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THE EFFECT OF IRRIGATION AND MINERAL FERTILIZATION ON THE PHOTOSYNTHETIC ACTIVITY AND WATER USE IN RESPECT OF CHERRY CV. 'KELLERIS 16' YIELDING

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Abstract. Taking the decreasing water supplies into consideration, more attention should be paid to reasonable water management. However, in order to be able to minimise the water use and manage it reasonably, it seems necessary to investigate the plants water management and their reactions to water stress. Most of the previous studies concerning the effects of irrigation and fertilisation was conducted on apple orchards and there is little information in the literature about the influence of these factors on stone fruit trees.The study was conducted in 2011, 2013 and 2014 years in the Agricultural Experimental Station in Lipnik. The objective of the present study was to assess the impact of irrigation and mineral fertilization on photosynthetic activity, water use and yielding in cherry cv. 'Kelleris 16'. The first factor of the study was under-crown watering: 0 – controlled objects, with no irrigation, W – irrigated objects, with soil water potential below – 0.01 MPa. The secondary factor was nitrogen and potassium fertilization: 0 NK (control, no fertilization), 1 NK – 80 $kg\cdot ha^{-1}$ (40 + 40), 2 NK – 160 $kg\cdot ha^{-1}$ (80 + 80). The measurements of the leaves photosynthetic activity in each year were taken in the dynamic fashion, using a LCA-4 analyser (ADC Bioscentific LTD, Hoddeson, Great Britain). WUE increased under water shortage conditions and decreased when water was more available. The calculated water use efficiencies, both WUE and WUEI, were higher for the objects fertilized with 1NK dose. The application of the supplementary irrigation as well as NK fertilization significantly influenced the increase in cherry cv. 'Kelleris 16' yielding. Moreover, it was found a significant positive correlation between yielding and intensity of assimilation, as well as between yielding and water use efficiency (WUE).

Key words: fertilizer application; water stress; yield, water use efficiency

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INTRODUCTION

According to current prognoses the number of countries that will have to struggle with water shortage or scarcity is going to rise in the course of the next several years. A lot of regions will have to adjust their water resources management and polices as well as water demand. It should be remembered that we all contribute in decreasing the levels of sweet water in the world and unless we take proper actions, the water shortage problem will concern us directly. It is necessary to develop systems which would allow the reduction of water use in households as well as in large companies, both in industry and farming. Water is a factor needed for plants' growth and development, it is a nutrient carrier and a substrate for photosynthesis. The plants' production requires large amounts of water. Most of the crop plants need regular irrigation and often also even spraying with water. Water deficiency in plants causes disruption of life processes. This can cause growth and development inhibition which often results in decreased yield and its lower quality [Olszewska et al. 2010]. Taking the decreasing water supplies into consideration, more attention should be paid to reasonable water management, including water management in crop farming [Kang et al. 2002]. However, in order to be able to minimise the water use and manage it reasonably, it seems necessary to investigate the plants water management and their reactions to water stress. Water stress, which can be defined as both water excess and shortage, is a reason for alternations in plants' biochemical and physiological processes Dąbrowska et al. [2010], Tavarini et al. [2011], Chenafi et al. [2013], Razouk et al. [2013]. Minerals are as important as water for the process of photosynthesis. This concerns especially those minerals that directly or indirectly take part in the process, such as nitrogen, potassium, iron, magnesium and manganese. There is a clear correlation between the supply of these minerals and photosynthesis intensity in plants. Nitrogen deficiency causes a decrease in photosynthesis intensity. Most of the total nitrogen in leaves is contained in chloroplasts and this is the reason for its crucial meaning for the process of photosynthesis. Potassium is in turn an activator of the enzymes taking part in the light-dependent phase of photosynthesis, for example in photosynthetic phosphorylation [Borowiak and Korszun 2011].

Most of the previous studies concerning the effects of irrigation and fertilisation was conducted on apple orchards and there is little information in the literature about the influence of these factors on stone fruit trees [Treder and Pacholak 2006]. Therefore, the aim of this study was to determine the effect of irrigation and mineral fertilization on the photosynthetic activity and water use in respect of cherry cv. 'Kelleris 16' yielding.

