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YIELD AND QUALITY OF HEAD LETTUCE AFTER 24-EPIBRASSINOLIDE APPLICATION UNDER OPTIMAL AND REDUCED IRRIGATION

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Abstract

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The aim of this work was evaluation of 24-epibrassinolide influence on yield and quality of head lettuce in optimal and reduced moisture conditions and work out recommendation of 24-brassinosteroids use for lettuce in growers praxis. Field trials were carried out on land belonging to the Demonstration and Research Station of CULS in Prague – Troja in 2009 and 2011. Planting on 27. 8. 2009 and 20. 8. 2011 was done at planting space 0.25 × 0.30 m, each variant in four repetition (single plot 4,5 m^2). Seedlings of head lettuce (cultivar Santoro – Rijk Zwaan) were used. Irrigation was carried out by microspraying, and was based on current values of efficient water capacity (EWC); the critical value of the EWC was 80% for optimally irrigated fields (irrigation O), and 50% for variants with reduced levels of irrigation (irrigation S). The total amount of irrigation water during vegetation were as follows: the variant with optimal levels of irrigation (O) had 131 mm in 2009 and 123 mm in 2011; the variant with reduced levels of irrigation (S): 58 mm in 2009 and 63 mm in 2011 Three variants were in both (O and S) conditions: A – no application of 24-epibrassinolide, B – 1 × 24-epibrassinolide application immediately after planting, and C – application of 24-epibrassinolide 2 x (immediately after planting and then after 14 days after 1st application). Concentration of 24-epibrassinolide was 10^{-6}. Following parameters of head lettuce were set after harvesting (10.–12. 10. 2009 and 14.–15. 10. 2011): weight of single heads, marketable heads, marketable yield (in pcs/ha and t/ha) and ascorbic acid and nitrate contents. Influence of 24-epibrassinolide on single lettuce head weight was not significant, decrease of head weight was evident after 24-epibrassinolide application in some variants. Significant increase of marketable heads number and their percentages were noted after 24-epibrassinolide application in optimal moisture conditions – in variant B of 12 261 heads/ha (11.1 %) and in variant C of 16 279 heads/ha (14.7 %) compared with non treated variant A. This trend was not visible in reduced moisture conditions. Increase (nonsignificant) of total marketable yield (in t/ha) was noted after 24-epibrassinolide application. No significant differences were founded among the ascorbic acid contents in each irrigation variant. A higher ascorbic acid content (by approximately 11.9 % in variant C compared with control A) is evident after application of 24-epibrassinolide in the variant with lower levels of irrigation – S. Contrarily, decrease ascorbic acid content is indicated in the optimal levels of irrigation – O (by approximately 16.8 % in variant C compared with control A). The influence of 24-epibrassinolide application on the nitrate content was not significant, but the trend of nitrates decrease in optimal irrigation conditions is evident.

24-epibrassinolide, lettuce, yield, quality, ascorbic acid, nitrates

The imbalance in the water status (more water deficit) can occur wilting plants. The absence of accessible water in the soil usually occurs after the initial and transition stage of wilting the permanent wilting (the irreversible wilt) (Šebánek *et al.*, 1983). As shown by (Malý *et al.*, 1998) most vegetables have a high transpiration rate, ranging from 280 to 830 ml of water to 1 g dry weight, the transpiration rate of

cabbage gives Vogel, (1996) value between 500 and 580. Malý *et al.* (1998) also defines a limit value of 50% of the efficient water capacity, which when it drops below the value of all vegetables are suffering water shortages. In this context it is necessary to seek means to reduce the negative impact of water deficit for growers praxis. Applications of brassinosteroids could be one way to limit the negative impact of water defficit in vegetable production, because this hormons help by reducing of environmental stress impact of plant physiology, e.g. in connection to temperature (Ogweno *et al.*, 2008), to water deficiency (Jager *et al.*, 2008) or water excess (Takematsu and Takeuchi, 1999). The hypothesis of this work was: application of 24-epibrassinolide during vegetation can minimize negative influence of water defficit in head lettuce production.

