THE EFFECTS OF SELECTIVE HERBICIDE AND CONSEQUENT WATERLOGGING ON WHEAT

Zornitsa Katerova, Elena Shopova, Liliana Brankova, Ljudmila Dimitrova, Iskren Sergiev, Dessislava Todorova

Institute of Plant Physiology and Genetics, Bulgarian Academy of Science,

Sofia, Bulgaria

Water stress in wheat

- Most crops are selected for high yields thus being sensitive to different stresses (Mustroph, 2018). Wheat is rather waterlogging-sensitive.
- Flooding resulted of soil erosion, bad soil drainage, or sudden and heavy rainfall (including long lasting) due to storms, dam damages, etc.
- Flooding could be classified as: 1) waterlogging (only the root system inside the soil is affected); and 2) submergence (parts or the whole are also under water).
- Annual yield losses in wheat due to waterlogging was reported as 15–20% (Herzog et al. 2016, Sayre et al. 1994; Setter & Waters 2003).
- Waterlogging affects important soil physiochemical properties such as pH, redox potential and oxygen access.
- Plants grown on such soil suffer from negative developmental conditions such as hypoxia (O_2 insufficiency) or anoxia (lack of O_2) and oxidative stress, leading to impeded growth, survival and significant harvest losses.

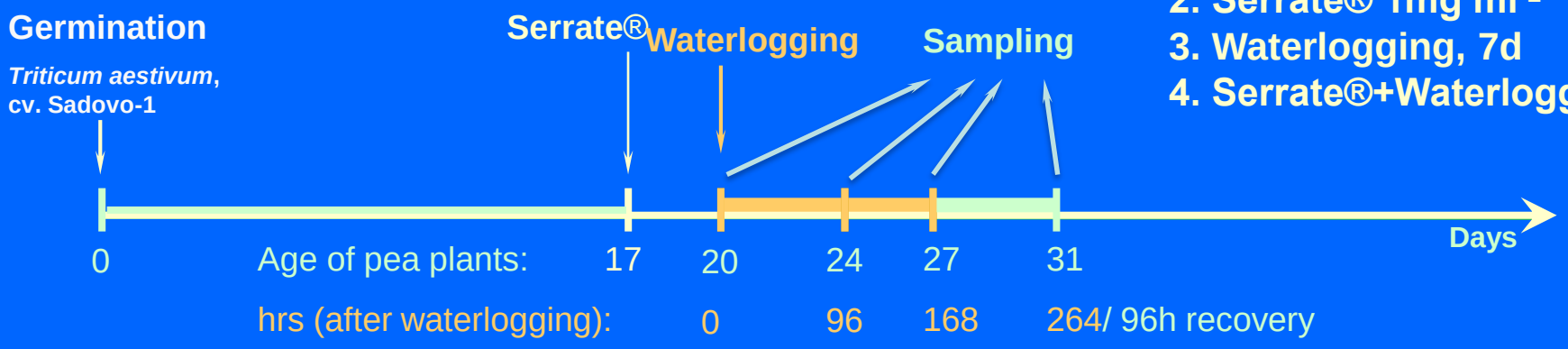
Herbicides

- Herbicides usage in moderation play important role in commercial agriculture to control weed growth.
- Due to their mechanism of action four major categories are known: affecting photosynthesis or photosynthesis related pigments; auxin-type; inhibitors of amino acid biosynthesis; and inhibitors of fatty acid biosynthesis
- Due to plant sensitivity herbicides are classified as selective (affect certain types of plant species) and total (affect all plant species).
- Serrate® (Syngenta, Bulgaria) contains clodinafop-propargyl (an inhibitor of fatty acid biosynthesis), pyroxsulam (an inhibitor of amino acid biosynthesis) and herbicide safener. It is systemic and selective for wheat, rye and triticale, which are tolerant to its composition.
- The dual composition of Serrate® caused its particular effectivity in wheat protection by controlling annual grass and broadleaf weeds and was chosen for our experimental design.

Model system

Variants:

1. **Control**
2. **Serrate® 1mg ml^{-1}**
3. **Waterlogging, 7d**
4. **Serrate®+Waterlogging**



Normal growth conditions:

- 16/8h photoperiod
- 150 µmol m^{-2} s^{-1}
- 22/19°C day/night temperatures

Measurements:

- Stress markers – H_2O_2, MDA, proline
- Non-enzymatic antioxidants: thiols, phenolics
- Defence enzymes: SOD, POX, CAT, GR

Waterlogging stress conditions:

- 16/8 h photoperiod
- 150 µmol m^{-2} s^{-1}
- 22/19°C day/night temperatures

Waterlogging:

✓72 hrs after herbicide treatment .

