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The Influence of Drip Irrigation on Water Efficiency in Pear Cultivation

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ABSTRACT

This field experiment aimed to evaluate the impact of two distinct levels of irrigation, specifically drip irrigation, on a pear orchard to conserve water without compromising production. Kosovo boasts conducive conditions for tree cultivation; however, water scarcity, particularly during the vegetation period, necessitates supplementary irrigation. The study was carried out in the Dukagjini plain on a 10-hectare pear orchard, using a nested experimental design.. Per two levels of irrigation, for 13 rows with tress were used with 100% of evapotranspiration as control and 13 rows with 50% of deficit irrigation. One row were length 90 m and width 40 cm, in total area where applied irrigation were 936 m^2. Using ANOVA, we detected significant fluctuations in total yield, the number of fruits, and fruit weight. With this technology in 100% irrigation have been achieved a total 7497 kg/900 trees or an average of 8.33 kg/tree while in 50% irrigation have been achieved 4590 kg/900 trees or 5.10 kg/tree. In classification of fruits 85.41% (100% irrigation) were extra class while 92.30% in 50% of irrigation. Our results confirmed that drip irrigation combined with a moderate water stress increase all productive parameters especiallity in total yield, too with significant water saving.

Keywords: saving water, drip irrigation, *Pyrus communis*.

INTRODUCTION

In our experiment, drip irrigation, recognized as the most efficient irrigation system, was employed. Its adoption in fruit tree cultivation is increasingly widespread globally following its initial development in Israel. Drip irrigation offers unparalleled advantages, including the uniform distribution of water to each tree, a feat unattainable with alternative irrigation methods. Furthermore, its versatility extends to application across various terrains, ensuring uniform soil wetting, mitigating crust formation, facilitating unrestricted access for personnel and machinery post-irrigation, averting soil compaction and erosion, and enabling fertigation, among other benefits. The widespread adoption of drip irrigation in orchards is increasing globally. This surge is primarily attributed to the growing challenges of water scarcity and the concurrent demand for increased production (Bravdo and Proebsting, 1993), but with this type of irrigation, water is used rationally and water contact with leaves and fruits is impossible. In this way these conditions are less favorable for the development of diseases (Shock, 2006). Utilizing drip irrigation can lead to substantial water savings compared to surface irrigation, with reductions ranging from 40% to 60%, while simultaneously potentially doubling yield outputs. The overall irrigation efficiency varies across different methods: surface irrigation typically achieves 30 to 40%, sprinkler irrigation 60 to 70%, and drip irrigation demonstrates the highest efficiency at 85 to 90%. (Goyal, 2013; Potkonjak, 1995), while according to (Wilson and Bauer, 2014) the efficiency of the drip irrigation system point is more than 90%.

Experiments in open fields related to water stress, particularly with regulated deficit irrigation or partial root drying, depend on climatic conditions, thus, the application and quantities of water are related to a series of factors: annual rainfalls, distribution of rainfalls during vegetation, annual average temperature, particularly during the growing season, soil contents, maturity date, other features of the cultivars, rootstocks, cultural measures, etc.

Numerous factors, whether acting independently or synergistically, significantly influence the practical and efficient implementation of drip irrigation (DI). For instance, in regions where water reserves are readily accessible near orchards, the adoption of deficit irrigation may be postponed. Moreover, in soils with restricted percolation rates, it may be necessary to administer reduced water quantities to trees during periods of water stress to ensure adequate moisture reaches the root system's soil layer.

The other factor that influences the successful application of deficit irrigation is genotype (cultivar, clone and rootstock). In early cultivars, it is recommended that deficit irrigation is applied after harvest and this does not mean that if applied after harvest will not effect the production, because the effects of deficit irrigation are carried over from year to year and application only for one year does not achieve satisfying results. The more vigorous the tree is, more resistant is to drought, therefore, cultivars having a vigorous growth are more advantageous compared to less vigorous cultivars. Determining the optimal timing for implementing deficit irrigation, particularly concerning the age of orchard trees, is heavily influenced by genotype and rootstock characteristics. Early application may impede sufficient canopy development, highlighting the importance of initiating regulated deficit irrigation as early as feasible.

Exceeding the permitted water deficit threshold can result in adverse effects on fruit development and ripening. Additionally, it is essential to avoid over-irrigating trees, as this may lead to luxury consumption and subsequently affect fruit quality, either through excessive production or vegetative growth. The primary objective of this study was to assess the efficacy of drip irrigation in conserving water within a pear orchard setting.