MATERIAL AND METHODS

Field trials were carried out on land belonging to the Demonstration and Research Station of CULS in Prague – Troja in 2009 and 2011, which is situated 195 m above sea level, in a mild warm and dry area. Soil of the Demonstration and Research station in Troja is clasified as modal fluvisol with a pH of 6.6–6.9. Average temperatures during the vegetation period were 15.8 °C in 2009 and 16.9 °C in 2011. Planting on 27. 8. 2009 and 20. 8. 2011 was done at planting space 0.25 × 0.30 m, each variant in four repetition (single plot 4,5 m^2). Seedlings of head lettuce (cultivar Santoro – Rijk Zwaan) were used. Irrigation was carried out by microspraying, with an amount 10–20 mm (with respect to the development of the vegetation) and was based on current values of efficient water capacity (EWC); the critical value of the EWC was 80% for optimally irrigated fields (irrigation O – continuous line in graphs), and 50% for variants with reduced levels of irrigation (irrigation S – discontinuous line in graphs). The total amount of irrigation water during vegetation were as follows: the variant with optimal levels of irrigation (O) 131 mm in 2009 and 123 mm in 2011; for the variant with reduced levels of irrigation (S): 58 mm in 2009 and 63 mm in 2011. In the optimal conditions and also in the lower levels of irrigation were three variants: A – no application of 24-epibrassinolide, B – 1 × 24-epibrassinolide application immediately after outplanting, and C – application of 24-epibrassinolide 2 × (immediately after planting and then after 14 days after 1st application). Concentration of 24-epibrassinolide was 10^{-6}. The lettuce was cultivated in accordance with techniques recommended by Petříková *et al.* (2006). Standard fertilizer applications (according to the analysis) and weed control practices were used. Following parameters of head lettuce were evaluated after harvesting (10.–12. 10. 2009 and 14.–15. 10. 2011): weight of single heads, marketable heads, marketable yield (in pcs/ha and t/ha) and ascorbic acid and nitrate content. The contents of ascorbic acids, nitrates, dry matter, and values of total antioxidative capacity were also evaluated. The reflectometric method (Reflectoquant – Merck) was used for ascorbic acid and nitrate content determination. Mixed samples from three plants from each repetition (each trial variant was grown in 4 repetitions) were prepared for analysis. The measured values were statistically analyzed using the STATISTICA Cz, versions 9.0 software system for data analysis.

RESULTS AND DISCUSSION

Average values of the evaluated lettuce parameters are given in Table I. Influence of 24-epibrassinolide on single lettuce head weight was not significant, but decrease of head weight was evident after 24-epibrassinolide application in variant with lower irrigation and 1 x application of 24-epibrassinolide – compared to control variant. Increase of marketable heads number and their percentages were noted after 24-epibrassinolide application. This increase was significant in optimal moisture conditions in variant B with 12 261 heads/ha (of 11.1%) and in variant C with 16 279 heads/ha (of 14.7%) compared with non treated variant A. This trend was not visible in reduced moisture conditions.

Increase of total marketable yield was noted after 24-epibrassinolide application, but effect was not significant. But lettuce is sold for price per piece in praxis, therefore number of marketable heads has a greater interpretative value for praxis.

As indicated by numerous studies, application of brassinosteroids can reduce negative environmental impacts, e.g. application of brassinosteroids limits negative influence of salinisation (El-Fattah, 2007), pesticides (Xia *et al.*, 2006) or biotic stressors (Masuda *et al.*, 2007). The increase of marketable heads (pcs/ha) after 24-epibrassinolide is influenced mainly by reduction of heads rooting. The aditional protective effect is also reported by Nakashita *et al.* (2003).