MATERIAL AND METHODS

In the years 2011, 2013 and 2014 a two-factor field experiment was set in the Agricultural Experimental Station in Lipnik (53°20'35'' 14°58'10''E) near Stargard Szczeciński. The experiment evaluated the impact of irrigation and mineral fertilization on photosynthetic activity and water use in cherry cv. 'Kelleris 16'. The objects of studies were cherries of cultivar 'Kelleris 16' budded on the seedling of mahaleb cherry. The soil on which the experiment was conducted belongs to the typical rusty soils group

(Polish Soils Systematics 2011) and is classified as Haplic Cambisol (IUSS Working Group WRB 2006). In the Ap level it has a granulometric composition of clay sand with a slightly acidic pH, humus content (1.3–1.5%) and floated components (11–13%). The humus level was formed from clay sands. The content analysis of the soil minerals showed high levels of phosphorus (6 mg·100 g^{-1}) and moderate levels of magnesium (4 mg·100 g^{-1}) and potassium (7 mg·100 g^{-1}).

The experiment was designed by the split-plot method in 7 replications (one tree – one repeat). Among the trees was the lawn but in the rows the selective herbicide fallow was kept. The trees were planted in 4 × 2 m spacing. The research was conducted on trees in the 13th, 15th and 16th year after planting. The first factor studied was under-crown watering: 0 – controlled objects, with no irrigation, W – irrigated objects, with soil water potential below – 0.01 MPa. Hadar micro-sprinklers were used for watering, sprinkler range r = 1 m and efficiency of 2.5l × h^{-1}; one sprinkler per each tree. Determination of the doses and times of irrigation was performed using tension-meters buried 20 cm below the soil surface. The amounts of water applied to the trees were: 71.3 mm·ha^{-1} in the year 2011, 105 mm·ha^{-1} in the year 2013 and 66.3 mm·ha^{-1} in the year 2014 (e.i. 0.57, 0.84 and 0.53 m^3 per tree, respectively). The secondary factor was nitrogen and potassium fertilization: 0 NK (control, no fertilization), 1 NK – 80 kg·ha^{-1} (40 + 40), 2 NK – 160 kg·ha^{-1} (80 + 80). The nitrogen fertilizers was applied in early spring and potassium in autumn, according to agronomic recommendations. Ammonium nitrate containing 34% of N and potash salt containing 60% of K were used for fertilization.

Table 1. Sum of rainfall (mm) and mean air temperature (°C) in during the experiment

Month	Long-term average 1961–1994		Rain (mm)			Temperature (°C)		
	rain (mm)	temperature (°C)	years					
			2011	2013	2014	2011	2013	2014
IV	37.8	7.2	11.6	23.2	37.0	11.4	11.4	11.1
V	51.1	12.5	28.0	42.5	100.5	14.1	17.5	14.0
VI	61.3	15.9	32.3	14.4	48.5	17.5	20.3	16.9
VII	63.2	17.4	150.5	56.6	95.0	17.4	21.2	21.8
VIII	56.1	17.0	40.5	72.6	66.5	18.0	18.4	18.2
IX	46.8	13.2	56.1	65.6	106.0	15.0	12.8	13.9
IV–IX	316.3	13.9	319.0	274.8	453,5	15.6	16.9	16.0

Weather condition measurements. The atmospheric conditions in all of the years of the study are presented in table 1. During the vegetation seasons, the air temperature, and sum of rainfalls were measured at Weather Station in Lipnik localized near at the experimental plots. Mean monthly temperature and sum rainfall were slightly differentiated in the experimental years. In during experiment (2011, 2013–2014 years) mean monthly temperature was higher as compared multiyear average by 2.5°C, 3.8°C, 2.9°C, respectively. In 2011 year sum rainfall was higher in comparison with multiyear average (ie. 0.8%) in 2014 was higher (ie. 43.4%). In 2013 year was lower in comparison with multiyear average (ie. 13.1%).

