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THE STEM STRUCTURE OF *TRITICUM AESTIVUM* L. UNDER DIFFERENT MINERAL NUTRITION

Olga I. Zhuk

Abstract. The effect of supplying of winter wheat (*Triticum aestivum* L.) plants by nitrogen, phosphorus and potassium on the main stem structure and plant productivity was studied for cultivars *'Mironivska 808'* and *'Smuglyanka'*. It was shown that increased mineral nutrition causes increasing stem and central xylem vessels diameter on average of 1 mm. Increased plant productivity was supported by increasing grains quantity per ear and mass of 1000 grains.

Key words: *Triticum aestivum*, winter wheat, internode, mineral nutrition

Institute of Plant Physiology and Genetics NAS of Ukraine, Vasylkivska str. 31/17, 03022 Kyiv, Ukraine; zhuk_bas@voliacable.com

Introduction

Productivity of wheat plants depends from plant mineral nutrients supplying, which significantly influences on growth and development of winter wheat plants (Huang *et al.* 2007; Makino 2011). Spikelet and flowers formation, development and reduction are closely connected with the level of mineral nutrition of wheat plants (Bancal 2009). Wheat grains are supplied by photoassimilates during their growth not only from leaves photosynthesis but also from stems stocks. The size of stem upper internodes depends from the content of carbohydrates assimilates stocks for ear during grain filling. Effective photosynthesis and carbohydrate reserve accumulation significantly influence on final yield of wheat. The quantity of carbohydrates preserved in wheat stems defines grain mass, especially in drought conditions resulting in early defoliation (Asseng & Herwaarden 2007). Structure of wheat stem is well known, but the effect of mineral nutrition on stem parenchyma development remains uninvestigated. Despite the importance of stems structure it remains little studied (Zwieniecki & Holbrook 2009). Our previous studies showed that basic mineral nutrients significantly effect on the growth of the third, and predominantly on the fourth and fifth internodes of winter wheat plants (Zhuk 2013). Significant support of plant by mineral nutrition prolongates growth of internodes up to the milky ripeness phase. Under deficient nutrition the growth processes in the internodes complete only in earing-flowering phases. The aim of our work was to study the influence of mineral nutrition on stem tissue structure and winter wheat plants productivity.

Material and methods

Winter wheat (*Triticum aestivum* L.) cultivars *'Mironivska 808'* and *'Smuglyanka'* were grown on mixture of soil and sand in pots with a capacity of 7.5 kg. Optimal plant mineral nutrition was $N_{160}P_{160}K_{160}$, deficit supply was $N_{32}P_{32}K_{32}$. During milky ripeness phase the part of the stem with segments of the fourth internodes was isolated. Internodes' segments were placed in fixing mixture of Brodsky (formalin:ethanol:acetic acid 3:1:0,5) for 24 h. Then mixture exchanged to 70% ethanol. Parts of stem internodes were removed from alcohol and were sliced by blade to 0.5-1 mm cross-sections, and then were photographed. On cross-sections the diameter of stem and central xylem vessels were measured. After maturing the internodes and ears length, quantity of grains in ear, and mass of 1000 grains were measured. Different stages of grain development