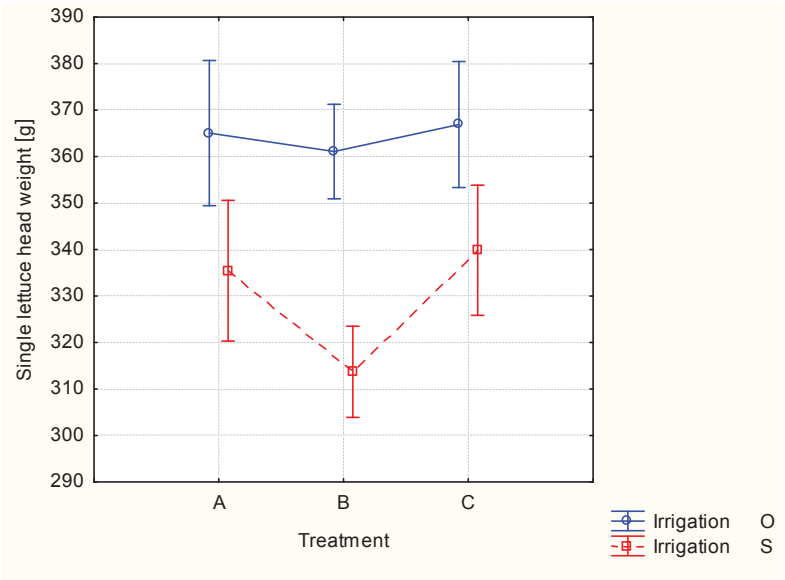
The positive effect of brassinosteroids are therefore not reflected only in increased volumes of phytomass, but by its higher quality, which has considerable significance for quality classification. It can lead to greater profitability of production for per piece sold vegetables such as for lettuce.

Average values of the ascorbic acid and nitrates contents are given in Table II. However significant differences in ascorbic acid content was not influenced by irrigation, a higher ascorbic acid content is evident after application of 24-epibrassinolide in the variant with lower levels of irrigation (by approximately 11.9% in variant C compared with control A). Contrarily, decreasing ascorbic acid content is evident in the optimal levels of irrigation – O (by approximately 16.8% in variant C compared with control A).

The increase antioxidant compounds (including ascorbic acid) in plants due to abiotic stresses is mentioned by Babu and Devaraj (2008) in trials with *Phaseolus vulgaris* L., Nair *et al.* (2008) in trials with *Vigna unguiculata* L. and Koudela *et al.* (2011) in

I: *Yield and quality of head lettuce*

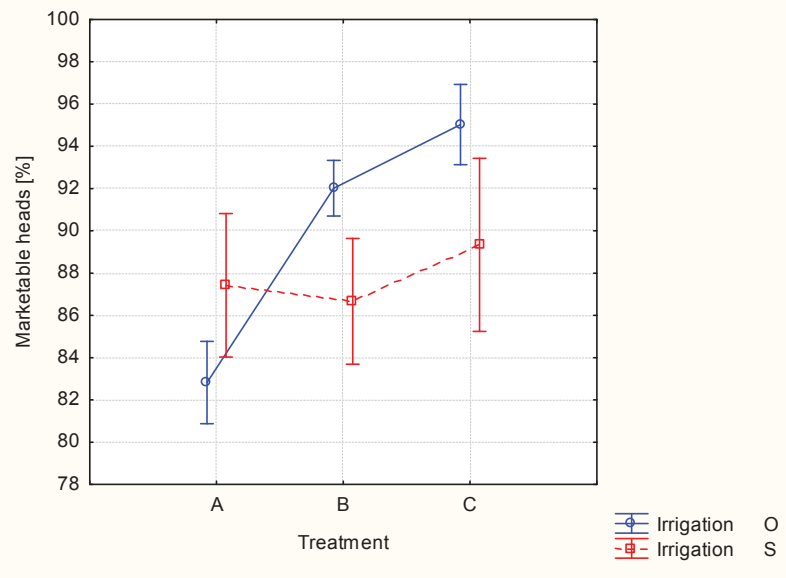
Year	Irrigation	Treatment	Single head weight [g]	Marketable heads [%]	Marketable yield [pcs/ha]	Marketable yield [t/ha]
2009	O	A	352.7^{a}	82.79^{a}	110 390^{a}	39.14^{ab}
		B	353.3^{a}	93.37^{ab}	124 490^{ab}	44.09^{ab}
		C	362.3^{a}	96.56^{b}	128 750^{b}	46.73^{a}
	S	A	332.2^{ab}	87.42^{ab}	116 564^{ab}	38.96^{ab}
		B	330.9^{ab}	86.66^{ab}	115 550^{ab}	38.35^{ab}
		C	338.6^{ab}	89.33^{ab}	119 112^{ab}	40.49^{ab}
The significant differences (P < 0.05) between average values are indicated in the column above by various letters (LSD test).						
2011	O	A	377.4^{a}	82.85^{a}	110 464^{a}	41.86^{ab}
		B	368.8^{a}	90.66^{ab}	120 886^{ab}	44.64^{ab}
		C	371.5^{a}	93.50^{ab}	124 662^{ab}	46.64^{a}
	S	A	338.8^{ab}	87.42^{ab}	116 564^{ab}	39.99^{ab}
		B	296.4^{b}	86.66^{ab}	115 550^{ab}	34.49^{b}
		C	341.1^{ab}	89.33^{ab}	119 112^{ab}	40.98^{ab}
The significant differences (P < 0.05) between average values are indicated in the column above by various letters (LSD test).						
Average	O	A	365.1^{a}	82.82^{b}	110 427^{b}	40.50^{ab}
		B	361.1^{a}	92.02^{a}	122 688^{a}	44.36^{a}
		C	366.9^{a}	95.03^{a}	126 706^{a}	46.69^{a}
	S	A	335.5^{ab}	87.42^{ab}	116 564^{ab}	39.48^{ab}
		B	313.7^{b}	86.66^{ab}	115 550^{ab}	36.42^{b}
		C	339.9^{ab}	89.33^{ab}	119 112^{ab}	40.74^{ab}
The significant differences (P < 0.05) between average values are indicated in the column above by various letters (LSD test).						



