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TENDINȚE NOI PRIVIND EVAPOTRANSPIRAȚIA ŞI CERINȚELE PENTRU APA DE IRIGARE A UNOR CULTURI HORTICOLE ÎN PRIMUL DECENIU AL SECOLULUI XXI ÎN SUDUL ROMÂNIEI

NEW TRENDS FOR CROP EVAPOTRANSPIRATION AND IRRIGATION WATER REQUIREMENTS IN SOME HORTICULTURAL CROPS DURING THE FIRST DECADE OF THE 21st CENTURY IN SOUTHERN ROMANIA

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Abstract
This paper deals with the trend for Penman-Monteith reference evapotranspiration (ET_o), crop evapotranspiration (ET_c) and irrigation water requirements (IWRs) of some horticultural species during the first decade of the 21st century in Southern Romania. The species studied here were: strawberry, tomato and table grapes. These indices were calculated for three weather stations in various relief regions of southern Romania: Pitesti, Bucharest-Baneasa and Constanta. Monthly distribution of ET_o for the three locations studied showed that for the first half of the year, the monthly values were higher for the first decade of the 21st century versus the means of the 20th century. In the first decade of century XXI versus century XX, ET_c specifically increased in May, June and July, while in August the increase was negligible, and in September ET_c decreased. Remarkable high ET_c values were especially met for tomato. IWRs have not shown a clear pattern with regard to the trend in the first decade of the XX century versus century XX. IWRs increased in May versus century XX. The following months: July and August had practically the same IWRs values, whereas September was the month where irrigation application decreased by about 60-80% versus last century. Because this study only refers to one decade from a new century, and this decade showed high dynamics in global warming versus century XX, these changes could also have either a cyclic or a long term character, and this finding should be confirmed by further studies.

Keywords: arid conditions, drought, global warming
Cuvinte cheie: condițiile aride, seceta, încălzirea globală

1. Introduction

During the much debated global warming (e.g. Hansen et al., 2006), the increase in crop evapotranspiration (ET_c) is predicted by some model scenarios evaluating the impact of global changes in Romania (Marica and Busuioc, 2004); according to these authors, ET_c would increase especially during the crop growing season in the southern parts of Romania. In this context, Paltineanu et al. (2007a and b, 2009), among others have reported data on arid or drought-affected areas, including water-crop response and irrigation water requirements (IWRs) for various regions of Romania.

However, some authors have predicted that little or no change in reference evapotranspiration (ET_o) is likely to occur due to increasing temperature (Snyder et al., 2010), as effect of increasing air humidity and higher CO_2 concentrations which both tend to reduce transpiration and counteract the higher temperature effects on ET_o. Consequently, ET_c would remain unchanged if crop coefficients were stable.

The purpose of this paper is to show the new trends for crop evapotranspiration and irrigation water requirements (IWRs) for some horticultural crops during the first decade of the 21st century in some areas of Southern Romania.

2. Materials and Method

The crops investigated here are represented by strawberry, tomato and table grapes, all of them grown in the three locations chosen for this study.

Mean daily, monthly and annual weather statistics were calculated for three weather stations in various relief regions of southern Romania: Pitesti, Bucharest-Baneasa and Constanta. Constanta is representative for the south-eastern part of the country – the Dobrogea Plateau region with most of its territory between 100 and 300 m altitude – whereas Bucharest-Baneasa and Pitesti are representative for the central part of the Romanian Danube Plain (altitude mainly between 60 and 100 m) and the northern part of the same plain (the High Plain of Pitesti, with an altitude mainly around 300 m), respectively. The southern part of Romania was chosen for this study due to the fact that it is the most arid region of this country.

The data set used in this paper consisted of mean daily data for temperature and precipitation, as well as for other climatic parameters needed in calculating the FAO recommended Penman-Monteith reference evapotranspiration (ET_o) like: sunshine hours, air humidity, as well as wind speed at 10 m or 2 m height. Wind speed measured at a height of 10 m was transformed into wind speed values at 2 m height using regressions equations given by Paltineanu et al. (2007b) for these regions. The period of investigation was one decade, mainly from 2000 to 2010, and these data were compared to similar data obtained for century XX (Paltineanu et al., 2007b).

The quality of data set was reliable because they were recorded in the national network, and standard quality control methods were applied to the data set used.