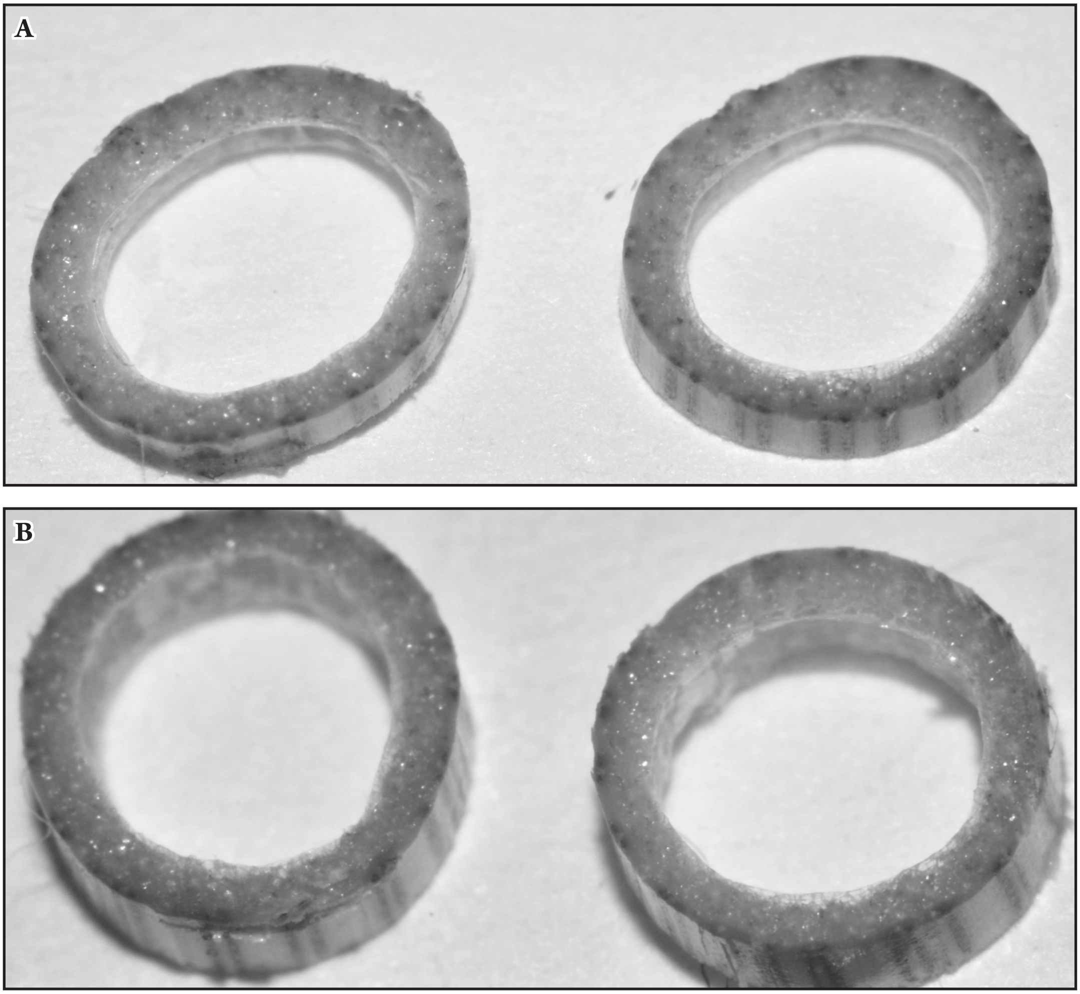

Fig. 1. Effect of mineral nutrition on stem development of wheat cultivar *'Mironivska 808'*: **A** – deficient nutrition; **B** – optimal nutrition.

were studied. Results were statistically analyzed with ANOVA.

Results and discussion

Optimal mineral nutrition increased the diameter of fourth internode in cultivar *'Mironivska 808'* (Fig. 1).

Simultaneously the diameter of the central xylem vessels was increased. The thickness of the stem parenchyma increased slightly. In cultivar *'Smuglyanka'* the deficit of mineral nutrients increased parenchyma tissue development, as well as reduced central xylem vessel diameter (Fig. 2).

Size of central xylem vessels and stem diameter increased under optimal mineral nutrition of cultivar *'Smuglyanka'*. The stem wall thickness slightly decreased but its length significantly increased.

Developing of winter wheat grains under optimal conditions is a series of stages that lead to endosperm and the germ formation (Fig. 3). Stopping grain development under deficit of mineral nutrition usually occurs on early stages. In these grains only small endosperm developes and germ do not develops at all. These undeveloped reduced grains are incapable for germination.

