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LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

The Response of Baby Leaf Lettuce to Selenium Biofortification under Different Lighting Conditions

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Introduction

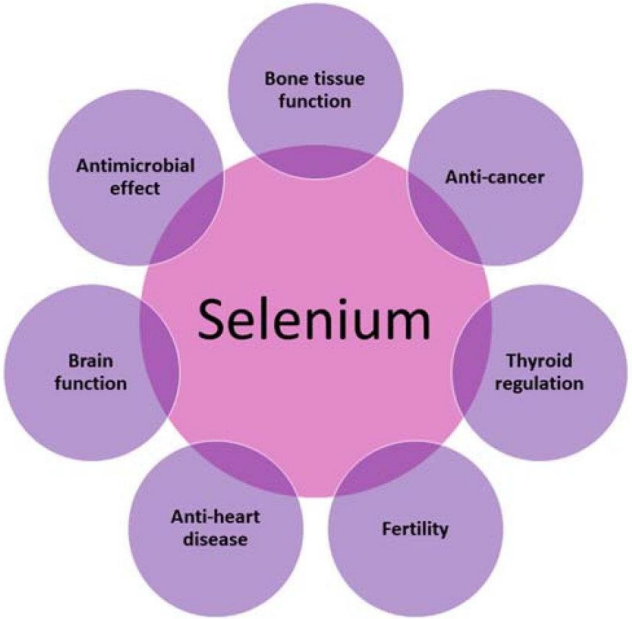

Figure 1. The health benefits of selenium. Source: Crystals 2018, 8, 188; doi:10.3390/cryst8050188

Introduction

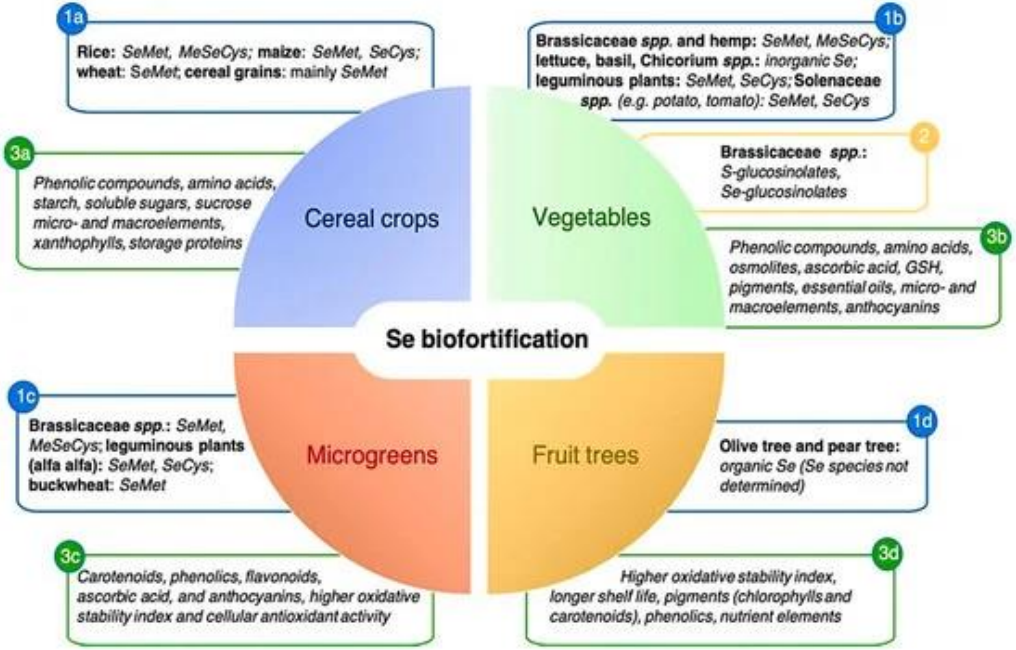

Figure 2. Se biofortification to improve human plant-foods. Source: Molecules, 2021, 26, 881. https://doi.org/ 10.3390/molecules26040881

Introduction

The aim of study was to determine the responses of baby leaf lettuce to various Se doses in hydroponic solution at different ratio of blue and red light in light-emitting diodes lighting.

