

Changes of structural characteristic of leaves in wheat varieties under the influence of experimentally contaminated water

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Abstract

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Two varieties of wheat were grown on different soil types (chernozem carbonate and humus-carbonate). The influence of experimentally polluted water was investigated on the structural characteristics on the leaves of the two varieties. A positive impact is detected under the influence of Mg600 and Cu300 on the thickness of leaves, leaf lamina and mezophils. Variety “Yantar” with humus-carbonate soils has better characteristics of structural leafy parameters in comparison with a variety “Sadovo” in the same soil parameters, which indicates that it is more resistant to the effects of the pollutants.

Keywords: wheat; leaves; polluted water; *Triticum aestivum*; soil

Abbreviations: FAO (Food and Agriculture Organization); BSS (Bulgarian state standard)

Introduction

The metals like iron, manganese, copper and zinc are essential for plant life but are required in a very small or trace amounts and become toxic at higher concentrations (Vinot et al., 2012). The rapid industrialization in developing countries leads to an increased of heavy metals into the soil (Marschner, 1995). Accumulation of metals in food chain and their toxic effects can lead to serious ecological and health problem (Malik, 2004). The phytotoxic effect of heavy metals in plants appear itself through visual symptoms such as chlorosis, necrosis and through reduced growth and biomass accumulation (Sanità di Troppi and Gabbrielli, 1999; Marques et al., 2000). Accumulation of heavy metals in plants occurs constantly during vegetation (Krstić et al., 2007). Plants can uptake heavy metals and accumulate them in their tissues, the accumulation of potentially toxic elements can produce adverse effects on plant morphology and health (Bini et al., 2012). Studying changes in leaf structural parameters helps understand the process of metal accumulation and tolerance, since the absorption of these ions from the soil solution is closely related to the

leaf transpiration rate (Gomes et al., 2011). Wheat (*Triticum aestivum* L.) is an important source of food for people over the world (Bhatti et al., 2013).

The aim of this study is to investigate the influence of experimentally polluted water on the structural characteristics of the leaves of two varieties of wheat grown on different soil types.

Materials and Methods

Grains of wheat varieties „Sadovo” and „Yantar” were planted in vessels on Rendzina soil by FAO (Humus carbonate by BSS) and Calcic chernozem, by FAO (Carbonic chernozem by BSS) soil. To trace the structural response of pollutants on plants parallel to the control (distilled water) they are watered with different polluted water. About variety „Sadovo” with carbonate chernozem soil, parallel to the control plants were watered with $(\text{NH}_2)\text{SO}_4$ with concentration 600 mg/l (NH 600); CuSO_4 with concentration 300 mg/l (Cu 300). About variety „Sadovo” with humus-carbonate soils (parallel to the control) plants were watered with MgSO_4

with concentration 600 mg/l (Mg 600); CuSO₄ with concentration 600 mg/l (Cu 600). About the variety „Yantar” with humus-carbonate soils (parallel to the control) plants were watered with MnSO₄ with concentration 300 mg/l (Mn 300); CuSO₄ with concentration 300 mg/l (Cu 300). At the end of the trial (45 days), plants were fixed in 70% C₂H₅OH.

The classical comparative structural method is used. Most significant structural features were selected for the purposes of bioindication by variations in growth performance metric: main vein thickness (t), height of vascular bundle (h), trachea diameter (d), leaf thickness (lt), thickness of the leaf lamina between the bundles (ltb), thickness mezophils (tm).

Data analyses were conducted by one-way analysis of variance ANOVA (MS Office, 2010).

Results and Discussion

The effect of the impact of irrigated water is dependent to a large extent on the concentration of mineral elements, the specifics of their physiological effects on exchange processes in plants, and synergistic or antagonistic interactions in mixed minerals. The contents of mineral elements in irrigated water used for the cultivation of cultural plants have various effect on the morphological, physiological indicators and productive opportunities. An essential role also has the soil with its chemical, physical and biological properties, which increases or decreases the effect of the mineral impact (Velichkova et al., 2012).