Penman-Monteith method (Monteith, 1965; Jensen et al., 1990; Allen et al., 1998) was used to calculate daily and monthly values of ET_o:

$$ET_o = (0.408\Delta(Rn-G)+900\gamma\ U(e_a-e_d)/(T+273))/(\Delta+\gamma(1+0.34U))$$

where Rn is the net radiation at grass surface (MJ m^{-2} d^{-1}), G is the soil heat flux (MJ m^{-2} d^{-1}), T is average temperature (°C), U is wind speed at 2 m height (m s^{-1}), (e_a-e_d) is vapour pressure deficit (kPa), Δ is slope of the vapour pressure curve (kPa C^{-1}), γ is psychrometric constant (kPa C^{-1}). The other terms needed to calculate ET_o were taken from Jensen et al. (1990) and Allen et al. (1998).

Crop coefficient (K_c) for mid-season ($K_{c\ mid}$) and final plant stage ($K_{c\ end}$) was calculated according to the formulae given by Allen et al. (1998):

$$K_{c\ mid} = K_{c\ mid}' + (0.04\ (U_2 - 2) - 0.004\ (RH_{min} - 45))\ (h/3)^{0.3}$$

where $K_{c\ mid}'$ was tabulated in Allen et al. (1998) and *h* denominated the average crop height. $K_{c\ end}$ was similarly estimated with the same formula by replacing $K_{c\ mid}'$ with $K_{c\ end}'$, also tabulated, and initial K_c, namely ($K_{c\ ini}$) was taken from the same table (Allen et al., 1998). The procedure was similar to that presented by Doorenbos and Pruitt (1977). Crop coefficients for each 10-day period in the growing season were then plotted versus time for all months of interest.

Crop evapotranspiration (ET_c) was then estimated by multiplying the ET_o values with the K_c values, and irrigation water requirements (*IWRs)* data resulted from subtracting effective precipitation from ET_c (CROPWAT Programme, Smith, 1992), without taking into account the variation in soil water content.

The method given by Allen et al. (1998) was previously checked in Romania by Paltineanu et al. (2007b).

3. Results and discussions

3.1. Reference evapotranspiration (ET_o)

The mean values ranged between 3.34 and 3.39 mm/day during the growing season and between 4.38 and 4.52 mm/day in the summer time (Paltineanu et al., 2011); the highest mean values occurred in Constanta, due to sunshine hours and wind speed alike. Using annual values as replicates, test *t* analysis revealed no significant differences between the ET_o means in the case of the growing season in spite of the fact that their altitudes and relief positions are quite different, and highly significant differences between Constanta on the one hand and the other two locations on the other hand in the case of summer time.

Monthly distribution of ET_o for the three locations studied and the comparison between the mean values of the first decade of the 21st century and the ones of the 20th century are shown in fig. 1. For all the three stations studied, for the first half of the year it can be noted that the monthly values are higher for the first decade of the 21st century versus the means of the 20th century.

3.2. Crop evapotranspiration (ET_c)

For the main months regarding the magnitude of ET_c, e.g. the May through September period, in the first decade of century XXI versus century XX, ET_c specifically increased in May, June and July, while in August the values were almost steady, and in September ET_c decreased, fig. 2 (real values) and fig. 3 (as percentage).

Remarkable high ET_c values were especially met in July for tomatoes: around 180 mm/month in Constanta and Bucharest-Baneasa, and about 170 mm/month in Pitesti, fig. 2. In the case of strawberry and table grapes one might say that the maximum values of July were about 120-130 mm in Constanta and Bucharest-Baneasa and Pitesti.

The lowest ET_c values occurred in May and September, especially in the latter, with about 40-60 mm in all places investigated.

3.3. Irrigation water requirements (IWRs)

IWRs are depicted in fig. 4. For the mean climatic conditions of this decade, in May there is no need to irrigate the crops studied, except strawberry; IWRs increased for all the three locations in this month and reached about 60 mm in Constanta and Bucharest Baneasa and about 40 mm in Pitesti. As seen above, IWRs increased in the first decade of century XXI versus century XX.

June represents the second month when IWRs went up versus century XX. During June, for Constanta strawberry and table grapes require about 65-70 mm and tomato about 90 mm irrigation water, respectively. For the other two locations IWRs are as much as 40-50 mm for strawberry, 50-60 mm for tomato, and 30-40 mm for table grapes.