Physiological measurement and yield. The measurements of the leaves photosynthetic activity in each year were taken in the dynamic fashion (in the period of fruit setting, harvesting and one month after harvesting) using a LCA-4 analyser (ADC Bioscentific LTD, Hoddeson, Great Britain). In the year 2011 the measurements were taken on June 27, July 25 and August 18. In the year 2013 the measurements were taken on June 13, of July 15 and August 22. In the year 2014, June 14, July 25 and August 12. In the year 2012 there was no data recorded due to the apparatus damage. The leaves chosen for the measurements were well developed, taken from the middle part of one year old shoots on the outer part of tree crown, in the middle of its height. The analysis was conducted on fully developed leaves without any signs of ageing or mechanical damage. The measurements included: NET photosynthesis intensity (Pn), stomatal conductivity (gs), internal CO_2 concentration (Ci) and leaves transpiration index (E). The photosynthesis water use efficiency (WUE), which mainly depends on the environmental factors, was determined on basis of the ratio of the photosynthesis index to the transpiration (Pn/T). At the same time, the genetically determined instantaneous water use efficiency (WUEI) was assessed on basis of the ratio of the photosynthesis intensity to stomatal conductivity (Pn/g_s). The cherry fruit harvesting took place on July 22, July 10 and July 15 in the three years of study (2011, 2013, 2014, respectively).

Statistical analysis. The results of the photosynthetic activity, water use by cherry cv. 'Kelleris 16' and yield were processed statistically by means of a variance analysis for long-term experiments, and the significance of differences with NIR of $_{0.05}$ was evaluated with the Tuckey's test. The statistical analysis was carried out using the ANALWAR-5.1.FR programme. The analysis of the correlation of the characteristics significantly differentiating the interaction of experimental factors was performed using the STATISTICA V.10 programme.

RESULTS AND DISCUSSION

Drought is the most important limiter factor in plant growth and products in orchards all over the world [Alizadeh et al. 2011]. The response of fruit trees to water stress and mineral fertilisation may be different depending on many factors, including the species and the age of the trees.

According to the obtained results, the trees in the particular experimental objects showed various photosynthetic activity. Despite there was no significant influence of the irrigation on the most of the studied traits, a tendency to decreased photosynthetic activity in the irrigated trees was observed (tab. 2), which is consistent with the research of Wibbe and Blanke [1997], who claim that a decrease in the photosynthesis intensity could be caused not only by lack of water but also by its excess. Many researchers emphasise the decrease of CO_2 concentration is as a result of water stress [Šircelj et al. 2007, Alizadeh et al. 2011, Jaroszewska et al. 2011, Xu and Leskovar 2014]. The irriga-

Table 2. Photosynthetic activity of cherry in 2011, 2013 and 2014 years

Year		Irrigation*	Fertilization	P_n***	T	C_i	gc	T_{leaf}
2011		O	0	4.59	0.66	260.9	0.50	22.8
			1	4.04	0.68	305.3	0.54	22.7
			2	3.97	0.55	201.4	0.50	22.6
		W	0	3.41	0.67	173.9	0.55	22.7
			1	4.66	0.54	223.2	0.50	22.7
			2	3.20	0.54	199.7	0.46	22.7
	influence of irrigation		O	4.20	0.63	255.9	0.51	22.7
			W	3.75	0.58	187.9	0.50	22.7
	influence of fertilization		0	3.99	0.67	217.4	0.52	22.73
			1	4.35	0.61	264.3	0.52	22.67
			2	3.59	0.55	184.6	0.48	22.62
			irrigation (A)	**n.s.	n.s.	n.s.	n.s.	n.s.
			fertilization (B)	0.69	0.11	57.5	0.04	n.s.
			B × A	0.98	n.s.	n.s.	0.06	n.s.
			A × B	1.22	n.s.	n.s	0.07	n.s
2013		O	0	1.70	0.67	99.5	0.35	20.7
			1	3.78	0.65	97.3	0.18	21.5
			2	3.31	0.64	106.9	0.57	21.4
		W	0	1.90	0.64	100.8	0.37	21.5
			1	2.57	0.63	95.5	0.16	21.4
			2	1.59	0.57	91.6	0.53	21.9
	influence of irrigation		O	2.93	0.65	101.3	0.37	21.2
			W	2.02	0.61	95.9	0.35	21.6
	influence of fertilization		0	1.80	0.65	100.2	0.36	21.1
			1	3.18	0.64	96.4	0.17	21.4
			2	2.45	0.61	99.2	0.55	21.6
			irrigation (A)	n.s.	n.s.	4.09	n.s.	n.s.
			fertilization (B)	1.13	n.s.	n.s.	0.20	n.s.
			B × A	n.s.	n.s.	n.s.	n.s.	n.s.
			A × B	n.s	n.s	n.s	n.s	n.s
2014		O	0	1.48	1.24	388.2	0.27	24.0
			1	1.41	1.07	377.7	0.16	24.0
			2	1.59	1.36	388.4	0.42	24.0
		W	0	1.93	1.14	446.4	0.38	24.0
			1	2.28	1.19	396.9	0.29	23.7
			2	1.67	1.13	375.2	0.31	23.7
	Influence of irrigation		O	1.49	1.22	384.8	0.28	24.0
			W	1.96	1.15	406.2	0.33	23.8
	Influence of fertilization		0	1.70	1.19	417.3	0.32	24.0
			1	1.85	1.13	387.3	0.23	23.8
			2	1.63	1.25	381.8	0.37	23.8
			irrigation (A)	0.01	n.s.	21.07	n.s.	n.s.
			fertilization (B)	n.s.	n.s.	31.45	0.12	n.s.
			B × A	n.s.	n.s	44.47	0.16	n.s.
			A × B	n.s.	n.s	36.26	0.15	n.s.