Analysis of structural parameters of the variety „Sadovo” with carbonate chernozem soil

The structural characteristics of the leaves in *Triticum aestivum* variety „Sadovo”, grown on carbonate chernozem soil are

substantially changed depending on the quality of water used for irrigation. The content of mineral substances in the water in high concentrations has a stronger impact on the structural parameters of the wheat leaves. The variant treated with ammonium sulfate (NH 600) is with significantly lower values from the all features (Table 1). The high level of ammonium in the water has led to negative impact in leaf and main vein thickness.

In the variant with copper sulfate (Cu 300) deviations from the control are in both directions. A high level of copper in water leads to reducing the thickness of mezophils, vein thickness and area of the vascular bundle. It increases the diameter of the trachea, the leaf thickness and leaf thickness of the portions with secondary bundles, which is visible on the graphical configuration (Fig. 1).

Analysis of structural parameters of the variety „Sadovo” with humus-carbonate soil

In the cultivation on humus-carbonate soil, variety “Sadovo” developed leaves with smaller values of the structural indicators, compared to those of the same variety grown on carbonate chernozem soil. The leaves of controls are with a small thickness of the veins, mezophils, lamina and with a smaller area of the vascular bundles compared to the treatment with magnesium sulfate (Mg 600). Only tracheal diameter is larger (Table 1). All of this could be taken as an indicator of a less favorably soil complex and on the positive effect of magnesium in cases.

Parameters of the leaves vary differently under the influence of mineral substances. The treatment with copper sulphate (Cu 600) leads to reduced value of almost all features. These results correlates with another study in which it inhibits the growth of plants by alteration in enzyme activity and induction of oxidative stress due to presence

Table 1. Impact of experimentally contaminated water on structural leaf parameters of *Triticum aestivum*

Variety/ Soil	Water variant	Parameters (average)					
		main vein thickness	height of vascular bundle	trachea diameter	leaf thickness	thickness of the leaf lamina between the bundles	thickness mezophils
Sadovo carbonate chernozem	Control		28.1	6.6*	49.1	37.0	21.6
	NH600		21.5	5.9	38.1	28.1	17.7
	Cu300	89.5	24.8	6.9*	55.6	39.5	20.2
Sadovo humus carbonate	Control	72.5	26.2*	8.1	40.7	27.9	16.5
	Mg600	74.9	26.5*	6.9	42.1	29.9	18.0
	Cu600	67.3	26.1*	6.9	36.9	25.7	16.5
Yantar humus carbonate	Control	85.1*	33.9	7.0	43.4	32.9	20.5
	Cu300	81.2	24.8	10.0	37.8	32.4	18.6
	Mn300	85.4*	32.2	8.2	45.7	34.0	22.1

* P < 0.05

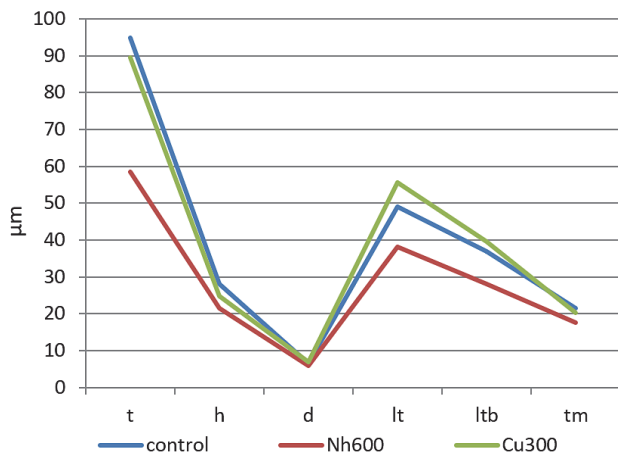


Fig. 1. Effect of polluted water on structural parameters of the variety „Sadovo” with carbonate-chernozem soil: main vein thickness (*t*), height of vascular bundle (*h*), trachea diameter (*d*), leaf thickness (*lt*), thickness of the leaf lamina between the bundles (*ltb*), thickness mezophylls (*tm*)

of heavy metals (Kaur et al., 2012). The deviations from the control are mainly in the leaf thickness and thickness of the leaf lamina between the bundles (Fig. 2). This confirms the negative and suppressive action of copper on the growth of leave.

