

THE EFFECT OF *TRICHODERMA* SPP. ON PHYSIOLOGICAL PARAMETERS OF TWO TOMATO CULTIVARS GROWN UNDER GREENHOUSE CONDITIONS

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INTRODUCTION

Fungi that belong to the genus *Trichoderma* colonize plant rhizosphere and are considered as good candidates for the use in environmentally friendly agriculture as plant growth promoters and biocontrol agents. In recent years, investigations are focused on the use of non-destructive characterization of plant responses to different abiotic and biotic stresses. Dualex sensor was used in order to pre-screen the reaction of tomato plants treated with different *Trichoderma* isolates, based on the previous investigations that imply that the positive effects of this fungi depend on the plant genotype.

METHODS

The experiment was conducted in a randomized block design under greenhouse conditions with two replicates. In total 30 plants of two tomato cultivars were transplanted in soil, per treatment: NC-control Narvik, GZC- control Gruzanski zlatni, NT1 - *T. harzianum*; NT2 - *T. brevicompactum*; NT3 - *T. harzianum* + *T. brevicompactum*; GZT1 - *T. harzianum*; GZT2 - *T. brevicompactum*; GZT3 - *T. harzianum* + *T. brevicompactum*. The suspensions of *Trichoderma* isolates were applied in the root zone of tomato plants, in the phase of three established leaves per plant. Measurements of chlorophyll (Chl), flavonols (Flav) and anthocyanins (Ant) content were done *in vivo* on fully developed leaves of the tomato plants, using Dualex optical sensor (Force-A, Orsay, France), once per week during 50 days of plant growth. NBI (Nitrogen Balance Index) was calculated as Chl/Flav ratio. Results were analyzed by one-way ANOVA followed by Tukey test ($p < 0.05$) (GraphPad Software 6.0, San Diego, CA)

RESULTS AND DISCUSSION

Results obtained in this experiment showed that in both cultivars, the content of chlorophyll did not change significantly after *Trichoderma* application (Table 1.). However, positive trend for Flav content was observed for the cultivar GZ in the treatment with T2 (Table 2.). In contrast, at the beginning of the experiment, NBI index decreased in GZ as influenced with T1 and T2 treatments, which could indicate a shift from primary to secondary metabolism in mentioned cultivar (Table 4.). Moreover, it could be noticed that during plant growth content of anthocyanin decreased in both control and *Trichoderma* treatment conditions (Table 3.).

Table 1. Relative Chl content of tomato genotypes grown under different *Trichoderma* treatments: NC-control Narvik, GZC- control Gruzanski zlatni, NT1 - *T. harzianum*; NT2 - *T. brevicompactum*; NT3 - *T. harzianum* + *T. brevicompactum*; GZT1 - *T. harzianum*; GZT2 - *T. brevicompactum*; GZT3 - *T. harzianum* + *T. brevicompactum*.

No. of week	Narvik				Gruzanski zlatni			
	K	T1	T2	T3	K	T1	T2	T3
1	15.42±2.35 ^a	16.49±3.96 ^a	17.00±3.49 ^a	15.32±3.41 ^a	20.16±5.09 ^a	16.35±7.27 ^a	17.365±8.19 ^a	18.815±4.03 ^a
2	17.07±1.99 ^a	15.85±2.13 ^a	17.28±1.47 ^a	17.21±2.40 ^a	17.39±1.69 ^a	18.77±2.40 ^a	15.748±2.36 ^b	16.044±3.98 ^a
3	17.73±3.76 ^b	19.79±5.17 ^{ab}	18.43±2.44 ^{ab}	21.04±2.25 ^a	19.82±2.51 ^a	19.65±2.87 ^{abc}	17.742±1.67 ^c	19.936±2.608 ^{ab}
4	23.38±3.16 ^a	24.15±3.03 ^a	23.52±2.95 ^a	24.23±1.97 ^a	23.03±1.84 ^a	22.257±2.33 ^a	23.893±3.69 ^a	22.302±1.83 ^a
5	27.68±3.27 ^{ab}	25.43±2.39 ^b	28.83±3.11 ^a	28.01±2.65 ^a	27.48±3.39 ^a	27.140±3.55 ^a	26.835±2.35 ^a	25.931±2.162 ^a
6	29.01±1.89 ^a	25.08±3.85 ^b	29.13±1.80 ^a	29.31±2.43 ^a	30.02±3.52 ^a	28.246±3.57 ^a	27.257±6.17 ^a	28.771±3.12 ^a
7	26.17±2.73 ^c	22.51±2.84 ^b	27.41±3.89 ^{bc}	27.93±3.14 ^{bc}	28.17±2.62 ^a	25.560±2.07 ^{bc}	25.896±3.42 ^{bc}	26.212±2.80 ^{bc}

