on the other hand, namely in a shorter period of time for NJA 42 variety (May to June), and on a longer time (May, June and July) in the case of the later maturation variety that is Tudor.

The negative correlations between soil water reserves on May in the NJA 42 variety, and May and June for Tudor late variety on the one hand and the fruit quality indicators are consistent with the data analysis presented by many authors (Uriu and Magness, 1967; Mills et al., 1994; Raiese et al., 1982; Haller and Harding, 1937; Iancu and Negoita, 1991; Iancu and Sotiriu 1983; M. a.C. Ruiz – Sanchez et al 2000).

It is also worth to highlight the much higher efficiency of irrigation water for drip irrigation methods versus micro sprinkler irrigation methods. Thus, although increases in yield for drip irrigation were almost similar to those achieved with micro sprinkler irrigation, the water amounts used were much lower for drip irrigation versus micro sprinkler irrigation. In order to save more irrigation water, the differentiation described above is of particular importance due to the fact that the drip irrigation has an obvious superiority versus the micro sprinkler irrigation. Due to the scarcity of research conducted in our country, especially in terms of recovery of water needed by the two localized irrigation methods (drip and micro sprinkler irrigation), it is worth to develop such investigations in a much higher number and under a wider range of conditions that could lead to recommend them in farming with higher certainty.

#### 4. Conclusions

1. On average over three years of experimentation and five different variants of irrigation regime and soil water content, within the NJA 42 variety the fruit yield was significantly higher by 32% and the number of fruit per tree by 66% versus Tudor variety. In contrast, in the case of Tudor variety there was a significant greater increase in average fruit weight by 27%, in sugar content by 90% and in dry matter by 49% versus NJA 42 variety.

2. On average over both varieties, the localized irrigation application in the four methods determined a significant increase in fruit yield by 32-37%, in the number of fruit per tree by 5%, and the average fruit weight by 34%, versus to the non-irrigated one. The fruits from the non irrigated variant had a sugar content exceeding 27% and higher dry matter content (by 11%), versus to the irrigated variants.

3. On average over three years, for 1 m<sup>3</sup> of water applied by both localized irrigation methods the fruit yield showed an increase of 11.06 kg, and in the two micro sprinkler irrigation methods, the increase in yield per 1 m<sup>3</sup> of water applied was 5.18 kg.

#### References

1. Haller, M. H., and Harding, L. P., (1937) – Relation of soil moisture to firmness and storage quality of apple. *Amer. Soc. Hort. Sci., Proc.* 35:205-211;
2. Iancu M., Sotiriu D. (1983) – Contribuții noi privitoare la influența umidității solului asupra unor însușiri fizico-chimice și comportării la păstrare a merelor. *Lucr. Știin. ICPP, Vol. X:*187-202;
3. Iancu M., Mariana Negoită 1991 – Influența sistemului de întreținere a solului și a irigației prin picurare asupra unor componente chimice din frunzele și fructele soiului de măr Golden spur;
4. Iancu M., Stănică Fl., Isac Il., Dumitrescu Monica (2009). Influence of the groundcover management system and drip irrigation on behaviour of the "Golden spur" apple cultivar grafted on MM106 rootstock. *Proceedings of VI – International Symposium on irrigation of Horticultural crops.* In pres.
5. Ionescu Pr., Tomuleț T., 1967. Contribuțiile la stabilirea regimului de irigație la măr și păr în condițiile Dobrogei. *Analele Stațiunii Experimentale Dobrogea*;
6. Ionescu Pr. (1979) - Studii privind efectele irigației piersicului în condițiile din Dobrogea. Teza doctorat ASAS București.
7. Mills, T.M., M.H. Behboudian, and B.E. Clothier, 1996b. Water relations, growth, and composition of Braeburn apple fruit under deficit irrigation. *J. Am Soc. Hort. Sci* 121:286-291;
8. Mills, T.M., M.H. Behboudian, P.Y. Tan, and B.E. Clothier, 1994. Plant Water status and fruit quality in Braeburn apples. *HortScience* 29:1274-1278.
9. Perez Pastor, A., Domingo, R., Torrecillas A and Ma.C. Ruiz Sanchez (2008). Response of apricot to deficit irrigation strategies. *Irrigation Science* Vol.27, Nr.3:231-242;
10. Popa Cristache, 1987. Influența irigației mărului în condițiile din Dobrogea. *L. Științifice ICPP, Vol. XII*;
11. Powell, D.B.B. 1974. Some effects of water stress in late spring on apple trees. *J. Hort. Sci.* 49:257-272;
12. Raiese, J.T., C.A. Brun, and E.J. Seeley, 1982. Effect of irrigation regimes and supplemental nitrogen on alfaalfa greening, cork spot and fruit quality of d'Anjou pears. *HortScience* 17:666-668.
13. Ma. C Ruiz-Sanchez, Torrecillas, A.; Perez-Pastor, A. and Domingo, R. 2000. Regulated deficit irrigation in apricot trees *ACTA HORT* 537, p. 759-766.
14. Septar Leinar, Iancu M. (2009). Efectul irigației localizate asupra proceselor de creștere a două soiuri de cais în condițiile din Dobrogea. *Lucr. Simp. Științific „Agricultura în regiunile aride” 3-4-sept.2009, Constanta- Romania*;
15. Uriu. K and J.R. Magness (1967) Deciduous tree fruit and nuts. In R.M. Hagan et al (ed). *Irrigation of Agricultural lands.* *Adronomy* 11: 686-703.

