The response of drought-stressed green pea (*Pisum sativum* L.) to boron nanoparticle application

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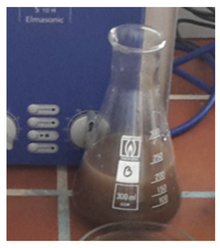
INTRODUCTION

Maintaining pea-growing areas is becoming increasingly difficult because they are highly sensitive to environmental stresses, especially drought. Green peas (Pisum sativum L.) are a very important source of amino acids in the diet of humans, poultry, and livestock nutrition, as well as in crop rotation. To reduce the potential adverse effects of drought on peas, this study aimed to investigate the effects of different concentrations of boron nanoparticles (B NPs) on plants via different routes of exposure: through leaves spraying and root watering.

METHODS

The research was carried out in a greenhouse, 10 green pea seeds ('Respect') were sown in 10 L vegetative pots and were thinned up to 7 plants per pot after germination. When the peas reached the 39 BBCH growth stage (had 9 or more visibly extended internodes) they were foliar sprayed to full wetness (ca. 14±0.5 mL plant−1) or watered (100±1 mL per pot) with suspensions containing different concentrations of B NPs: 0 (watered or sprayed with distilled water), 0.0125, 0.025, and 0.05 mg mL-1 During the 10-day drought period, low substrate moisture (30%) was maintained for peas exposed to B NPs, other plants (controls) were grown under normal substrate moisture (80%). At the end of the experiment, peas were harvested to assess the interactive effects of B NPs and drought on plants growth and enzymatic (SOD, GR, APX) and non-enzymatic (TPC, FRAP) antioxidants activity.



1 Picture: Concentrated suspension of Boron. nanoparticles.

2 Picture: Vegetation pots in greenhouse.

2019	Temperature, C^0		Humidity, %	
	Day	Night	Day	Night
Before drought	24.2	14.4	54.1	75.3
During drought	26.2	17	50.1	73.2
After drought	26.7	16.6	52.8	73.5

Table 1. Temperature and humidity in greenhous during eksperiment.

CONCLUSION

In general B NPs protected green peas from the adverse effects of drought stress if the appropriate concentration and application to the plant were selected.

RESULTS

The results showed that foliar spraying or watering at a concentration of 0.05 mg L-1 B NPs had a strong positive effect on pea leaf area, shoot height, fresh biomass, root length, and the number of nodules when plants grown in drought conditions. Positive effects on the activity of enzymatic (SOD, GR, APX) and non-enzymatic (TPC, FRAP) antioxidants in the pea plant were found.

Suspension of B NPs of 50 ppm concentration	
Zeta potential (ζ; mV)	-28.54 ± 0,359
Polydispersity index (PDI)	0.237

Table 2. Properties of B NPs suspension in DI water.

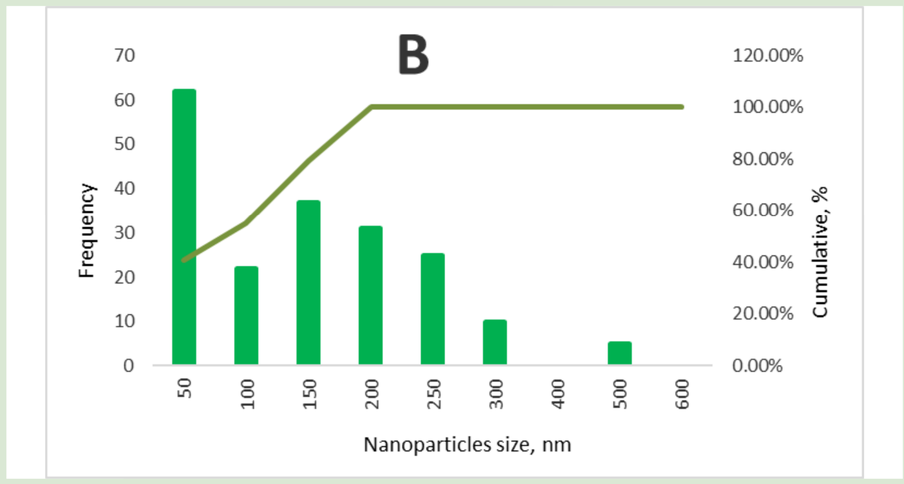


Figure 1. Size distribution of B nanoparticles in DI water.