✓Pots were mounted in container filled with additional water supplying 2 cm higher water level than the soil (Yordanova et al., 2001)

Phenotype effects

96 h waterlogging

168 h waterlogging

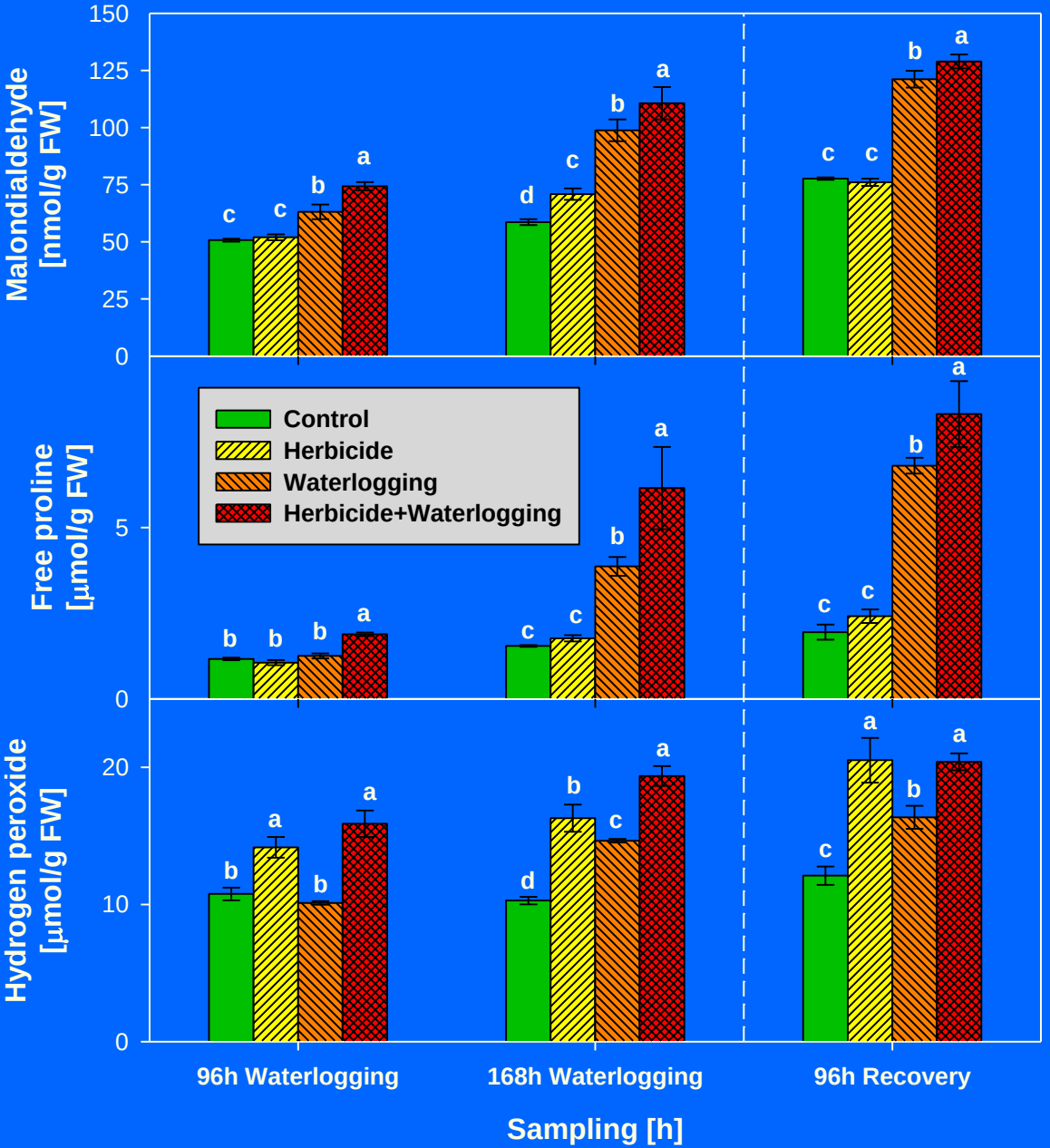
96 h recovery

Variants:

1. **Control**
2. **Serrate®**
3. **Waterlogging**
4. **Serrate®+Waterlogging**

The wilting and yellowing was most obvious after 96 h recovery in combined treatment.