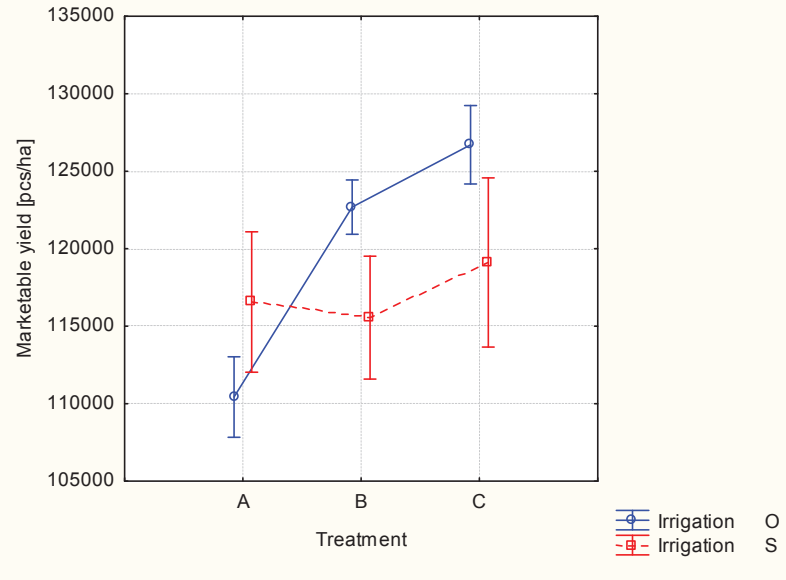
1: *Single lettuce head weight [g] – average of 2009 and 2011*

trials with cauliflower. The effect of oxidative biotic and abiotic stress on the increase of antioxidant components in plants is also reported by Hernandez *et al.* (2009).

The influence of 24-epibrassinolide application on the nitrate content was not significantly different, but the trend of nitrates decrease was confirmed in optimal irrigation conditions. This trend may occurs better physiological status and faster metabolism of nitrates in lettuce leaves. Positive influence of the brassionosteroids on the physiological status of crops is described by Müssig (2005) such as effect on the increase photosynthesis rate and by Yadav and Pandey (1997) such as influence on the reduction of the transpiration rate.