Means with the same letter in the same column are not significantly different from each other according to Tukey's test ($p < 0.05$). Error lines represent \pm standard deviation of the mean. Different letters (a, b, c) indicate statistically significant differences according to Tukey's test ($p < 0.05$).

Table 2. Relative Flav content of tomato genotypes grown under different *Trichoderma* treatments : NC-control Narvik, GZC- control Gruzanski zlatni, NT1 - *T. harzianum*; NT2 - *T. brevicompactum*; NT3 - *T. harzianum* + *T. brevicompactum*; GZT1 - *T. harzianum*; GZT2 - *T. brevicompactum*; GZT3 - *T. harzianum* + *T. brevicompactum*.

No. of week	Narvik				Gruzanski zlatni			
	K	T1	T2	T3	K	T1	T2	T3
1	0.39±0.08 ^a	0.43±0.11 ^a	0.54±0.21 ^b	0.55±0.17 ^a	0.49±0.15 ^a	0.64±0.20 ^a	0.48±0.21 ^a	0.43±0.20 ^{ab}
2	0.53±0.13 ^b	0.74±0.17 ^a	0.73±0.17 ^{ab}	0.69±0.12 ^a	0.65±0.09 ^b	0.81±0.14 ^a	0.87±0.19 ^a	0.73±0.15 ^b
3	0.65±0.14 ^a	0.68±0.19 ^a	0.80±0.26 ^a	0.72±0.19 ^a	0.68±0.15 ^a	0.80±0.16 ^a	0.77±0.16 ^a	0.77±0.18 ^a
4	0.62±0.15 ^b	0.77±0.13 ^a	0.89±0.16 ^a	0.80±0.15 ^a	0.81±0.14 ^a	0.83±0.17 ^a	0.84±0.16 ^a	0.84±0.12 ^a
5	0.51±0.09 ^b	0.55±0.11 ^{bc}	0.68±0.11 ^a	0.64±0.17 ^{bc}	0.53±0.10 ^b	0.63±0.15 ^c	0.74±0.12 ^a	0.65±0.09 ^{bc}
6	0.46±0.10 ^b	0.58±0.14 ^b	0.74±0.15 ^a	0.74±0.19 ^a	0.62±0.11 ^a	0.69±0.17 ^a	0.71±0.17 ^a	0.64±0.10 ^a
7	0.52±0.12 ^b	0.63±0.15 ^{ab}	0.75±0.18 ^{ab}	0.75±0.16 ^a	0.60±0.15 ^b	0.73±0.15 ^{ab}	0.79±0.18 ^a	0.67±0.13 ^{ab}

Means with the same letter in the same column are not significantly different from each other according to Tukey's test ($p < 0.05$). Error lines represent \pm standard deviation of the mean. Different letters (a, b, c) indicate statistically significant differences according to Tukey's test ($p < 0.05$).

Table 3. Relative Anth content of tomato genotypes grown under different *Trichoderma* treatments : NC-control Narvik, GZC- control Gruzanski zlatni, NT1 - *T. harzianum*; NT2 - *T. brevicompactum*; NT3 - *T. harzianum* + *T. brevicompactum*; GZT1 - *T. harzianum*; GZT2 - *T. brevicompactum*; GZT3 - *T. harzianum* + *T. brevicompactum*.