Materials and Methods

- **Lettuce** (*Lactuca sativa*, 'Little Gem') (CN Seeds, United Kingdom)
- **Lighting**: blue (B - 447 nm) and red (R - 660 nm) light-emitting diodes (LED) ratios: 10%B:90%R, 75%B:25%R (treatments code B10R90, B75R25)
- **Se doses - natrium selenate (Na_2SeO_4):**
  - EXP1 - Se of 0, 1, 3 ppm were applied at 11th DAS (days after sowing)
  - EXP2 - Se of 0, 0.5, 1 ppm were applied at 11th DAS and 17th DAS
- **Nutrient solution [mg L^{-1}]**: N, 120; P, 20; K, 128; Ca, 88; Mg, 40; S, 53; Fe, 1.6; Mn, 0.08; Cu, 0.08; B, 0.16; Zn, 0.8; Mo, 0.2

Results - growth

EXP1

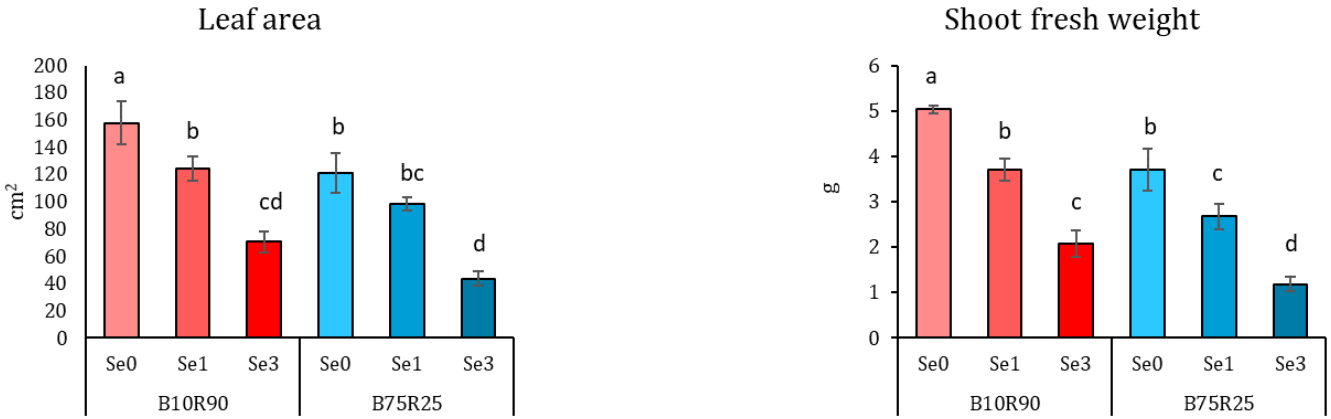

Figure 3. Effect of different blue-red light ratio in LED lighting and selenium doses on growth parameter of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