* – as in the methodology, ** – n.s. – not significant difference, LSD$_{0.05}$ for (A), (B), interaction (B × A), (A × B), *** – the intensity of assimilation (Pn) (umol $CO_2 \cdot m^{-2} \cdot s^{-1}$), intensity of transpiration (T) (mmol $H_2O \cdot m^{-2} \cdot s^{-1}$), stomatal conductance (gc) (mmol $H_2O \cdot m^{-2} \cdot s^{-1}$), the concentration of CO_2 into the distance intercellular (Ci) (umol $CO_2 \cdot mol^{-1}$ air), temperature (T leaf) (°C)

tion applied during the experiment appeared to be a factor that significantly altered only the assimilation and CO_2 concentration values. In 2013 the CO_2 concentration was 5.3% lower in the plants on the irrigated plots than in the control plants (no irrigation). In the subsequent year the CO_2 in the leaves of the irrigated plants increased by 5.6% and the assimilation was 31.5% higher (tab. 2), which was probably influenced by the amount of water the plants received from irrigation as well as the precipitation (tab. 1). The second assessed factor – fertilisation, significantly altered the assimilation in the leaves of the fertilised cherry plants both in the first and second year of the experiment: in 2011 by 9% (1 NK), in 2013 by 76.7% (1 NK) and by 36.1% (2 NK) compared to the control objects (no fertilisation) (tab. 2). The significant influence of the fertilisation on the transpiration was observed only in the first year of the study. In the observed objects the transpiration was lower by 8.9% (1 NK) and 17.9% (2 NK) (tab. 2). Also the CO_2 concentration in the leaves of the trees fertilised with 80 $kg \cdot ha^{-1}$ (1 NK) dose was 21.6% higher compared to the control. Fertilisation with a 160 $kg \cdot ha^{-1}$ (2 NK) dose decreased its value by 15.1%. In the year 2014 the CO_2 concentration was 7.2% and 8.5% lower, respectively (tab. 2). Also the influence of NK fertilisation on the stomatal conductivity in leaves of cherry trees was determined in the study. In the first year the stomatal conductivity in the leaves of the plants on the plots fertilised with 1 NK and 2 NK was lower by 1 and 8.2%, respectively, in comparison to the plants without fertilisation (tab. 2). In both years 2013 and 2014 the 1 NK fertilisation decreased the stomatal conductivity by 52.8 and 30.2%, respectively, whilst the 2 NK fertilisation increased the value by 52.8 (in 2013) and 13% (in 2014) (tab. 2). There was no statistical proof of significant influence of the irrigation and fertilisation on the change in the air temperature (tab. 2). Such results find their partial confirmation in the available subject literature [Guzewski et al. 1998, Jaroszewska et al. 2009, Bavec et al. 2013, Podsiadło and Jaroszewska 2013]. The conducted statistical analysis showed that the interference and interactions of the studied factors affect the photosynthetic activity in leaves of cherry tree (tab. 2). In the first year of the study the highest value of the assimilation was observed in the irrigated and fertilised (1 NK) plants. Irrigation combined with fertilisation, however, decreased the leaves stomatal conductivity. The highest values of this trait were noted in the plants on the irrigated, but not fertilised plots (tab. 2). In the last year of the study the highest CO_2 concentration was observed in the irrigated but not fertilised cherry trees. At the same time the cell conductivity was clearly the highest in the plants which were not irrigated but fertilised with the highest dose (160 $kg \cdot ha^{-1}$) as well as in the irrigated but not fertilised ones (tab. 2).