## Tables and Figures

Table 1 - Influence of localized irrigation on the fruit yield and its quality for both apricot varieties (average values of experimental factors)

No.	Studied character	Experimental factors								
		a1	a2	5%LSD	b1	b2	b3	b4	b5	5%LSD
1	Fruit production (t/ha)	29.9	22.6	0.69	20.6	28.2	27.5	27.1	27.8	0.82
2	Number of fruit/tree	1605	968	26.7	1242	1286	1268	1343	1294	35.7
3	Fruit mass (g)	33.4	42.6	1.15	29.8	41.0	41.2	37.6	40.4	1.07
4	Productivity index (kg/cm <sup>2</sup> )	0.25	0.19	0.029	0.23	0.24	0.22	0.20	0.21	0.023
5	Dry matter (%)	8.27	12.34	0.57	11.17	9.67	9.50	10.50	10.67	0.83
6	Sugar (%)	4.87	9.27	0.99	8.50	6.50	6.34	7.00	7.00	0.67

Significance of experimental factors a1-a2, b1-b5 was shown in Chapter. "Material and methods"

Table 2 - Influence of localized irrigation on fruit yield and its quality for both apricot varieties (interaction of experimental factors A/B)

No	Studied character	a1					a2					5% LSD	
		b1	b2	b3	b4	b5	b1	b2	b3	b4	b5	1	2
1	Fruit yield (t/ha)	23.3	31.2	31.0	31.1	32.8	17.9	25.3	24.0	23.1	22.8	1.17	1.55
2	Number of fruit/tree	1393	1601	1643	1696	1696	1093	970	893	989	896	51.0	59.8
3	Fruit mass (g)	30.1	35.1	34.0	33.1	34.8	29.6	46.9	48.4	42.1	46.0	1.51	2.56
4	Productivity index (kg/cm <sup>2</sup> )	0.26	0.26	0.25	0.21	0.24	0.19	0.21	0.18	0.18	0.18	0.032	0.065
5	Dry matter (%)	8.67	7.67	8.33	8.33	8.33	13.67	11.67	10.67	12.67	13.0	1.17	1.28
6	Sugar (%)	5.67	4.33	5.0	4.33	5	11.33	8.67	7.67	9.67	9.0	0.95	2.22

Significance of the experimental factors was shown in Chapter "Material and methods".

5% LSD, 1=constant a, b= different; 2= constant b, a= different

Table 3 - Correlations between soil water reserve (weighted average-% g/g) for different periods, on the depth of 0-100 cm and fruit yield (t / ha) for NJA 42 and Tudor apricot varieties

Year	Month	Correlation coefficient (R)	
		NJA 42	TUDOR
2003	May	Ns	0.589
	June	0.924***	0.892***
	July	-	0.836***
2004	May	0.890***	0.889***
	June	0.822***	0.931***
	July	-	0.925***
2005	May	0.918***	0.604*
	June	0.890***	0.660**
	July	-	0.807**

Table 4 - Correlations between soil water reserve (weighted average -% g/g) for different periods, on the depth of 0-100 cm, and the average fruit weight for Tudor apricot variety

Year	Month	Correlation coefficient (R)	
		TUDOR	
2003	May	Ns	
	June	0.928	
	July	0.948*	
2004	May	Ns	
	June	0.949*	
	July	0.969**	
2005	May	Ns	
	June	Ns	
	July	0.944*	

Table 5 - Correlations between soil water reserve (weighted average -% g/g) for different periods, sugar content and dry matter content in fruit for NJA 42 and Tudor apricot varieties

Year	Month	Correlation coefficient (R)			
		Sugar content		Dry matter content	
		NJA 42	TUDOR	NJA 42	TUDOR
2003-2005	May	-0.71**	-0.78***	-0.664**	-0.802***
	June	Ns	-0.779***	Ns	-0.781***
	July	-	Ns	-	Ns

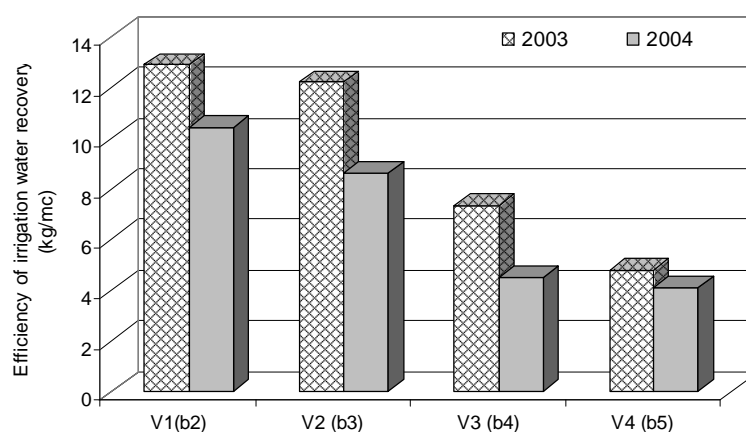
 Table 6 - Influence of localized irrigation on the annual growth of trunk (cm<sup>2</sup>) and fruit yield (t/ha) in NJA42 and Tudor apricot varieties

Year	Correlation coefficient (R)	
	NJA 42	TUDOR
2003	0.746**	0.644**
2004	0.915***	0.665**
2005	0.863***	Ns

Table7 - Influence of variety and irrigation treatment on economic indicators

Economic indicator	Experimental variants									
	a1b1	a1b2	a1b3	a1b4	a1b5	a2b1	a2b2	a2b3	a2b4	a2b5
Profit rate (%)	315	374	372	363	349	153	193	184	169	159
Work productivity (zo/to)	7.5	6.3	6.3	6.7	6.6	8.6	7.1	7.4	7.7	7.8

Significance of experimental factors a1b1-a1b5; a2b1-a2b5 was shown in Chapter "Material and methods"


 Fig.1. Efficiency of irrigation water recovery (kg/m<sup>3</sup>) in localized irrigation variants – 2003-2004  
 Significance of experimental factors b2-b5 was shown in Chapter "Material and methods"