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Results - growth

EXP2

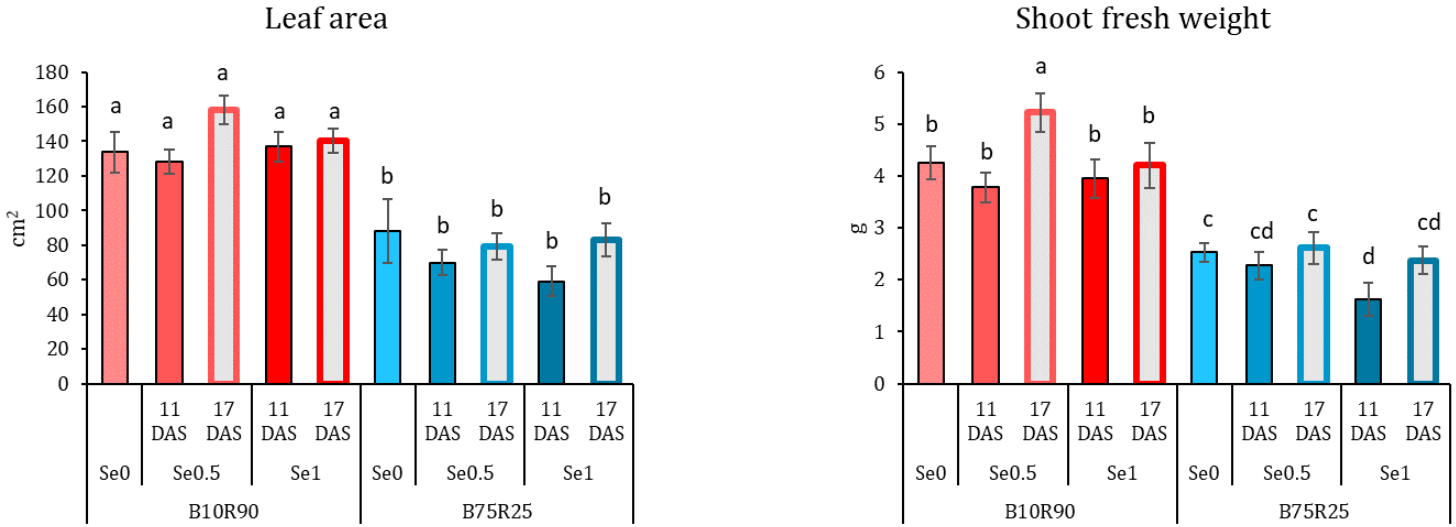

Figure 4. Effect of different blue-red light ratio in LED lighting, selenium doses and their application time on growth parameter of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. DAS – days after sowing. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

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Results – photosynthetic rate, chlorophyll and flavonols index

EXP1

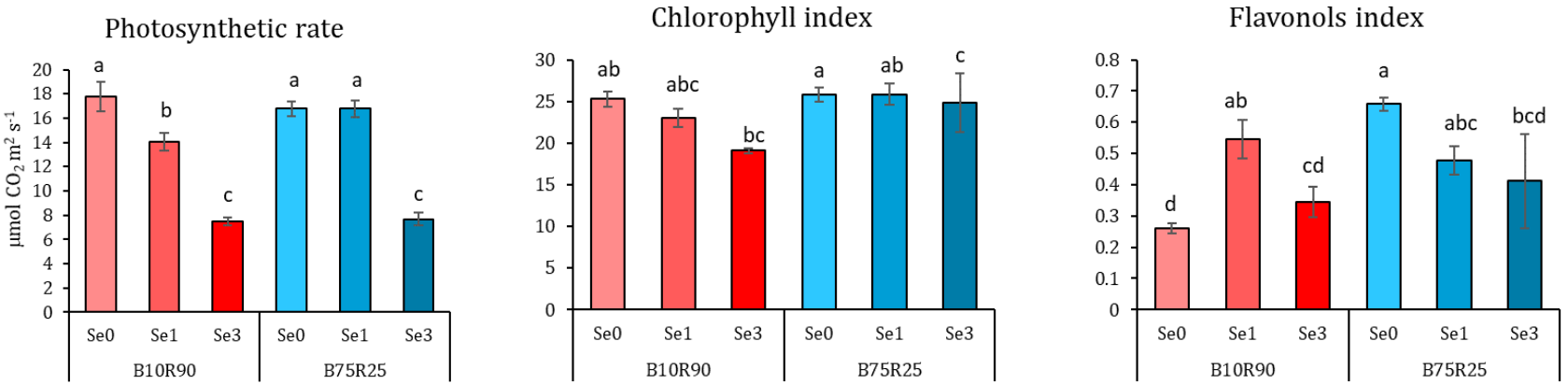

Figure 5. Effect of different blue-red light ratio in LED lighting and selenium doses on photosynthetic rate, chlorophyll and flavonols indexes of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