No. of week	Narvik				Gruzanski zlatni			
	K	T1	T2	T3	K	T1	T2	T3
1	0.101±0.017 ^a	0.101±0.012 ^a	0.094±0.022 ^a	0.097±0.022 ^a	0.078±0.020 ^a	0.088±0.024 ^a	0.092±0.028 ^a	0.075±0.034 ^a
2	0.092±0.011 ^a	0.095±0.009 ^a	0.094±0.009 ^a	0.088±0.014 ^a	0.083±0.011 ^c	0.086±0.014 ^c	0.104±0.010 ^b	0.093±0.013 ^b
3	0.097±0.012 ^a	0.093±0.024 ^a	0.102±0.015 ^a	0.091±0.019 ^a	0.092±0.014 ^a	0.092±0.013 ^a	0.101±0.009 ^a	0.089±0.011 ^b
4	0.066±0.015 ^b	0.065±0.018 ^b	0.081±0.014 ^a	0.075±0.016 ^a	0.080±0.016 ^a	0.082±0.008 ^a	0.076±0.014 ^a	0.081±0.014 ^a
5	0.077±0.012 ^a	0.082±0.011 ^a	0.064±0.016 ^b	0.060±0.012 ^c	0.050±0.012 ^b	0.072±0.014 ^a	0.070±0.009 ^a	0.064±0.009 ^a
6	0.037±0.012 ^b	0.057±0.016 ^b	0.052±0.011 ^a	0.050±0.012 ^a	0.042±0.011 ^a	0.055±0.015 ^a	0.055±0.020 ^a	0.051±0.025 ^a
7	0.059±0.017 ^b	0.072±0.016 ^a	0.064±0.019 ^a	0.061±0.012 ^a	0.053±0.014 ^b	0.070±0.011 ^a	0.070±0.014 ^a	0.068±0.020 ^a

Means with the same letter in the same column are not significantly different from each other according to Tukey's test ($p < 0.05$). Error lines represent \pm standard deviation of the mean. Different letters (a, b, c) indicate statistically significant differences according to Tukey's test ($p < 0.05$).

Table 4. NBI content of tomato genotypes grown under different *Trichoderma* treatments : NC-control Narvik, GZC- control Gruzanski zlatni, NT1 - *T. harzianum*; NT2 - *T. brevicompactum*; NT3 - *T. harzianum* + *T. brevicompactum*; GZT1 - *T. harzianum*; GZT2 - *T. brevicompactum*; GZT3 - *T. harzianum* + *T. brevicompactum*.

No. of weeks	Narvik				Gruzanski zlatni			
	K	T1	T2	T3	K	T1	T2	T3
1	43.50±6.34 ^a	41.66±16.38 ^a	34.92±11.55 ^{ab}	26.71±6.89 ^b	44.16±17.03 ^{ab}	27.56±14.17 ^b	49.07±32.29 ^a	50.03±30.21 ^a
2	34.99±13.22 ^a	22.18±5.24 ^b	25.17±6.30 ^b	25.61±5.91 ^b	27.56±6.14 ^a	24.01±5.52 ^a	18.82±4.40 ^b	23.22±8.11 ^{ab}
3	29.01±9.91 ^a	32.85±19.20 ^a	27.11±14.26 ^a	31.59±10.26 ^a	31.35±10.21 ^a	25.75±7.79 ^a	23.85±4.99 ^a	28.60±13.44 ^a
4	40.47±12.85 ^a	32.57±8.82 ^b	27.47±6.59 ^b	31.23±6.33 ^b	29.34±5.94 ^a	28.54±9.97 ^a	29.57±7.26 ^a	27.14±4.56 ^a
5	56.10±12.63 ^a	48.29±10.81 ^{ab}	43.59±9.79 ^b	47.83±17.11 ^{ab}	54.19±16.24 ^a	47.18±20.45 ^a	37.17±6.87 ^b	40.81±6.65 ^b
6	66.52±15.19 ^a	47.30±12.98 ^b	40.99±8.56 ^b	42.71±14.02 ^b	51.10±14.62 ^a	43.97±13.86 ^a	43.63±31.73 ^a	46.58±11.73 ^a
7	52.13±13.17 ^a	38.05±11.61 ^b	40.23±16.04 ^b	38.99±9.65 ^b	50.35±16.72 ^a	37.33±11.24 ^b	35.01±12.44 ^b	41.14±11.48 ^a

Means with the same letter in the same column are not significantly different from each other according to Tukey's test ($p < 0.05$). Error lines represent \pm standard deviation of the mean. Different letters (a, b, c) indicate statistically significant differences according to Tukey's test ($p < 0.05$).

CONCLUSIONS

In conclusion, we can suggest that use of non-destructive measurements with Dualex sensor could serve as starting point to better understanding of plant responses to *Trichoderma* presence. Moreover, measurements with Dualex can serve as a pre-screening method for testing the effect of larger number of *Trichoderma* isolates and their effect on more different tomato genotypes.