Measurements of plant growth in milky

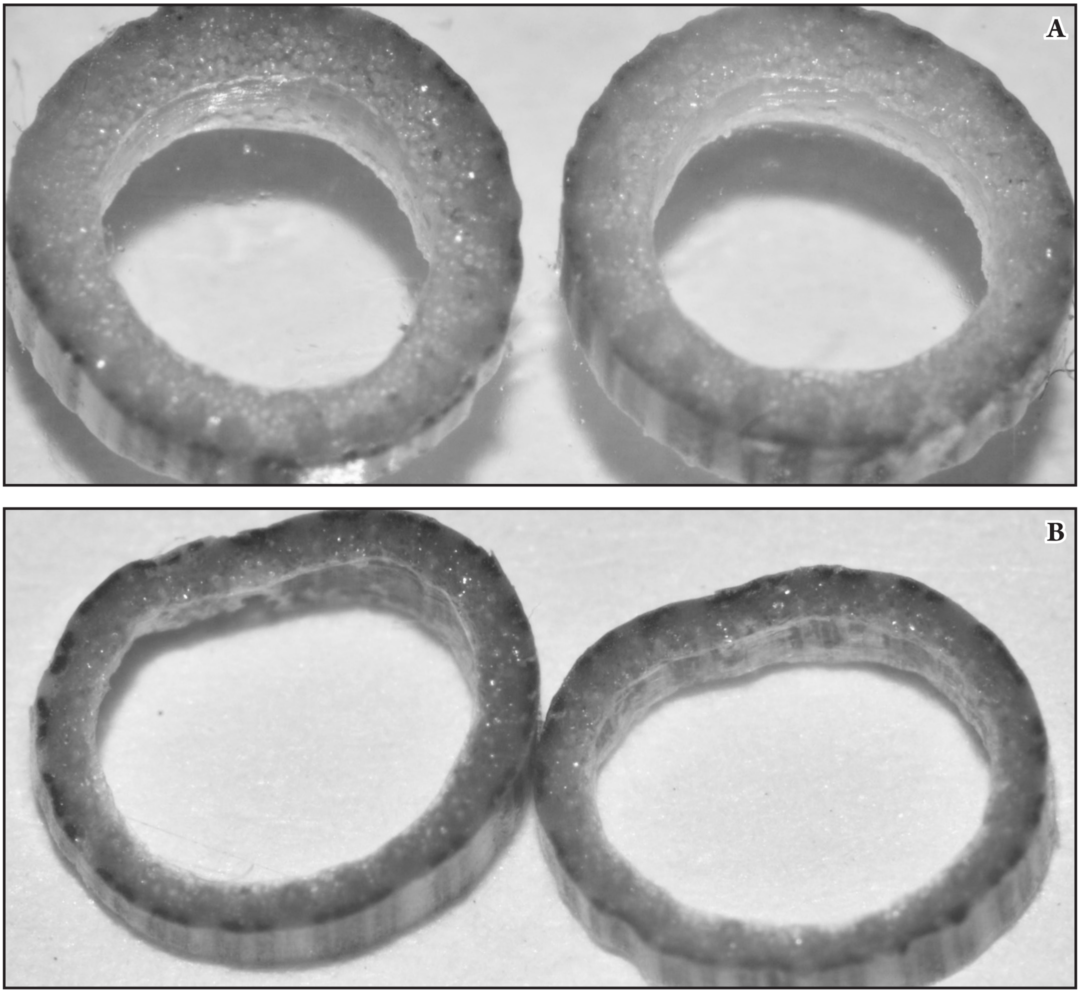

Fig. 2. Effect of mineral nutrition on stem development of wheat cultivar *'Smuglyanka'*: **A** – deficient nutrition; **B** – optimal nutrition.

ripeness phase showed increasing of fourth and fifth internodes length under optimal mineral nutrition of cultivars *'Mironivska 808'* and *'Smuglyanca'* (Fig. 4).

However, stem diameter increasing reaches approximately of 1 mm. Enhanced mineral nutrition results in increasing the central xylem vessels diameter, which supply and transport water and assimilates from the root (Fig. 5).

Cultivar *'Smuglyanca'* showed better reaction on mineral nutrients in comparison with *'Mironivska 808'* during the pot experiment. Investigation of stem structure of various plants showed that increasing supply of shoot by water and minerals leads to enhanced development of vascular system, especially xylem vessels (ZWIENIECKI & HOLBROOK 2009). Parenchyma development is important for increasing carbohydrates reserves in the stem. But increasing stem thickness does not led to significant changes in features of parenchyma. Stem diameter increasing in cultivar *'Smuglyanca'* was more significant than in *'Mironivska 808'*. Optimal supply of reproductive organs by water, ions and metabolites in these cultivars of winter wheat increased formation and number of grains per ear, and, as a result, of 1000 grains mass (Tab. 1).