Results – photosynthetic rate, chlorophyll and flavonols index

EXP2

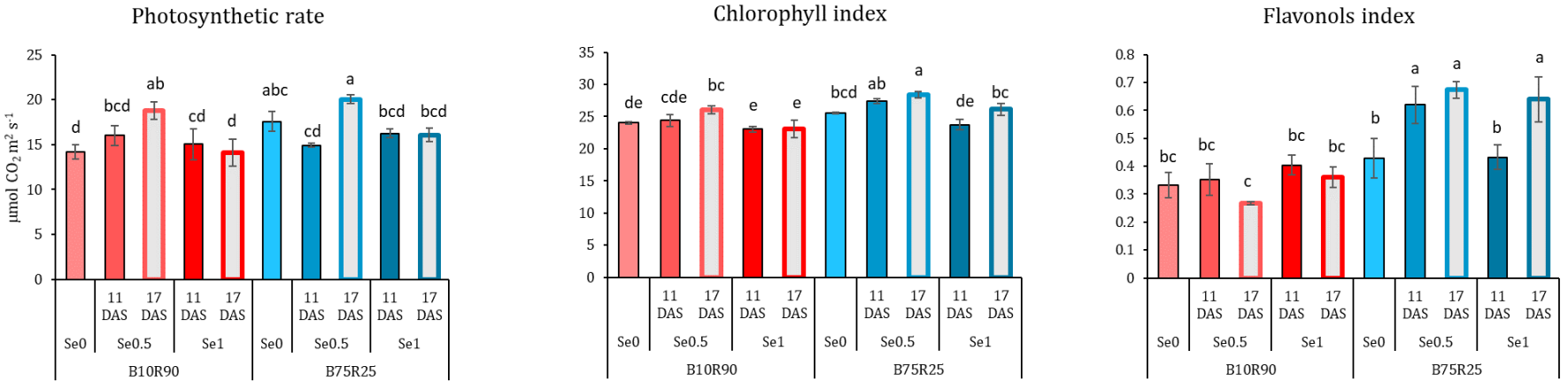

Figure 6. Effect of different blue-red light ratio in LED lighting, selenium doses and their application time on photosynthetic rate, chlorophyll and flavonols indexes of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. DAS – days after sowing. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

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Results – mineral nutrients

EXP1

Variables	Treatment					
	B10R90			B75R25		
	Se0	Se1	Se3	Se0	Se1	Se3
P	6.37±0.70^{d}	8.95±1.69^{bc}	7.61±0.31^{cd}	14.47±0.61^{a}	14.36±0.45^{a}	10.13±0.75^{b}
K	12.75±0.36^{d}	15.67±0.27^{c}	21.38±0.32^{b}	22.09±0.21^{b}	21.96±0.26^{b}	27.05±1.07^{a}
Ca	2.53±0.87^{c}	5.96±2.11^{b}	8.95±0.16^{a}	10.14±0.21^{a}	10.34±0.13^{a}	9.67±0.64^{a}
Mg	2.31±0.41^{d}	3.23±0.32^{c}	4.48±0.14^{ab}	4.23±0.03^{b}	4.29±0.08^{b}	4.96±0.25^{a}
S	0.76±0.04^{ab}	0.72±0.09^{b}	0.88±0.06^{a}	0.48±0.01^{c}	0.48±0.02^{c}	0.68±0.04^{b}
Mn	0.021±0.004^{c}	0.031±0.007^{bc}	0.035±0.004^{b}	0.049±0.0.002^{a}	0.050±0.004^{a}	0.048±0.002^{a}
Fe	0.046±0.007^{c}	0.081±0.033^{bc}	0.098±0.011^{abc}	0.123±0.010^{ab}	0.140±0.026^{ab}	0.160±0.034^{a}
Zn	0.037±0.002^{c}	0.064±0.018^{b}	0.066±0.002^{b}	0.100±0.005^{a}	0.101±0.002^{a}	0.081±0.004^{ab}

Table 1. Effect of different blue-red light ratio in LED lighting and selenium doses on mineral nutrients content of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