2: *Marketable lettuce heads [%] – average of 2009 and 2011*



3: *Marketable yield of lettuce [pcs/ha] – average of 2009 and 2011*

CONCLUSIONS

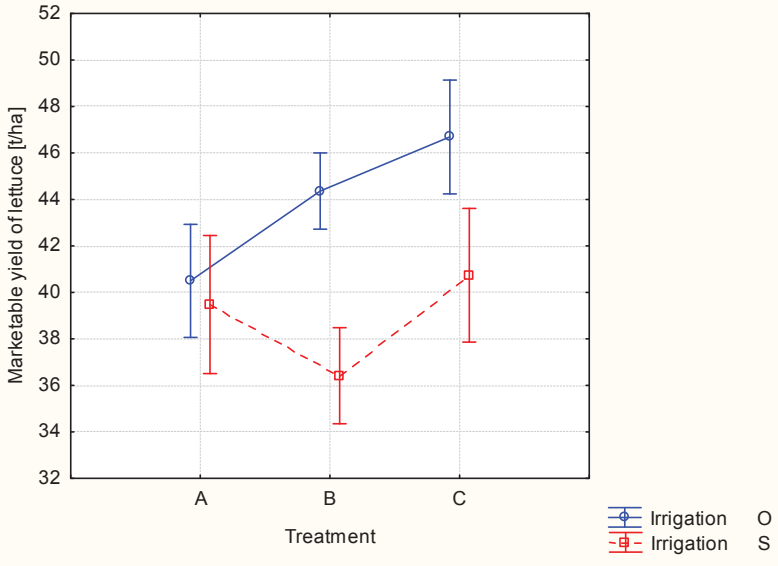
Influence of 24-epibrassinolide on single lettuce head weight was not significant, in some variants was evident decrease of head weight after 24-epibrassinolide application.

Significant increase of marketable heads number and their percentages were noted after 24-epibrassinolide application. Increasing of marketable heads number was significant in optimal moisture conditions in variant B of 10 421 heads/ha (7.8%) and in variant C of 14 197 heads/ha (10.7%) compared with untreated variant A. This trend was not visible in reduced moisture conditions.

Nonsignificant increase of total marketable yield was noted after 24-epibrassinolide application, but significant increase of marketable heads number per hectare is more valuable for praxis.

Although no significant differences between ascorbic acid content in each irrigation variant were found, a higher ascorbic acid content (by 11.9% in variant C compared with control A) was confirmed after application of 24-epibrassinolide in the variant with lower levels of irrigation (S). Contrarily, decrease of ascorbic acid content (by 16.8% in variant C compared with control A) was found in the optimal levels of irrigation (O).

The influence of 24-epibrassinolide application on the nitrate content was not significant, but the trend of nitrates decrease was evident in optimal irrigation conditions.