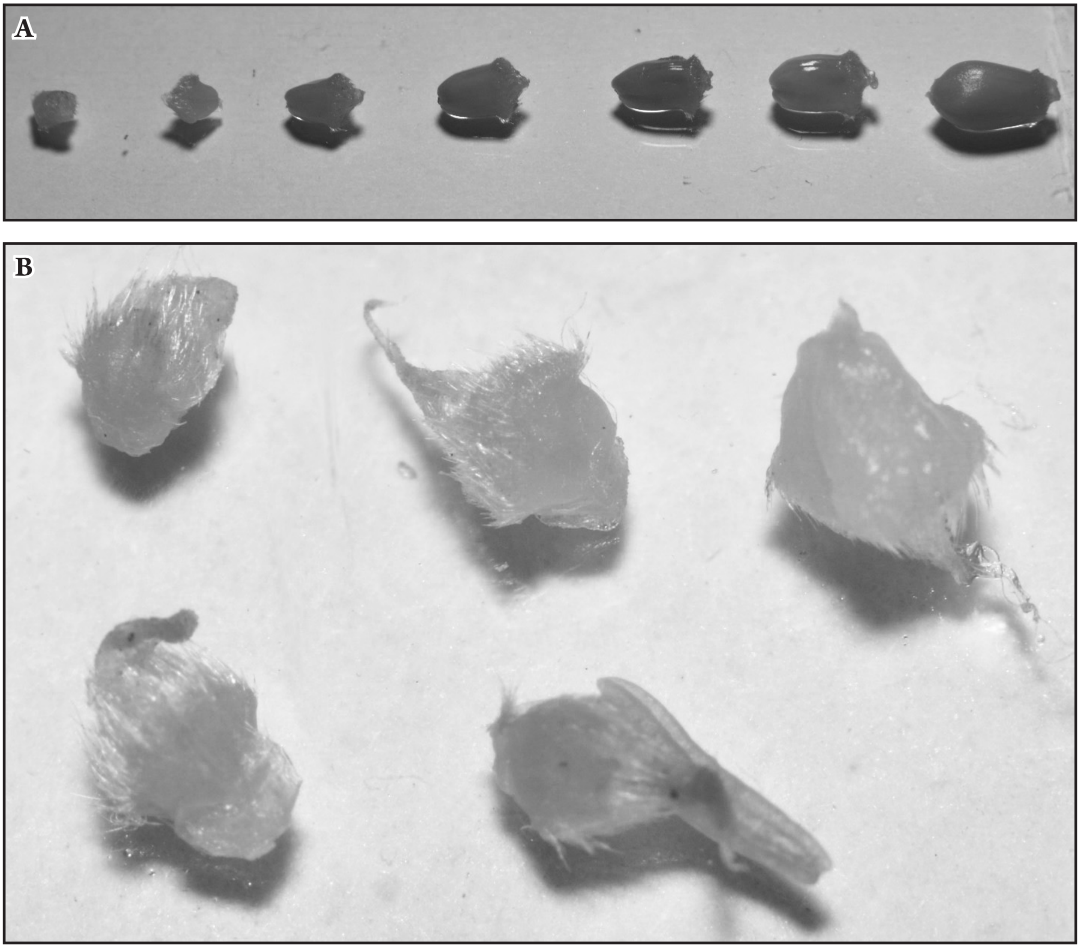

Fig. 3. The development of wheat grains: **A** – normal development; **B** – undeveloped wheat grains.

Conclusions

It was ascertained that increasing supply of winter wheat plants of cultivars *'Mironivska 808'* and *'Smuglyanca'* by nitrogen, phosphorus and potassium during pot experiment stimulates growth of the fourth and fifth internodes, as well as increases stem and xylem vessels diameter. Changes in stem morphology are correlated with increasing plant productivity by increasing number of grains per ear and their mass.