Results – mineral nutrients
EXP2

Variables	Treatment									
	B10R90					B75R25				
	Se0	Se0.5		Se1		Se0	Se0.5		Se1	
		11 DAS	17 DAS	11 DAS	17 DAS		11 DAS	17 DAS	11 DAS	17 DAS
P	12.12±0.17^{cd}	12.55±0.27^{c}	10.31±0.23^{e}	10.99±0.48^{cde}	10.97±0.61^{de}	14.23±0.26^{b}	16.03±0.99^{a}	15.77±0.63^{ab}	11.29±0.14^{cde}	16.06±1.00^{a}
K	21.91±057^{ab}	22.04±0.63^{ab}	20.91±0.14^{b}	21.43±0.70^{ab}	21.46±0.96^{ab}	23.21±0.39^{a}	22.72±0.43^{ab}	22.84±1.54^{ab}	23.10±0.80^{a}	23.30±0.57^{a}
Ca	8.99±0.86^{bcd}	9.37±0.08^{bc}	7.89±0.05^{d}	8.29±0.37^{cd}	7.92±0.37^{d}	9.95±0.50^{ab}	11.16±0.27^{a}	11.17±0.19^{a}	8.61±0.43^{bcd}	11.31±0.48^{a}
Mg	3.68±0.30^{bc}	3.78±0.11^{abc}	3.55±0.07^{bc}	3.40±0.01^{c}	3.32±0.11^{c}	4.12±0.27^{ab}	4.19±0.13^{ab}	4.41±0.32^{a}	4.14±0.19^{ab}	4.41±0.25^{a}
S	0.44±0.02^{cd}	0.46±0.01^{bcd}	0.40±0.01^{d}	0.44±0.01^{bcd}	0.48±0.01^{bcd}	0.67±0.05^{a}	0.52±0.03^{bc}	0.52±0.05^{bc}	0.52±0.05^{bc}	0.54±0.01^{b}
Mn	0.050±0.008^{abc}	0.043±0.001^{abc}	0.041±0.001^{bc}	0.042±0.003^{bc}	0.040±0.002^{c}	0.053±0.004^{abc}	0.062±0.003^{a}	0.059±0.011^{abc}	0.049±0.003^{ab}	0.059±0.015^{ab}
Fe	0.14±0.05^{a}	0.15±0.01a	0.12±0.02^{a}	0.15±0.05^{a}	0.10±0.01^{a}	0.15±0.02^{a}	0.20±0.03^{a}	0.18±0.07^{a}	0.17±0.02^{a}	0.15±0.02^{a}
Zn	0.082±0.004^{bcd}	0.073±0.006^{d}	0.076±0.008^{d}	0.078±0.005^{cd}	0.071±0.004^{d}	0.094±0.004^{abc}	0.104±0.012^{a}	0.098±0.005^{ab}	0.074±0.003^{d}	0.095±0.006^{ab}

Table 2. Effect of different blue-red light ratio in LED lighting, selenium doses and their application time on mineral nutrients content of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. DAS – days after sowing. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