The water shortage in the soils is a factor which significantly limits the trees yielding. The decrease in the trees yielding under the conditions of water stress is a result of decreased photosynthesis intensity and growth. Even a small decrease in the water content in leaves caused by its shortage in soil leads to a strong inhibition of growth as well as a decrease in the yield [Starck 2002, Olszewska and Grzegorczyk 2013]. Many publications concerning irrigation and fertilisation [Sadowski and Jadczuk 1998, Zygmuntowska and Jadczuk-Tobjasz 2008, Feldmane 2011, Woción et al. 2011, Veverka and Pavlačka 2012, Glonek and Komosa 2013] show that the application of the studied agronomical treatments significantly increase the fruit tree yielding, which also was confirmed during this study. A significant influence of the irrigation on cherry tree yielding was observed in the years 2014. The fruit yields were higher by 72.5% (ie. 5.8 kg·tree^{-1}), in comparison to the control. Probably this was a result of subsequent several years irrigation of cherry trees, which developed more shoots than not irrigated trees in the same period. Slight water shortage in the soil and climatic conditions favourable in terms of rainfall in the year 2014 contributed to higher yield. Similarly, in the first study year (2011) the irrigated trees yielded significantly more fruit compared to not irrigated trees (by 54%, 5.9 kg·tree^{-1}), although there was no statistically significant influence of the study factor on yielding recorded. In the year 2013 the water influence on yielding was the least, although not proven statistically (it was higher by 4.3%, ie. 0.40 kg·tree^{-1} in comparison to the control). It was probably influenced by a lower photosynthetic activity in the irrigated leaves as well as the weather conditions. This year was the warmest and the driest year of all the years of the study. From the plots fertilised with 1 NK and 2 NK in 2013 there was 51.5% (ie. 3.4 kg·tree^{-1}) and 83% (ie. 5.3 kg·tree^{-1}) more fruits harvested, respectively, compared to the control plots. In the subsequent year, respectively, 70.0% (ie. 5.5 kg·tree^{-1}) and 64.1% (ie. 4.8 kg·tree^{-1}) more fruits was collected (tab. 3). The significant influence of the two treatments on cherry tree yielding was not proven statistically.

Table 3. Yield of cherry in during the experiment (kg·tree^{-1})

	Irrigation*	Fertilization	2011	2013	2014	Means
	O	0	10.8	4.80	5.40	7.0
		1	10.5	10.8	8.80	10.0
		2	11.3	12.6	10.1	11.3
	W	0	12.3	8.40	9.70	10.1
		1	21.2	9.30	17.0	15.8
		2	16.9	11.6	14.7	14.4
Influence of irrigation		O	10.9	9.40	8.00	9.46
		W	16.8	9.80	13.8	13.5
Influence of fertilization		0	11.5	6.60	7.50	8.57
		1	15.9	10.0	12.8	12.9
		2	14.1	12.1	12.4	12.9
		irrigation (A)	n.s.	n.s.	3.27	n.s.
		fertilization (B)	n.s.	3.40	3.44	3.46
		B × A	n.s	n.s.	n.s.	n.s.
		A × B	n.s.	n.s	n.s.	n.s

* – as in the methodology, ** – n.s. – not significant difference, LSD $_{0.05}$ for (A), (B), interaction (B × A), (A × B)

According to researchers [Yilong et al. 2005, Quezada et al. 2011, Jaroszewska et al. 2011] the supplementary irrigation differentiates the value of the water use coefficient. Water use efficiency can be improved by modifying both terms of the ratio. Agronomic

Table 4. Water use efficiency (WUE), μmol $CO_2 \cdot m^{-2} \cdot s^{-1}$ m mol $H_2O \cdot m^{-2} \cdot s^{-1}$

