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INFLUENCE OF RDI, MULCHING AND THEIR COMBINATIONS ON NUTRIENT CONTENT OF YOUNG "WILLIAM" PEAR STORED IN BASEMENT

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Abstract
The aim of this research was to determine the content of macro- and micro-elements in pear fruits stored in basement after the application of regulated deficit irrigation (RDI) combined with mulching. Using a water budged methodology, four levels of irrigation, specifically 100% of ET (control) and deficits of 80%, 60% and 40%, were applied to 10 trees, 5 of which were mulched by a 10 cm layer. The experiment was conducted in Kosovo (Dukagjini Plain) during 2013 on a pear orchard of 10 ha on third year using a nested experimental design. Using ANOVA two-way with post hoc testing we found significant changes in a series of nutrient elements. Irrigation levels significantly influenced pH, acids, brix, carbohydrates, dry matter, organic matter, ash, Ca and Na, while mulch has influenced brix, dry matter, pH, Cu, P, Fe, Mg and Na. The combination of irrigation and mulching have influenced pH, acids, brix, carbohydrates, dry matter, organic matter, proteins and Na while changes were not significant for fat, K, Pb and Zn. Young age of trees especially first year of production and long-term plant responses to RDI are more accurate than short-term responses so experiment is continuing.

Key words: water stress, *Pyruscommunis*, wood chips, nutrient elements, basement

Introduction

Production of pear considered (*Pyruscommunis*) that is of particular importance for the economy of Kosovo. Until now about 600 ha are planted with pear.

Regulated deficit irrigation (RDI) was developed to improve control of vegetative vigour in high-density orchards in order to optimize fruit size, fruitfulness and fruit quality. RDI is usually applied during the period of slow fruit growth when shoot growth is rapid. However, it can also be applied after harvest in early-maturing varieties. Furthermore, RDI can generate considerable water savings. Thus, it is useful for reducing excessive vegetative vigour, and also for minimizing irrigation and nutrient loss through leaching RDI is an ideal water saving technique. Its application and adaptation in various environments have led to improved understanding of the process, the benefits, and the requirements for adoption (Goodwin and Boland, 2002).

RDI consists of applying water in quantities below those necessary to satisfy ETc during certain periods of the crop cycle when production and crop quality are hardly affected, and in the application of all the water needed during the rest of the cycle, especially at critical periods of the cycle when the yield and/or quality would be most affected by a lack of water. RDI is normally applied during stages of the cycle when reproductive growth is relatively slow and when vegetative growth and other plant processes may be affected, such effects frequently being translated into improved fruit quality (Sanchez *et al.,* 2010).

Fruit quantity and quality is directly connected with optimum soil moisture. In other words, irrigation plays a crucial role in achieving high yields and quality besides other measures like agricultural and pomological techniques. Through their root system plants receive nutrients dissolved in water thus reduction of water absorbed by the roots reduces mineral uptake. Drip irrigation, used also in our experiment is the most effective irrigation system and its application in fruit tree production is spreading around the world after its first discovery in Israel. The uniform distribution of water for each tree cannot be achieved with other types of irrigation. In addition, other advantages of this way of irrigation are: application in different terrains, uniform soil wetting, prevention of crust formation, free access for people and machinery after every irrigation event, avoidance of soil compression, prevention of erosion, possibility for the use of fertigation, etc. (Lepaja*et al.,* 2015).

Today, irrigation is the largest single consumer on the planet. Competition for water from other sectors will force irrigation to operate under water scarcity. Deficit irrigation, by reducing irrigation water use, can aid in coping with situations where supply is restricted (Fereres and Soriano, 2007).

Responses of Asian pear *(Pyrusserotina*Rehd. 'Nijisseiki') to water stress were studied by (Behboudian and Lawes, 1994) and they gave information that fruit concentration of N, P, K, Ca and Mg decreased during the early stress period. Water stress did not affect the concentration of N, P, K, and Mg in fruit, but tended to reduce Ca in early stressed fruit. The latter had a higher concentration of sucrose, glucose, fructose, and sorbitol than nonstressed fruit after 35 days treatment.

Pliakoni and Nano, 2010 studied the effects of deficit water and mulch in quality and storage of peach fruit have found that peaches from reflective mulched trees had the most advanced maturity fruit at harvest compared to the other treatments, and higher quality fruit but also lower storage ability than control fruit. In short, fruit quality of both cultivars studied was improved due to deficit irrigation or reflective mulching but their storage ability was reduced from these treatments.

The objective of this study was to determine the impact of RDI in combination with mulching on quality parameters after fruits stored in basement where water resources are limited, and pear tress are in water stress.