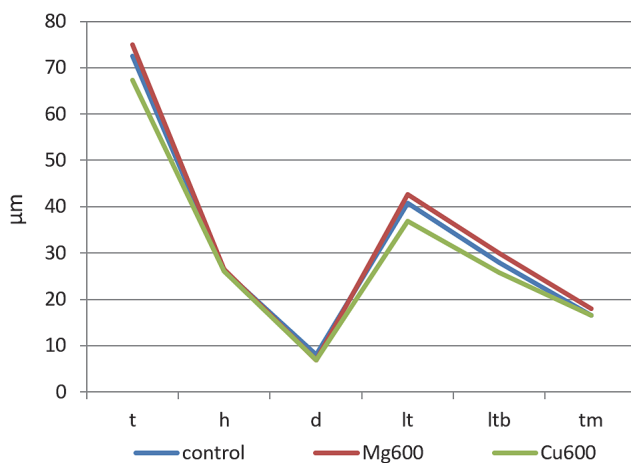


Fig. 2. Effect of polluted water on structural parameters of the variety „Sadovo” with humus-carbonate soil: main vein thickness (*t*), height of vascular bundle (*h*), trachea diameter (*d*), leaf thickness (*lt*), thickness of the leaf lamina between the bundles (*ltb*), thickness mezophylls (*tm*)

Analysis of structural parameters of the variety „Yantar” with humus-carbonate soil

The leaves of *Triticum aestivum* variety „Yantar“ are thinner and have a more gentle fixture compared with those of variety „Sadovo“. Only the diameter of the trachea is with a higher value (Table 1).

The mineral elements have a different impact on the structural parameters. The treatments comprised of Cu 300 (the lowest values of the concentrations of this heavy metal) were found to be most effective on structural leaves parameters. The effect of copper sulfate (Cu 300) leads to an increase in the value of almost all the features (exception is only for the conductive bundle-height in the cross section). Obviously variety “Yantar” is more sensitive to this reagent than variety “Sadovo”.

In the case of treatment with manganese sulfate (Mn 300), the greater part of the structural indicators are influenced negatively. The exception is for diameter of the trachea, which is visible on the graphical configuration (Fig. 3). In the variety „Yantar” similar tendencies of the negative influence of certain mineral elements and positive of others are observed, which demonstrated the different influence of mineral substance on the growth of plants.

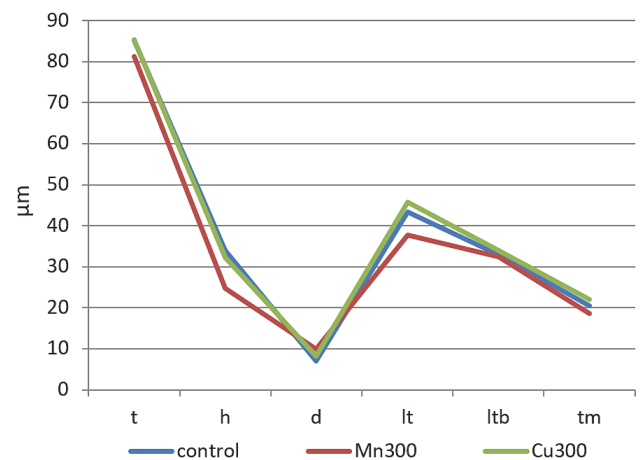


Fig. 3. Effect of polluted water on structural parameters of the variety „Yantar” with humus-carbonate soil: main vein thickness (*t*), height of vascular bundle (*h*), trachea diameter (*d*), leaf thickness (*lt*), thickness of the leaf lamina between the bundles (*ltb*), thickness mezophylls (*tm*)

Conclusion

The summarized analysis of the mineral substances in the water indicates that of all chemical elements ammonia has the most negative impact, which affects to a greater extent

the thickness of the leaves and their main veins. A positive impact is detected under the influence of Mg600 and Cu300 on the thickness of the leaves, leaf lamina and mezophils.

The comparison between the planned varieties indicates that there is a varietal-specific reaction against the influence of soil contaminants. Variety "Yantar" with humus-carbonate soils has better characteristics of structural leafy parameters in comparison with a variety "Sadovo" in the same soil parameters, which indicates that it is more resistant to the effects of the pollutants. Our comparative study on the influence of mineral elements as contaminants in water on two varieties of wheat on soil type humus carbonate shows that the two factors – variety and mineral elements have different impact on the structural parameters of the leaves of wheat.

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