Effects on stress markers



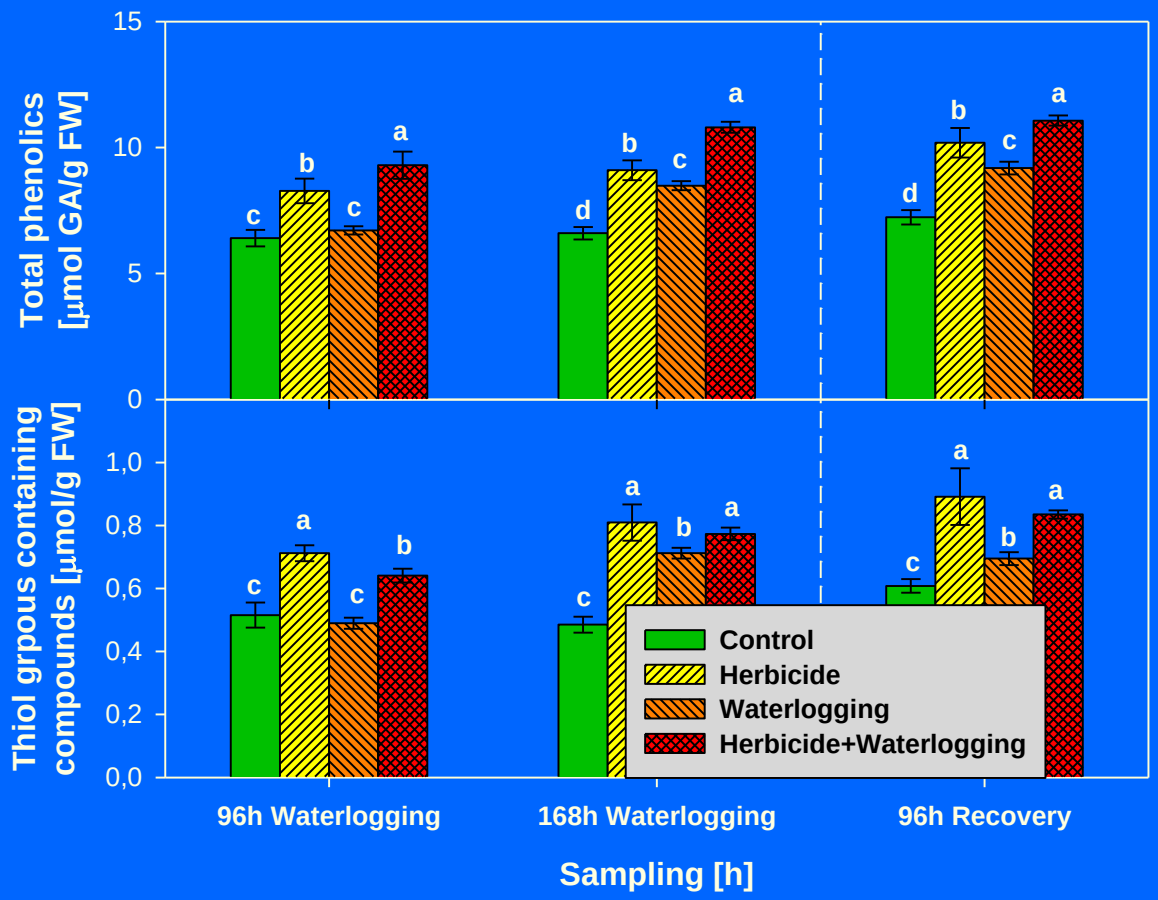
✓ **Herbicide kept high only H_2O_2 suggesting its signaling role.**

✓ **Waterlogging and combined treatment enhanced gradually the content of stress markers.**

✓ **The effect of combined treatment was stronger than waterlogging even after the recovery.**

Control values at 0 h
***MDA**: 57.2 ± 4.1 nmol/g FW;*
***Free proline**: 0.84 ± 0.04 µmol/g FW;*
***H_2O_2**: 6.6 ± 0.7 µmol/g FW;*