Results – Se, BCF_{Se}, TF_{Se}

EXP1

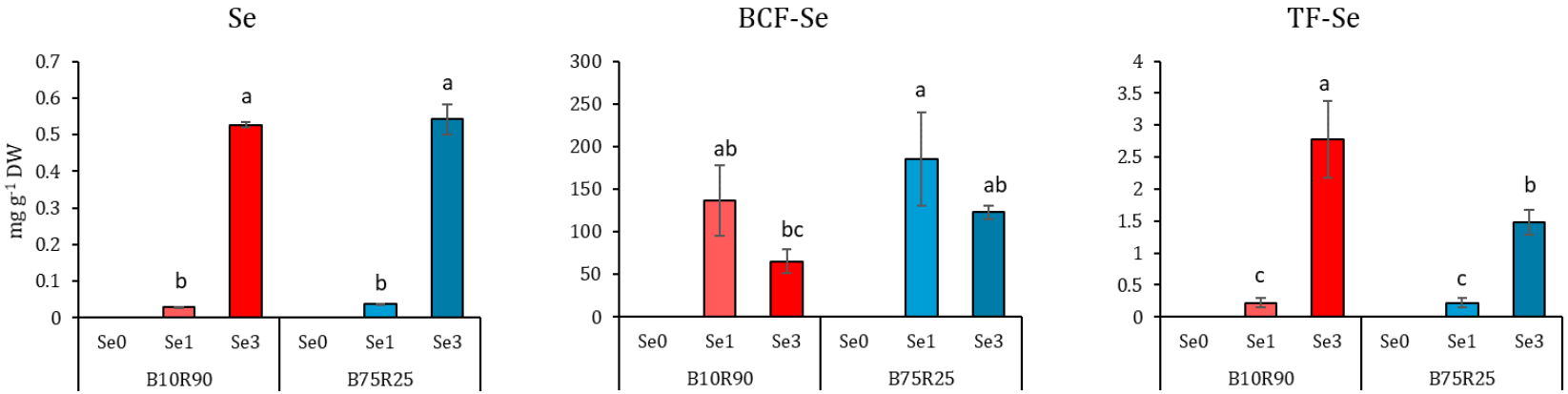

Figure 7. Effect of different blue-red light ratio in LED lighting and selenium doses on Se content, bioconcentration (BCF_{Se}) and translocation (TF_{Se}) factors of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

Results – Se, BCF_{Se}, TF_{Se}

EXP2

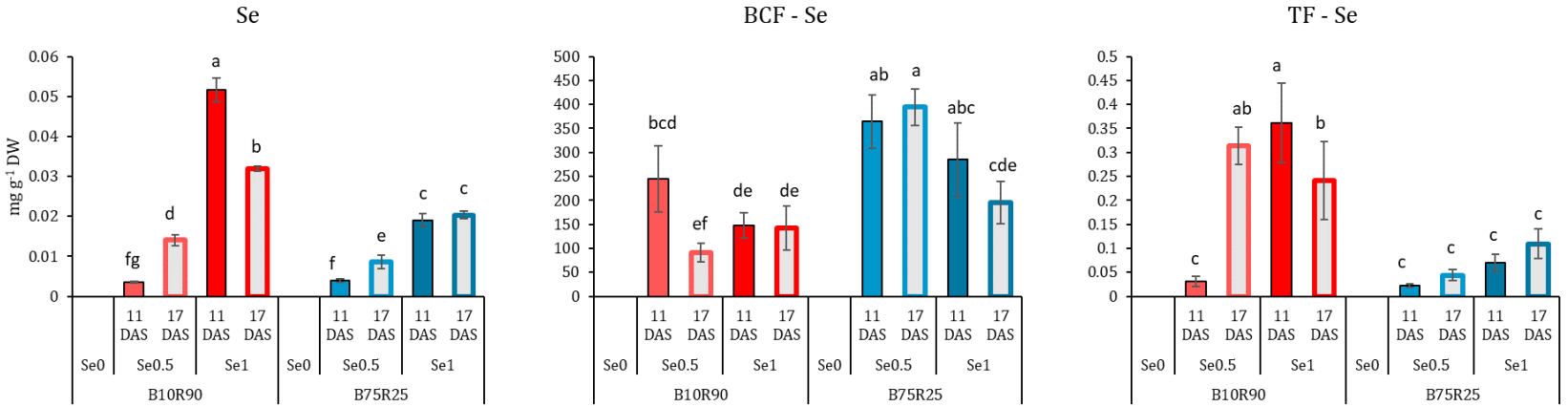

Figure 6. Effect of different blue-red light ratio in LED lighting, selenium doses and their application time on Se content, bioconcentration (BCF_{Se}) and translocation (TF_{Se}) factors of baby leaf lettuce. B10R90, B75R25 – a percentage of blue (B) and red (R) light. Se0, Se1, Se3 – selenium doses 0, 1, 3 ppm respectively. DAS – days after sowing. Means with different letters are significantly different at the $P < 0.05$ level by Tukey's honestly significant difference test.

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Conclusions

The content of Se in lettuce was the highest at 3 ppm under both blue and red light ratios. However, such a dose of Se inhibited the growth of lettuce and reduced the rate of photosynthesis and chlorophyll content. When 1 ppm Se was applied at 17th DAS under B:R ratios 10B:90R% , lettuce accumulated lower Se content compared to the 11th DAS, but this did not have a negative effect on their growth. Overall, these results suggest that properly composed doses of Se, LED lighting and application time could be suitable way for cultivation of selenium-biofortified baby leaf lettuces without any adverse effects on growth.

Funding

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