In July, the increase in IWRs versus century XX is apparent, especially for Constanta, with about 90 mm for strawberry, 150 mm for tomato and 100 mm for table grapes. As a remark, tomato is a really big water consumption crop in this month. In Bucharest-Baneasa, IWRs account for about 60 mm for strawberry, 120 mm for tomato and 70 mm for table grapes, whereas in Pitesti these figures are lower: about 40 mm for strawberry and table grapes and 80 mm for tomato.

In August, in Constanta IWRs decrease slowly versus century XX and reach as much as 70 mm for strawberry, 90 mm for tomato and 80 mm for table grapes. In Bucharest-Baneasa IWRs are like in century XX: about 70 mm for strawberry and table grapes and 80 mm for tomato; in Pitesti the IWR values are of the same order of magnitude for strawberry and table grapes in century XX (about 40 mm) and decrease slowly for tomato (to 55 mm).

In September IWRs are very low and decreased versus century XX; practically no crop needs irrigation application during this month.

IWRs recommended above could be carried out in 1-3 applications per month in the field, depending on the soil and climate conditions, water amount and on irrigation method used.

The percentage of IWRs in the first decade of XXI century versus XX century is shown in fig. 5. Due to the complex trend in ET_c and precipitation dynamics, IWRs increased in May (especially in Pitesti and Bucharest-Baneasa) and June. The increase was higher in Pitesti, as in this location IWRs were lower than in the other two. The following months: July and August have practically the same IWR values, whereas September is the month where irrigation application decreased by about 60-80% versus last century.

4. Conclusions

Monthly distribution of ET_o for the three locations studied showed that for the first half of the year, the monthly values were higher for the first decade of the 21st century versus the means of the 20th century.

In the first decade of century XXI, ET_c specifically increased in May, June and July, while in August the increase was negligible, and in September ET_c decreased versus century XX. Remarkable high ET_c values were especially met in July for tomato: around 180 mm/month in Constanta and Bucharest-Baneasa, and about 170 mm/month in Pitesti.

Due to the complex trend in ET_c and precipitation dynamics, IWRs increased in May (Constanta) and June. The following months: July and August have practically the same IWR values, whereas September is the month where irrigation application decreased by about 60-80% versus last century.

For scenarios using irrigation under soil water stress conditions, as regulated deficit irrigation, IWRs are substantially lower.

The extreme south-eastern part of the country located near the Black Sea (Constanta) maintained large IWRs differences versus the central part of the Danube Plain (Bucharest) and the High Plain of Pitesti.

Because this study only refers to one decade from a new century, and this decade showed high dynamics in global warming, these changes versus century XX could also have either a cyclic or a long term character. An answer to this dilemma could only be done after another past decade of this century.