	Irrigation*	Fertilization	2011	2013	2014	Mean
	O	0	5.26	2.55	1.25	3.02
		1	5.03	5.44	1.23	3.90
		2	5.80	4.90	1.17	3.96
	W	0	4.98	2.87	1.75	3.20
		1	7.26	3.83	1.92	4.34
		2	5.52	2.91	1.49	3.31
Influence of irrigation		O	5.36	4.30	1.22	3.63
		W	5.92	3.20	1.72	3.61
Influence of fertilization		0	5.12	2.71	1.50	3.11
		1	6.15	4.64	1.58	4.12
		2	5.66	3.91	1.33	3.63
		irrigation (A)	n.s.	1.10	n.s.	n.s.
		fertilization (B)	n.s.	1.46	n.s.	n.s.
		B × A	1.74	n.s.	n.s.	n.s.
		A × B	3.41	n.s.	n.s	n.s

*– as in the methodology, ** – n.s. – not significant difference, LSD $_{0.05}$ for (A), (B), interaction (B × A), (A × B)

Table 5. Momentary water use efficiency (WUEI), μmol $CO_2 \cdot m^{-2} \cdot s^{-1}$ m mol $H_2O \cdot m^{-2} \cdot s^{-1}$

	Irrigation*	Fertilization	2011	2013	2014	Mean
	O	0	9.33	20.4	6.43	12.1
		1	7.58	31.9	8.60	16.0
		2	8.00	29.4	1.90	13.1
	W	0	6,49	17.5	5.20	9.73
		1	9.66	25.6	8.95	14.7
		2	6.81	15.5	9.23	10.5
Influence of irrigation		O	8.30	27.2	5.64	13.7
		W	7.65	19.5	7.79	11.7
Influence of fertilization		0	7.91	18.9	5.82	10.9
		1	8.62	28.8	8.78	15.4
		2	7.41	22.5	5.57	11.8
		Irrigation (A)	n.s.	7.38	n.s.	n.s.
		Fertilization (B)	n.s.	7.14	3.06	n.s.
		B × A	2.47	n.s.	4.33	n.s.
		A × B	2.89	n.s	5.02	n.s

* – as in the methodology, ** – n.s. – not significant difference, LSD $_{0.05}$ for (A), (B), interaction (B × A), (A × B)

techniques aimed at reducing water losses (at irrigation, field or plant levels) and effectively conveying water to the root zone will increase WUE. Similarly any agronomic practice that will increase crop yield will ultimately enhance WUE. Other criteria to improve WUE may involve controlling physiological processes that affect plant transpiration and yield [Pascale et. al. 2011]. In 2013 there was a significant influence of the irrigation on the water use efficiency (WUE) and the instantaneous water use efficiency (WUEI), whilst the influence of the fertilisation was observed in the last year of the study. The combination of both treatments (irrigation and fertilisation) had a significant impact on the studied plant features in 2011 and 2014 (tab. 4–5). Both water use efficiency (WUE) and instantaneous water use efficiency (WUEI) for cherry was lower in the irrigated plots by 25.6 and 28.3%, respectively, compared to the control. Which may indicate that the plants make better use of water under conditions of scarcity water than under optimal moisture [Rouphael et al. 2008, Medrano et al. 2009, Yin et.al. 2012, Olszewska and Grzegorczyk 2013] The transpiration intensity is closely correlated to the water use effectiveness in the plants during their vegetation period. Lower water use coefficients in cherry (WUE) and (WUEI) were observed in the last year of the study (2014), when the plants showed intensive transpiration (tab. 2, 4, 5). The same phenomenon was also observed in various species by Olszewska and Grzegorczyk [2013] and Jaroszewska et al. [2011]. The WUE was 72.2% higher in the objects fertilised with the 80 kg NK$\cdot$ha^{-1} dose and 44.2% higher in the objects fertilised with the 160 kg NK$\cdot$ha^{-1} dose, compared to the control (tab. 4). Similar results were obtained Mikiciuk and Mikiciuk [2009]. The WUEI values were higher in the leaves of the plants fertilised with 1 NK, in 2013 by 52.4 and in 2014 by 50.8% compared to the control (tab. 5). During the first year of the study higher WUE values were observed in the fertilised but not irrigated objects, compared to the irrigated and fertilised ones. The leaves from the trees grown on the irrigated and fertilised (1 NK) plots showed higher WUE than any other experimental object (tab. 4). In the year 2011 the values of WUEI were similar (tab. 5). In the year 2014 the values were higher in the trees grown on the irrigated and fertilised (both 1 NK and 2 NK) plots in comparison to the trees grown on the fertilised but not irrigated plots (tab. 5).