MATERIAL AND METHODS

The study took place in the Dukagjini plain in 2022, focusing on a 10-hectare pear orchard and employing a nested experimental design (Figure 1). The orchard consisted of Williams pear trees grafted onto BA29 rootstock, all protected by an anti-hail system. The orchard layout included planting distances of 3.5 meters between rows and 1.3 meters within rows. Two irrigation levels were implemented, with 13 rows (900 trees) receiving 100% of evapotranspiration as the control (1.6 L/h^{-1} of water $drip^{-1}$) and another 13 rows (900 trees) subjected to 50% deficit irrigation (0.8 L/h^{-1} of water $drip^{-1}$). Evapotranspiration (ET) was calculated using the FAO Penman Monteith method (Allen et al.,

Figure 1. The orchard where the experiment was carried out

1998). The lateral pipe had a drip distance of 0.60 meters. Each row measured 90 meters in length and 40 centimeters in width, resulting in a total irrigated area of 936 square meters. Nineteen irrigation sessions were conducted, with each lasting two hours. Throughout the vegetation period, 118,560 liters of water were utilized for the 100% irrigation level (equivalent to 6,240 liters per day), while 59,280 liters of water were used for the 50% irrigation level (equivalent to 3,120 liters per day) (Figure 2).

To evaluate the impact of drip irrigation, we have include some fruiting parameters. All fruits on every tree were enumerated, and their dimensions (diameter and length) were measured in millimeters at the equator using an electronic digital calliper, with 20 fruits sampled per tree at harvest. The average fruit size, in grams, was determined at harvest using an analytical balance. Fruit size classification adhered to the UNECE STANDARD FFV-51. Yield, measured in kilograms per tree, was calculated by assessing the total weight of all fruits per tree at harvest.

Kosovo experiences a medium continental climate with a coastal influence that penetrates through the valley of the White Drin, moderating the typical elements of a continental climate. Based on long-term data in Kosovo, the average temperature during the growing (vegetative) season is 16.5 °C, where the hottest month is July (20.1 °C). 744.8 mm of rainfall falls during the year, of which 346.7 mm fall during the growing season, necessitating the need for supplementary irrigation (Zajmi, 1996). The average temperature and the temperature during the growing period were 1–2 °C higher compared to the 30-year average.

The data obtained from the measurements underwent analysis using a two-way ANOVA, followed by post hoc testing, conducted using StatPlus 2010 software from AnalystSoft Inc., USA.

RESULTS AND DISCUSSION

Today, irrigation ranks as the foremost consumer of water globally. Growing competition for water resources from other sectors will compel irrigation to function amid water scarcity. Deficit irrigation, characterized by reduced water usage, presents a strategy to navigate situations where water supply is constrained. Currently, and increasingly in the future, irrigated agriculture will occur in the context of water scarcity. Inadequate water availability for irrigation will become commonplace rather than rare, prompting a shift in irrigation management focus from maximizing production per unit area to optimizing production per unit of water consumed, known as water productivity (Fereres and Soriano, 2007). In Kosovo, as the vegetative period commences, trees receive ample moisture from abundant spring rainfalls, along with water reserves stored in the soil during winter from snow accumulation. This long-standing phenomenon has been observed for centuries. However, the effects of global warming present the potential for change, mirroring the trends seen in numerous countries where dry winters or spring floods have become increasingly common. In our experiment using two-way ANOVA with post hoc testing we identified meaningful variations in total yield, number of fruit, and fruit weight. The experiment's findings (Table 1) demonstrate notable variations in total yield, number of fruit, and fruit weight, as discerned through ANOVA analysis.

As it can be seen from the results (Table 1) during the experiment using ANOVA we found significant changes in total yield, no. of fruit and fruit weight. With this technology in 100% irrigation have been achieved a total 7497 kg/900 trees

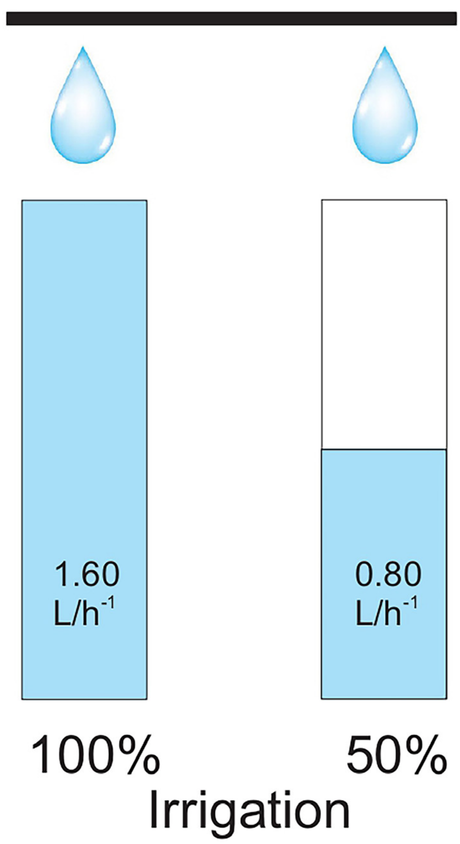

Figure 2. Amounts of water spent for each treatment/drip

Table 1. Assessing the effects of drip irrigation on the productive parameters of "Williams pear"