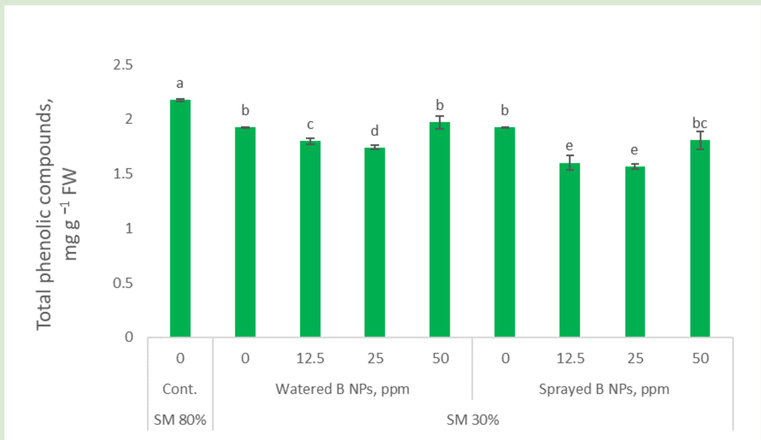


Figure 2. Influence of drought stress and B NPs (0; 12,5; 25; 50 ppm) on total phenolic compounds in *P. sativum* L. Cont. – control plants, substrate moisture (SM) 80%; drought stress – SM 30%. Values are mean ± SE of three replicates and different letters are differed significantly by Tukey HSD Test (P < 0.001).

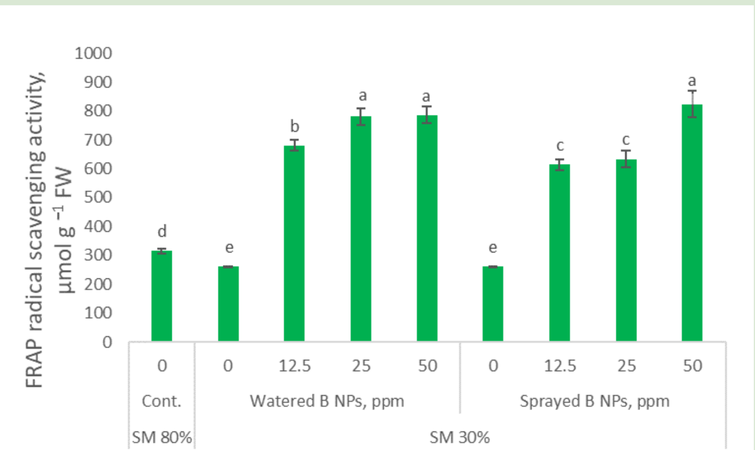


Figure 3. Influence of drought stress and B NPs (0; 12,5; 25; 50 ppm) on FRAP radical scavenging activity in *P. sativum* L. Cont. – control plants, substrate moisture (SM) 80%; drought stress – SM 30%. Values are mean ± SE of three replicates and different letters are differed significantly by Tukey HSD Test (P < 0.001).