Table 6. Correlation coefficients between yield and photosynthetic activity, WUE, WUEI

	Correlation coefficients					
Yield	P_n	T	C_i	gc	WUE	WUEI
	***0.47**	-0.45	-0.06	0.22	**0.48**	-0.18

* – (figures in bold) significant, explanations as in Table 2

Furthermore, when analysing the obtained results of own study, a positive, significant correlation was detected between yielding and intensity of assimilation, as well as between yielding and water use efficiency (WUE) (tab. 6).

CONCLUSIONS

In conclusion, the applied agronomic treatments significantly influenced the photosynthetic activity of the studied cherry trees. There was a trend observed to decrease in photosynthetic activity in the leaves of the irrigated trees. The water use efficiency (WUE) and the instantaneous water use efficiency (WUEI) were dependent on the applied irrigation and fertilisation. WUE increased under water shortage conditions and decreased when water was more available. Higher WUE and WUEI were observed on the plots no irrigation and plots fertilised with 80 kg NK·ha^{-1} dose. Irrigation and fertilisation significantly increased the cherry yield. It was found that with increasing intensity of assimilation and WUE increased the cherry yield.

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WPŁYW NAWADNIANIA I NAWOŻENIA MINERALNEGO NA AKTYWNOŚĆ FOTOSYNTETYCZNĄ I ZUŻYCIE WODY W ODNIESIENIU DO PLONOWANIA WIŚNI ODMIANY ‘KELLERIS 16’

Streszczenie. W związku ze zmniejszającymi się zasobami wodnymi, coraz więcej uwagi zwraca się na rozsądne gospodarowanie wodą. Aby móc zmniejszyć zużycie wody do minimum i gospodarować nią racjonalnie, niezbędnym wydaje się poznanie zarówno gospodarki wodnej roślin, jak i ich reakcji na stres wodny. W literaturze naukowej znajdujemy niewiele doniesień na temat wpływu nawadniania i nawożenia mineralnego na drzewa pestkowe, przeprowadzone dotychczas badania dotyczą przede wszystkim sadów jabłoniowych. Doświadczenie przeprowadzono w latach 2011, 2013 i 2014 w Stacji Doświadczalnej w Lipniku k. Stargardu. Określono wpływ nawadniania i nawożenia mineralnego na aktywność fotosyntetyczną, zużycie wody oraz plonowanie wiśni odmiany ‘Kelleris 16’. Pierwszym czynnikiem było nawadnianie uzupełniające: 0 – obiekty kontrolne, bez nawadniania, W – obiekty nawadnianie, przy potencjale wodnym gleby poniżej -0,01 MPa. Drugim czynnikiem było nawożenie mineralne NK: 0 NK (kontrola, bez nawożenia), 1 NK – 80 $kg \cdot ha^{-1}$ (40 + 40), 2 NK – 160 $kg \cdot ha^{-1}$ (80 + 80). Pomiary aktywności fotosyntetycznej liści wykonano analizatorem LCA-4 (ADC Bioscentific LTD, Hoddeson, Great Britain) w ujęciu dynamicznym. Współczynnik WUE wzrastał w warunkach niedoboru wody, malał w warunkach optymalnego uwilgotnienia. Wyliczone współczynniki wykorzystania wody (WUE) oraz (WUEI) były większe na obiektach nawożonych dawką na poziomie 1 NK. Zastosowane nawadnianie uzupełniające oraz nawożenie NK istotnie wpłynęło na wzrost plonowania drzew wiśni odmiany Kelleris. Ponadto wykazano istotną dodatnią korelację pomiędzy plonem a asymilacją oraz plonem a (WUE).

Słowa kluczowe: nawożenie, stres wodny, plon, współczynnik wykorzystania wody

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