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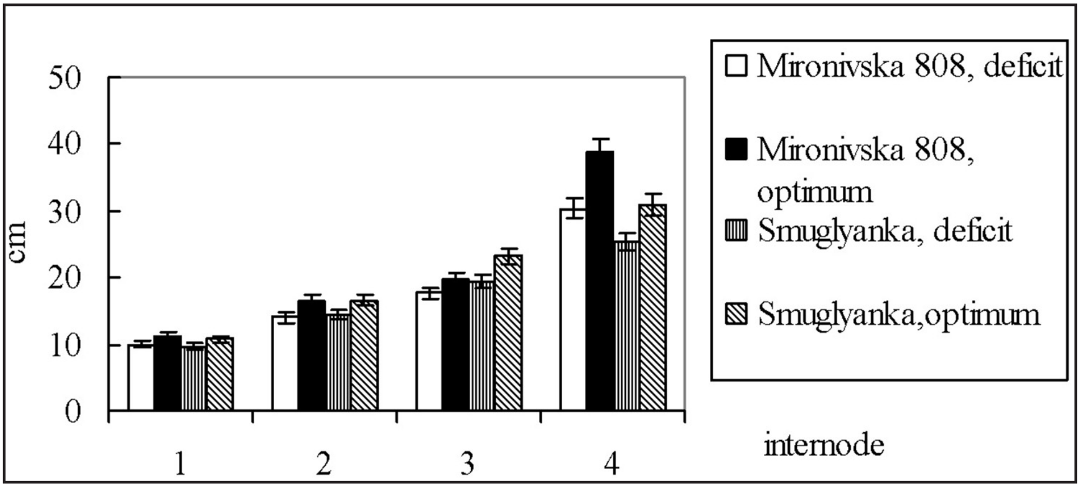

Fig. 4. Effect of different mineral nutrition on internodes size: **1-4** – number of internodes.

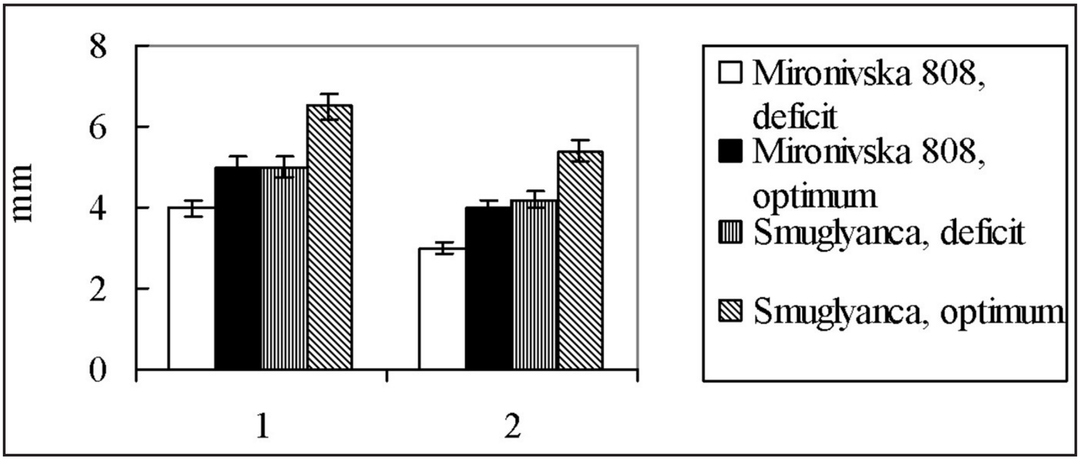

Fig. 5. Effect of different mineral nutrition on the stem diameter (**1**) and diameter of xylem vessels (**2**).

Table 1. Effect of mineral nutrition on wheat yielding.

Cultivar, variant	Length of ear, cm	Quantity of spikelets in ear	Quantity of grains in ear	1000 grains mass, g
'Mironivska 808', $N_{32}P_{32}K_{32}$	7,2±0,7	13±1	29±2	34,71±0,5
'Smuglyanca', $N_{32}P_{32}K_{32}$	6,9±0,5	14±1	34±3	35,4±0,4
'Mironivska 808', $N_{160}P_{160}K_{160}$	7,5±0,4	14±1	35±3	38,8±0,5
'Smuglyanca', $N_{160}P_{160}K_{160}$	7,6±0,7	15±1	43±3	40,5±0,6