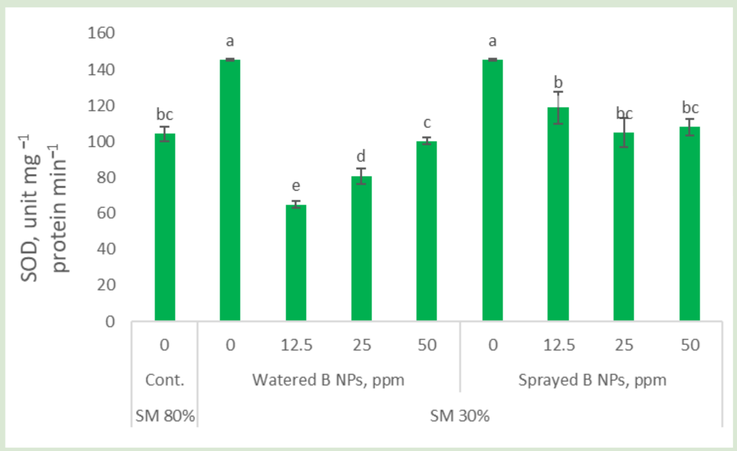


Figure 4. Response of (a), superoxide dismutase (SOD) activity to drought stress and B NPs (0; 12,5; 25; 50 ppm) in *P. sativum* L. Cont. – control plants, substrate moisture (SM) 80%; drought stress – SM 30%. Values are mean ± SE of three replicates and different letters are differed significantly by Tukey HSD Test (P < 0.001).

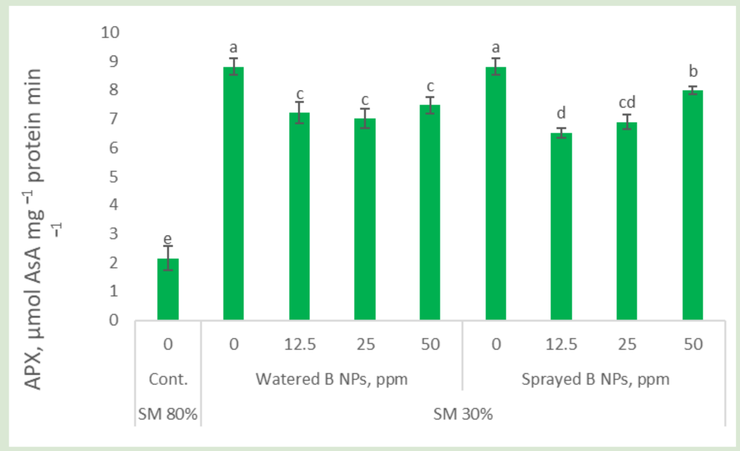


Figure 5. Response of ascorbate peroxidase (APX) activity to drought stress and B NPs (0; 12,5; 25; 50 ppm) in *P. sativum* L. Cont. – control plants, substrate moisture (SM) 80%; drought stress – SM 30%. Values are mean ± SE of three replicates and different letters are differed significantly by Tukey HSD Test (P < 0.001).

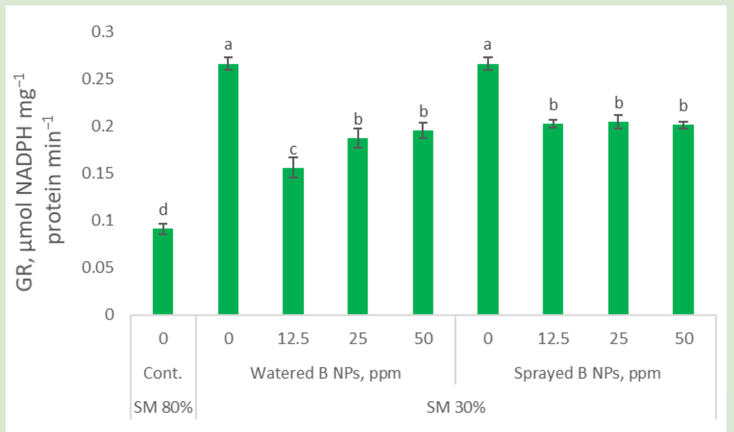


Figure 6. Response of glutathione re-ductase (GR) activity to drought stress and B NPs (0; 12,5; 25; 50 ppm) in *P. sativum* L. Cont. – control plants, substrate moisture (SM) 80%; drought stress – SM 30%. Values are mean ± SE of three replicates and different letters are differed significantly by Tukey HSD Test (P < 0.001).

3 Picture: Differences between pea plants after drought and exposure to B NPs.

Acknowledgments: R.S. is thankful to the Lithuanian Research Centre for Agriculture and Forestry for the opportunity to work with nanoparticles and for donated green pea "Respect" seeds. The authors are also grateful to Joana Bendoraitienė from the Kaunas University of Technology for measuring the size and zeta potential of nanoparticle suspension.