Materials and methods

To determine the content of macro- and micro-elements in pear fruits after the application of regulated deficit irrigation (RDI) combined with mulching, stored in basement were used in a commercial pear orchard. Ten ha orchard of pears was planted on April 2011 in Kosovo (Dukagjini Plain). The experimental set up was a nested or hierarchical design whereby the categories of nested factor within each level of the main factor are different, i.e. different trees give rise to the leaf/fruit samples within each of the main irrigation treatment. Trees were belonging to cv. ‘Williams’ on BA29 rootstock, on third year respectively on first year of production. Pear orchard was in under antihail system. Four levels of irrigation were applied during the season, 100% of evapotranspiration (ET) as control (1.6 liters of water/h per drip) and water deficit in 80% of full ET (1.28 liters of water/h per drip) 60% of full ET (0.96 liters of water/h per drip) and 40% (0.64 liters of water/h per drip). Drip distance in the lateral pipe was 0.60 m. First irrigation was applied on May 22, 2013, while the last irrigation was applied on September 20, 2013. A total of 19 irrigations (one irrigation per two hours) were applied. Each treatment (each level of irrigation) has been in a row. For each treatment we used 10 trees, 5 of which were mulched with a 10 cm thick layer of wood chips totalling 40 trees for the entire experiment. Mulching material was placed in a row of a width of 0.60 m on May 21, 2013. Planting distances were 3.5 m between the rows and 1.3 m in the row. After harvesting on September 6, 2013 for each trees two fruits were stored in basement in temperature 12 °C, for 21 days, then the same fruits were sent to the laboratory where the following quality indicators were analysed: pH, Brix, dry matter, organic matter, acids, proteins, fats, carbohydrates, Ca, K, Cu, Pb, Fe, Na, Mg, Zn, P and ash.

Our state has a moderate continental climate with a coastal impact which penetrates through the valley of the Driniibardhë moderating markedly continental climate elements (Lepaja *et al.*, 2014; 2015). In Kosovo average temperature multiyear (1951-1980) is 10.3 °C, that of vegetation 16.5 °C, the coldest month is January (-0.9 °C) while the hottest month is July with 20.1 °C. Regarding the annual rainfall is 744.8 mm, and during vegetation is 346.7 mm which shows the need to intervene with supplementary irrigation (Zajmi, 1996). Water shortages in the territory of Kosovo, especially during the vegetation period, need supplemental irrigation.

The amount of rainfalls for Peja region for a 30 - year period are 907.4 mm and 352.5 mm during the growing season. Rainfalls during the period of the study were much lower compared to the average 30 - year period with a total of 571.7 mm and 309.8 mm during the growing period. The first irrigation was applied at the end of May when temperatures started to raise and there were no rainfalls. The average temperature and the temperature during the growing period was 1°C higher compared to the 30 - year average. Data from the measurements were analysed using ANOVA two–way with post hoc testing.

Result and discussion

Early cultivars need less water than late cultivars. In Kosovo, at the beginning of the vegetative period trees have enough moisture supplied by the heavy spring rainfalls, as well as water reserves accumulated in the soil during winter from snow. This has happened for centuries, but with global warming it also can change, as it is increasingly witnessed in many countries with dry winters in one side, or spring floods on the other.

At the end of the treatment period (100% irrigation as control, deficit of 80%, 60 and 40%),normal irrigation, two laterals, side laterals, without irrigation), of RDI application, we found changes in a series of macro- and micro elements, after fruit stored in basement and then were sent to the laboratory.

Table 1, 2, 3 summarises the results of the application of RDI in combination with mulching on quality parameters of William pears, after fruits stored in basement, with differences between treatments according LSD testing. Using ANOVA we found significant changes in a series of nutrient elements. Irrigation levels significantly influenced pH, acids, brix, carbohydrates, dry matter, organic matter, ash, Ca and Na, while mulch has influenced brix, dry matter, pH, Cu, P, Fe, Mg and Na. The combination of irrigation and mulching have influenced pH, acids, brix, carbohydrates, dry matter, organic matter, proteins and Na while changes were not significant for fat, K, Pb and Zn (table 3).

As seen in Table 1, to 7 elements (pH, brix, dry matter, organic matter, acids, proteins and carbohydrates) the highest values were reaching in 100% irrigation, followed by 80%, 60% and lastly 40%. Higher values are reached without mulch treatments, but the same elements that have been made at the time of harvest after applying the RDI, treatments with mulch had higher value.

Unlike the elements of table 1 those in table 2. (ash, Ca, Fe, Cu, Na, Mg and P) higher values are reached with mulch treatments. The highest values were found in 80% irrigation, followed by 100%, while 60% and 40% irrigation have had approximate value.