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Tables and figures

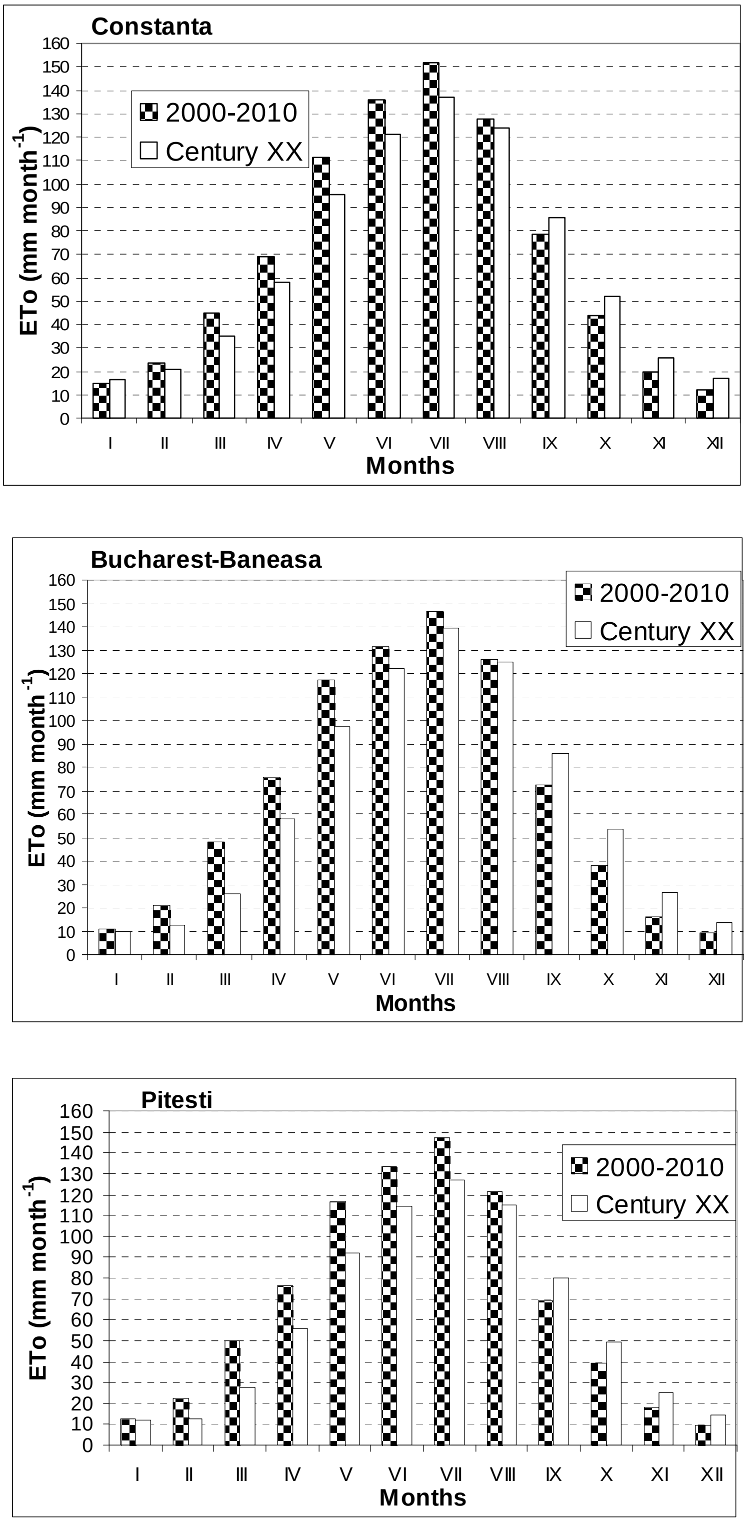


Fig. 1. Monthly distribution of Penman-Monteith ET_o for the three locations studied, comparison between the mean values of the first decade of the 21st century and the ones for the 20th century (after Paltineanu et al., 2011)