Treatment	No. of fruits/tree	Diameter of fruit (mm)	Length of fruit (mm)	Fruit weight (g)	Total yield
Irrigation 100%	48.00a	63.78a	89.50a	173.00a	7497.00a
Irrigation 50%	26.00b	64.01a	90.39a	196.00b	4590.00b

Note: significant differences at P≤0.05, as indicated by the letters in each column, are determined by the LSD test.

or an average of 8.33 kg/tree while in 50% irrigation have been achivied 4590 kg/900 trees or 5.10 kg/tree (Fig. 3). In total yield (in 50% irrigation) were achieved only 38% less compared with 100% irrigation, while were spent 50% of water capacity (Fig. 3). Number of fruits were reflected in fruit weight and finally in total yield. In classification of fruits 85.41% (100% irrigation) were extra class while, 92.30% in 50% of irrigation. Water stress has affected in quality of the fruits.

The ANOVA two-way analysis did not reveal any significant differences among treatments in terms of fruit diameter and length. The term "water stress" typically refers to situations characterized by insufficient water availability (Miho and Shuka, 2011). A slight deficiency in water typically does not present an issue for most plants, including pear trees. However, the term "water stress" remains subjective due to the difficulty in accurately determining the point at which a water deficit becomes sufficiently severe

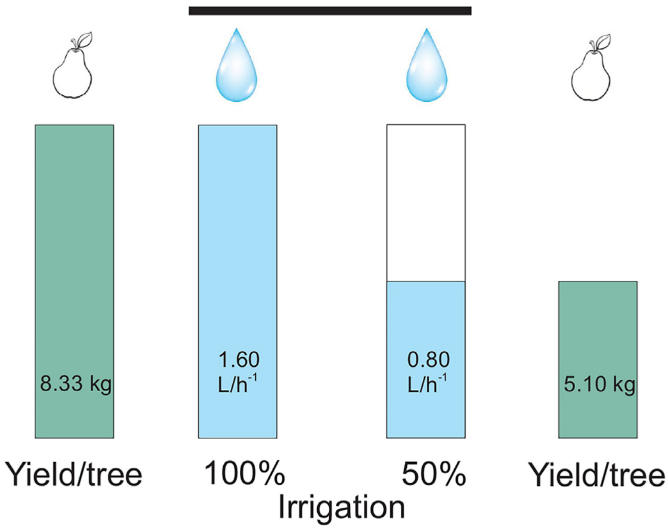

Figure 3. Water stress contributes to increased production

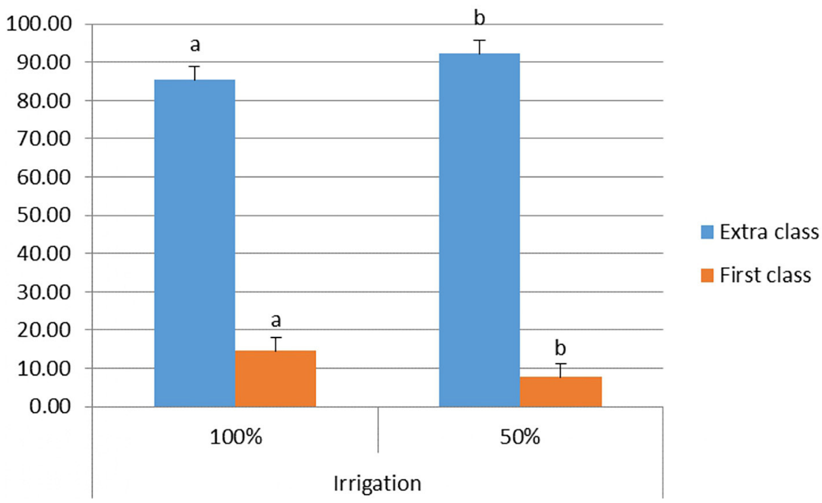

Figure 4. Classification of fruits

to qualify as plant water stress (Kullaj, 2008). Our results confirmed that drip irrigation combined with a moderate water stress increase all productive parameters especiallity in total yield, too with significant water saving (Anconelli and Mannini. 2002; Burn et al., 1985; Chalmers et al., 1985; Cheng et al., 2012; Mitchell et al., 1984; Mitchell et al., 1989; Sanchez et al., 2010).

CONCLUSIONS

The irrigation of pear trees has received comparatively less attention compared to apple and peach cultivation. In our country, the impact of climate change is evident in the rising temperatures, with an increase of approximately 2 °C throughout the year and growing season, coupled with reduced rainfall. Through our research conducted in the agroecological conditions of the Dukagjini region in Kosovo, focusing on water conservation in pear orchards, we draw several conclusions. Given the existing climatic conditions, it is evident that successful pear cultivation relies on irrigation to maintain fruit quality and production levels. In our experiment based on ANOVA we found changes in a series of productive indices. Our results confirmed that a moderate water increase all productive parameters especiallity in total yield, too with significant water saving.

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