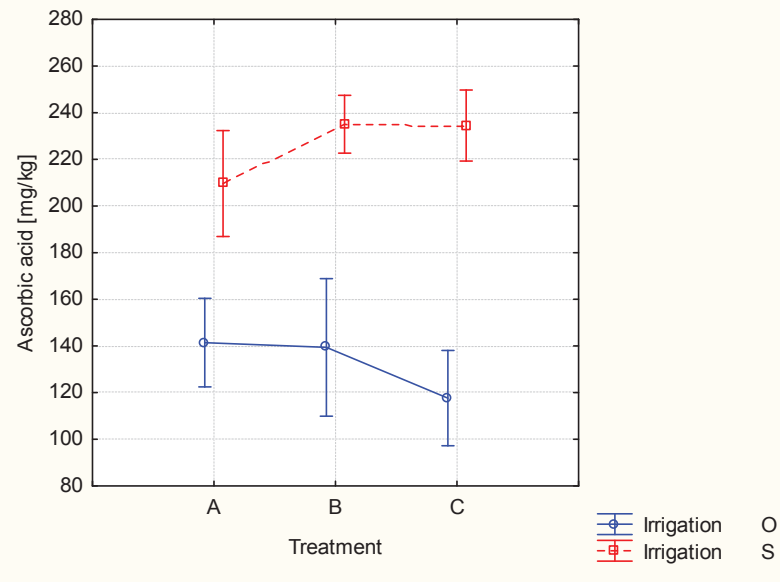


4: *Marketable yield of lettuce [t/ha] – average of 2009 and 2011*

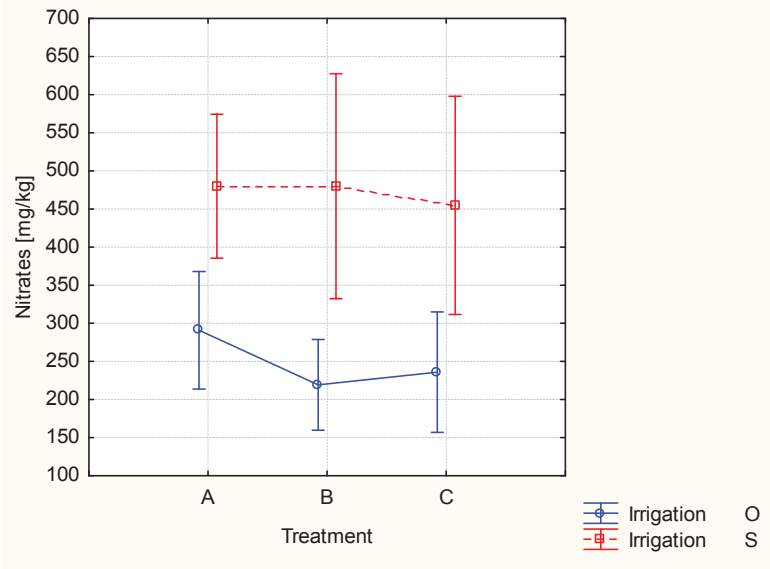
II: *Average values of ascorbic acid and nitrates content*

Year	Irrigation	Treatment	Ascorbic acid [mg/kg]	Nitrates [mg/kg]
2009	O	A	149.9^{abc}	487.3^{d}
		B	182.3^{abcd}	394.4^{cd}
		C	149.9^{abc}	478.2^{d}
	S	A	173.1^{abcd}	711.3^{f}
		B	245.4^{bcd}	936.0^{e}
		C	231.2^{bcd}	897.9^{e}
The significant differences (P < 0.05) between average values are indicated in the column above by various letters (LSD test).				
2011	O	A	135.1^{a}	143.6^{ab}
		B	118.1^{a}	131.7^{ab}
		C	101.6^{a}	114.9^{b}
	S	A	246.2^{d}	248.7^{ac}
		B	229.9^{bcd}	251.8^{ac}
		C	236.2^{cd}	233.2^{ab}
The significant differences (P < 0.05) between average values are indicated in the column above by various letters (LSD test).				
Average	O	A	141.5^{a}	290.9^{a}
		B	139.4^{a}	219.3^{a}
		C	117.7^{a}	236.0^{a}
	S	A	209.6^{b}	480.0^{b}
		B	235.1^{b}	479.9^{b}
		C	234.5^{b}	454.8^{b}
The significant differences (P < 0.05) between average values are indicated in the column above by various letters (LSD test).				

The obtained results indicated, that use of 24-brassinolide can be recommended only for good moisture conditions (statistically significant increase in quality) in praxis. 24-epibrassinolide treatment is not able to compensate the water deficit in insufficient moisture conditions.



5: *Ascorbic acid content in lettuce [mg/kg] – average of 2009 and 2011*



6: *Nitrate content [mg/kg] – average of 2009 and 2011*

SUMMARY

The aim of this work was evaluation of influence 24-epibrassinolide on yield and quality of head lettuce in different moisture conditions. Field trials were carried out on CULS Prague – Troja in 2009 and 2011. Package seedlings of head lettuce (cultivar Santoro – Rijk Zwaan) were used (spacing 0.30 × 0.25 m). Irrigation was carried out by microspraying and was based on current values of efficient water capacity – EWC (80% for optimal and 50% for limited irrigation). There were three treatments of 24-epibrassinolide in each moisture variant: A – no application, B – 1 × application immediately after outplanting, and C – 2 × application (1st application like in B and then after 14 days after 1st application). Observed parameters: weight of single heads, marketable heads (%), marketable yield (in pcs/ha and t/ha) and ascorbic acid and nitrate contents. Influence of 24-epibrassinolide on single lettuce head weight was not significant. Significant increase of marketable heads number and their percentages were noted after 24-epibrassinolide application in optimal moisture conditions – in variant B by 12 261 heads/ha (11.1%) and in variant C of 16 279 heads/ha (14.7%) compared with non treated variant A. This differences was not significant in reduced moisture conditions. Differences among marketable yields in t/ha were not significant. No significant differences were among the

ascorbic acid contents, but there is evident the higher content (11.9% in variant C compared with A) in the variant with limited irrigation and decrease of ascorbic acid content (16.8% in variant C compared with A) in the optimal moisture conditions after application of 24-epibrassinolide. The influence of 24-epibrassinolide on the nitrate content was not significant, but the trend of nitrates decrease was evident in optimal moisture conditions after 24-epibrassinolide treatment.

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