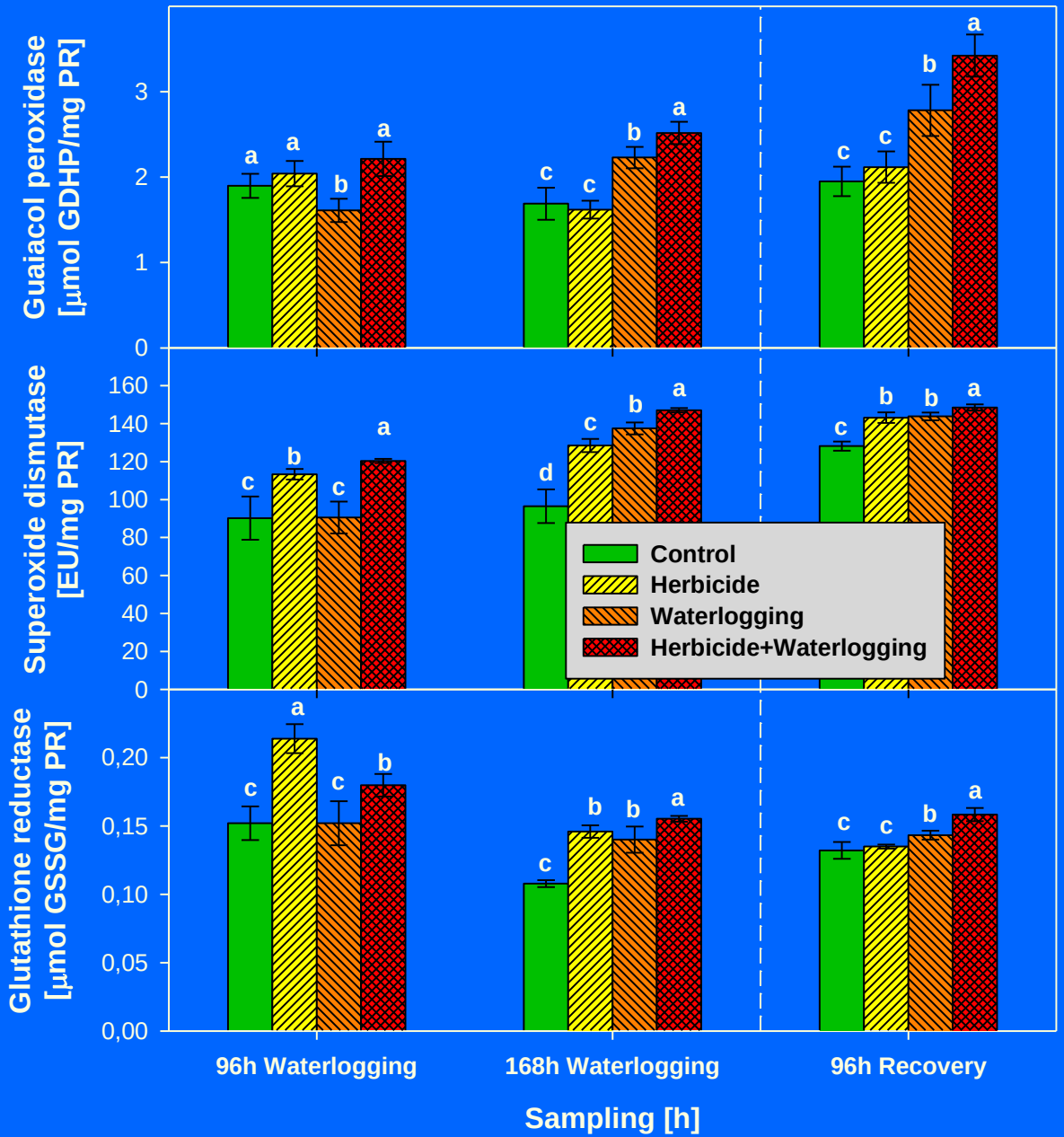
Effects on antioxidants



- ✓ **All treatments enhanced non-enzymatic antioxidants but waterlogging had lag-time.**
- ✓ **Thiols detect mainly glutathione expected to rise in Herbicide-treated plants as detoxification.**
- ✓ **Highest levels were recorded after combined treatment even in recovery period.**

Control values at 0 h
***Total phenolics**: 4.6± 0.22 µmol GA/g FW;*
***Thiol groups**: 0.375 ± 0.015 µmol/g FW;*

Effects on antioxidative enzymes



- ✓ **Expectedly, herbicide increased GR .**
- ✓ **Herbicide led to fastest recovery but waterlogging delayed the enzymatic induction.**
- ✓ **The effect of combined treatment was stronger than waterlogging even during the recovery.**

Control values at 0 h
***POX**: 1.77 ± 0.19 µmol GDHP/mg protein;*
***SOD**: 60.3 ± 9.9 EU/mg protein;*
***GR**: 0.158 ± 0.012 µmol GSSG/mg protein;*

Conclusions

- Serrate® application increased antioxidant defence and did not worsen phenotypic traits of wheat plants.
- Serrate® application induced synergistic response in wheat subjected to waterlogging as they aggravate the phenotypic traits of plants, and did not recovered successfully antioxidant defence after cessation of stress programme.
- A monitoring forecast for flooding incidents is highly recommended before Serrate® application to wheat as it might not be able to recover.

Team

Zornitsa Katerova
Assist. Professor,
PhD

Elena Shopova
Assist. Professor,
PhD

Liliana Brankova
Assist. Professor,
PhD

Iskren Sergiev
Assoc. Professor,
PhD

Dessislava Todorova
Assoc. Professor,
PhD

Ljudmila Dimitrova,
Biologist,
Msci

The authors express their gratitude to grant KP-06-N36/3 (30.09.2020) of the Bulgarian National Science Fund (BNSF).

Thank you for attention!

Благодаря за вниманието!

References

- Mustroph A. (2018) Agronomy, 8, 160
- Herzog M. et al. (2016) Plant, Cell and Environment 39, 1068–1086
- Sayre K. et al. (1994) Annual Wheat Newsletter 40, 165–171.
- Setter T. L. & Waters I. (2003) Plant and Soil 253, 1–34.
- Yordanova R.Y. et al. (2001) Photosynthetica 39 (4), 515-520