Table.1. Average values of the parameters tested in fruits at harvest with differences between treatments according LSD testing

Elements		pH	Brix	Dry matter	Org. matter	Acids	Proteins	Carbohy drates
Irrigation 100 %	Mulch +	a 3.88	a 15.44	a 17.65	a 17.27	a 0.28	a 0.24	a 16.48
	Mulch -	4.02 a	16.00a	18.06 a	17.52 a	0.24 a	0.32 a	16.61 a
Irrigation 80 %	Mulch +	b 3.64	b 14.66	b 16.24	b 16.10	b 0.40	b 0.42	b 15.15
	Mulch -	3.76 b	15.03b	16.77 b	16.35 b	0.38 b	0.24 b	15.62 b
Irrigation 60 %	Mulch +	c 3.77	b 14.29	b 15.99	c 15.57	c 0.22	c 0.33	c 14.78
	Mulch -	3.69 c	13.77c	15.66 c	15.19 c	0.33 c	0.27 b	14.28 c
Irrigation 40 %	Mulch +	c 3.52	c 12.50	c 14.28	d 13.74	c 0.23	a 0.22	d 13.09
	Mulch -	3.75 c	13.88c	15.44 c	14.92 d	0.26 a	0.37 c	14.08 c

Table.2. Average values of the parameters tested in fruits at harvest with differences between treatments according LSD testing

Elements		Ash	Calcium (Ca)	Cooper (Cu)	Sodium (Na)	Magnesium (Mg)	Phosphorus (P)
Irrigation 100 %	Mulch +	a 0.33	a 10.00	a 0.42	a 3.60	a 9.97	a 5.83
	Mulch -	0.32 a	13.33 a	0.09 a	3.10 a	8.57 a	4.67 a
Irrigation 80 %	Mulch +	a 0.32	b 16.33	b 0.23	a 3.77	a 9.73	a 7.80
	Mulch -	0.28 b	13.66 a	0.14 a	3.20 a	8.63 a	3.20 a
Irrigation 60 %	Mulch +	b 0.23	a 10.00	c 0.08	a 3.57	a 9.63	a 8.50
	Mulch -	0.27 b	12.33 a	0.08 a	4.30 b	8.00 a	4.80 a
Irrigation 40 %	Mulch +	b 0.25	c 12.67	d 0.20	a 3.93	b 8.40	b 3.53
	Mulch -	0.27 b	15.33 b	0.11 a	3.03 a	7.90 a	5.10 a

*In table 1 and 2. letters on the left in each column represent differences for mulch +, while on the right represent differences for mulch- (without mulch).

In Table 3 are presented the elements, which in based ANOVA variance analysis are not found significant differences (K, Zn, Pb and fat), but even here the highest values are reached in without mulch treatments.

Table.3. Average values of the parameters tested in fruits at harvest in which there were no differences between treatments

Elements		Fat	Iron (Fe)	Potassium (K)	Zinc (Zn)	Lead (Pb)
Irrigation 100 %	Mulch +	0.21	0.56	101.66	0.28	0.008
	Mulch -	0.25	0.45	111.66	0.32	0.010
Irrigation 80 %	Mulch +	0.20	0.56	102.00	0.32	0.010
	Mulch -	0.20	0.48	106.00	0.36	0.008
Irrigation 60 %	Mulch +	0.22	0.55	98.66	0.31	0.004
	Mulch -	0.24	0.49	93.66	0.30	0.011
Irrigation 40 %	Mulch +	0.18	0.55	94.00	0.33	0.006
	Mulch -	0.19	0.47	97.00	0.25	0.011

These results can be obtained primarily as a result of weather conditions: temperature and rainfall during the time the experiment, furthermore long-term effects of deficit irrigation, together with climatic conditions, crop techniques variations, type of soil, age of plants etc. must be considered, because the long-term plant responses to RDI or PRD are more accurate than short-term responses (Lepaja*et al.*, 2015).

Conclusions

High nutritional values of pear fruit make this crop highly demanded all around the world. Different cultivars have different nutrient values. However, changes in these values depend also on a number of factors such as climate, cultural practices, rootstocks, irrigation etc.

In experiments in open field where irrigation is applied, respectively deficit irrigation, RDI or PRD, crucial factors in the results of the research are the climatic conditions of that region but on the other side the results of the first year of the experiment, are only preliminary results and for sustainable results the experiment it must continue for many years. Pear culture is very demanding on the market throughout the year, as long preservation of fruit without losing their quality is an advantage.

The use of the four different levels of irrigation (100%, 80%, 60% and 40%) combination with mulch on Williams pear is a new thinks (innovation), so each result increases our understanding of the effects of regulated water deficit practices, respectively RDI practices. Based on our investigations on the optimal deficit irrigation regime under the agro ecological conditions of Kosovo and Dukagjini Plain in particular, under an intensive pear growing technology we can deduct that harvesting of fruits for storage cv. ‘Williams’ is to be done earlier to the beginning of August so that the fruits can be stored longer although preserving fruits can be affected by temperature. We found significant changes in a series of nutrient elements. Irrigation levels significantly influenced pH, acids, brix, carbohydrates, dry matter, organic matter, ash, Ca and Na, while mulch has influenced brix, dry matter, pH, Cu, P, Fe, Mg and Na. The combination of irrigation and mulching have influenced pH, acids, brix, carbohydrates, dry matter, organic matter, proteins and Na while changes were not significant for fat, K, Pb and Zn.

As the experiment is continuing, in the next years we expect an attenuation of the RDI effects in combination with mulching.

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