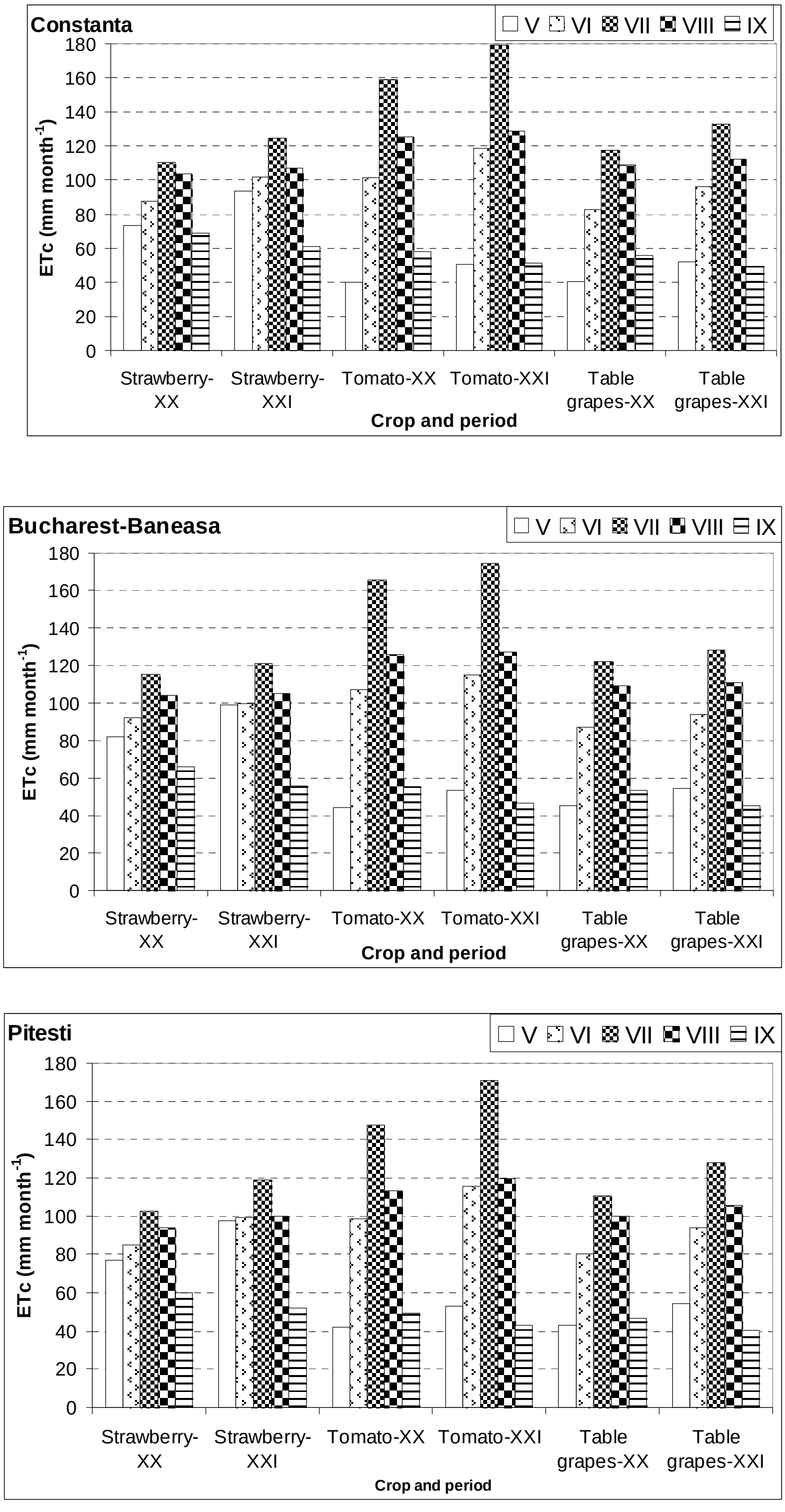


Fig. 2. Comparison between crop evapotranspiration (ET_c) for decade I of century XXI and century XX, monthly values, for five months and three locations of southern Romania; horticultural crops studied: strawberry, tomato and table grapes

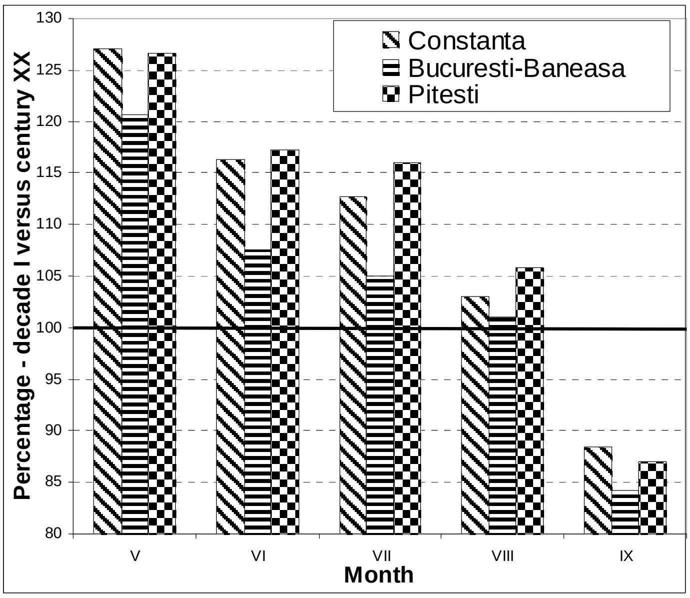
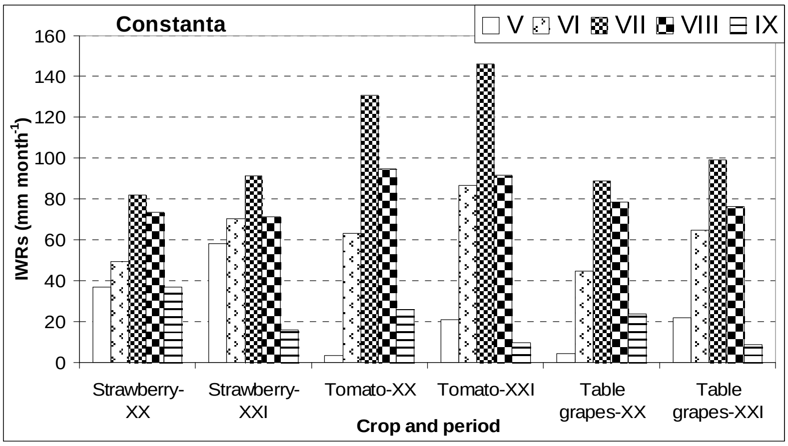
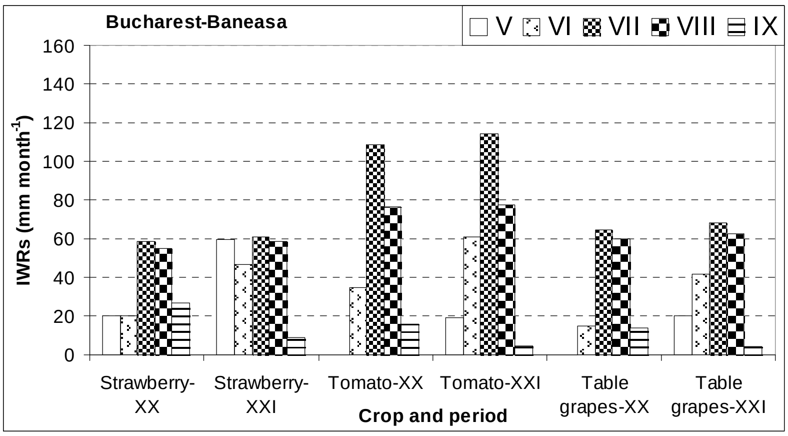


Fig. 3. Comparison between the percentage of the fruit tree crop evapotranspiration (ET_c) for decade I of century XXI versus century XX, for five months and three locations of southern Romania; averages for all crops studied





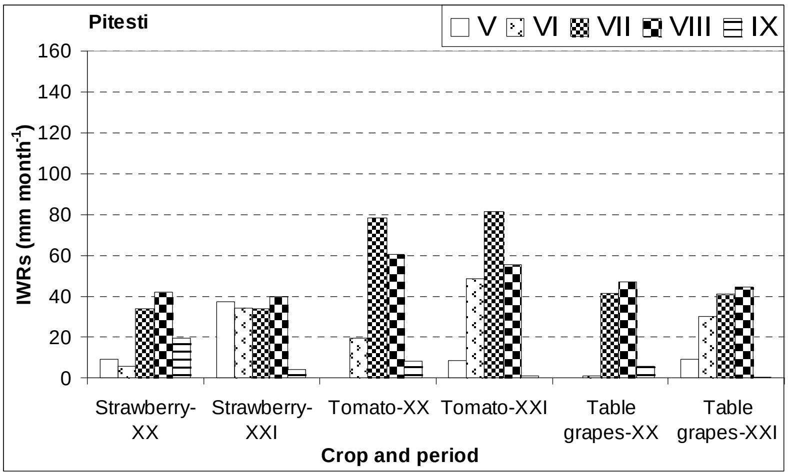


Fig. 4. Comparison between irrigation water requirements (IWRs) of the crops studied for decade I of century XXI and century XX, monthly values, for five months and three locations of southern Romania

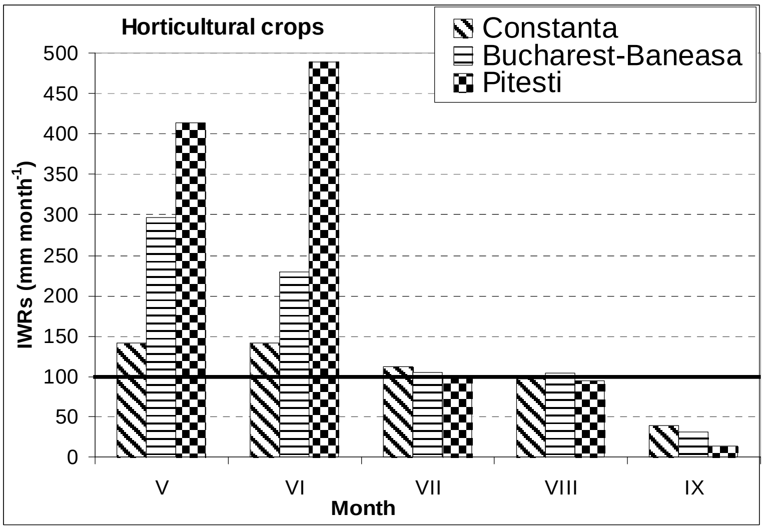


Fig. 5. Comparison between the percentage of the irrigation water requirements (IWRs) for decade I of century XXI versus century XX, for five months and three locations of southern Romania; averages for all three crops studied