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WINTER WHEAT MORPHOLOGY RESPONSE TO COLD TEMPERATURE STRESS DURING AUTUMN ACCLIMATION

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Abstract. Winter wheat (*Triticum aestivum* L.) abilities depend on development during autumn acclimation. The plant ability of acclimation to low temperatures is closely associated with the photosynthesis level, leaf area index (LAI), root system development. This study investigated the effect of liquid humic fertilizers (LHF) on biometric characteristics, namely LAI, root and shoot development. The fertilizers were applied in conventional and organic growth technologies of w. wheat to adapt to the low temperatures during autumn acclimation.

Winter wheat «*Širvinta 1*» was grown in different rotation fields of conventional (CF; Albi-EpihypogleyicLuvisol, LVg-p-w-ab) and organic (OF; Hapli-EpihypogleyicLuvisol, LVg-p-w-ha) farming of Training Farm at Aleksandras Stulginskis University (ASU) during 2010–2011.

The obtained results confirmed the significant LHF influence on enhancing winter wheat biometrical indices and seedling growth. Nonetheless, seed felting exhibited stronger effect on LAI (increased by 0.7-1.1 g m^{-1} day^{-1} in OF and 0.25-0.7 g m^{-1} day^{-1} in CF), root length (increased by 1166 mm in OF and 1182.55 mm in CF) and area (increased by 72.45 mm^2 in OF and 588.7 mm^2 in CF) during autumn acclimation rather than seedling spraying.

Key words: winter wheat, LAI, root, liquid humic fertilizer

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Introduction

A range of morphological adjustments occur in plants grown at low temperatures (Equiza *et al.* 2001). Low temperature stress severely curbs plant growth both shoot and root as well as productivity and is classified as one of the major abiotic adversities for many crops (Hassan 2006). Plant growth is cold-sensitive processes for decreases in photosynthetic rate under low temperatures may result in significant reduction of plant growth (Herman *et al.* 2006). The ability of plant species to acclimate to unfavourable temperatures has been found to be closely associated with the acclimation capacity (Xin & Browse 2000). Winter wheat is properly ready for wintering, at the start of tillering stage and when optimal assimilation (leaf) and absorption surface (root) is developed (Rinalducci *et al.* 2011; Stupnikova *et al.* 2002).

Leaf area index (LAI) (Breda 2003) describes the potential plant surface area available for gas exchange between the atmosphere and ecosystem biosphere (Sellers *et al.* 1992; Cowlinf & Field 2003). Consequently it is a quintessential characteristic indicating a number of biophysical processes of the vegetation, particularly the participation of light and water (rainfall, fog), attenuation of light through the canopy, transpiration, photosynthesis, autotrophic respiration, carbon and nutrient (N, P) cycles (Peñuelas *et al.* 1994). LAI is usually estimated across different spatial levels, ranging from individual plants to entire regions or continents has been used in interactive models of ecosystem processes (Sellers *et al.* 1995). LAI can be decomposed into photosynthetic and non-photosynthetic components. Photosynthetic LAI component measures green leaf area and presents physiologically active functional component (Viña *et al.* 2011).

Root area is considered a functional relationship between the plant parts and the environment (Equiza *et al.* 2001). Root growth is environmentally controlled (Saidi *et al.* 2010), Roots area a major sink for assimilates, requiring twice as much photosynthate to produce dry matter as the shoots (Liu *et al.* 2004). Moreover, it has been shown that more than 50% of assimilates are lost through root respiration or to maintain the root biomass increases.

The aim of this study was to determine the effect of liquid humic fertilizers on biometric characteristics, namely LAI, root, and shoot development and discuss the possible ecophysiological significance of these responses during low temperature stress in autumn. The fertilizers were applied in conventional and organic growth technologies of w. wheat to enhance the low temperatures during autumn acclimation.

Material and methods

Study site and experimental design. Winter

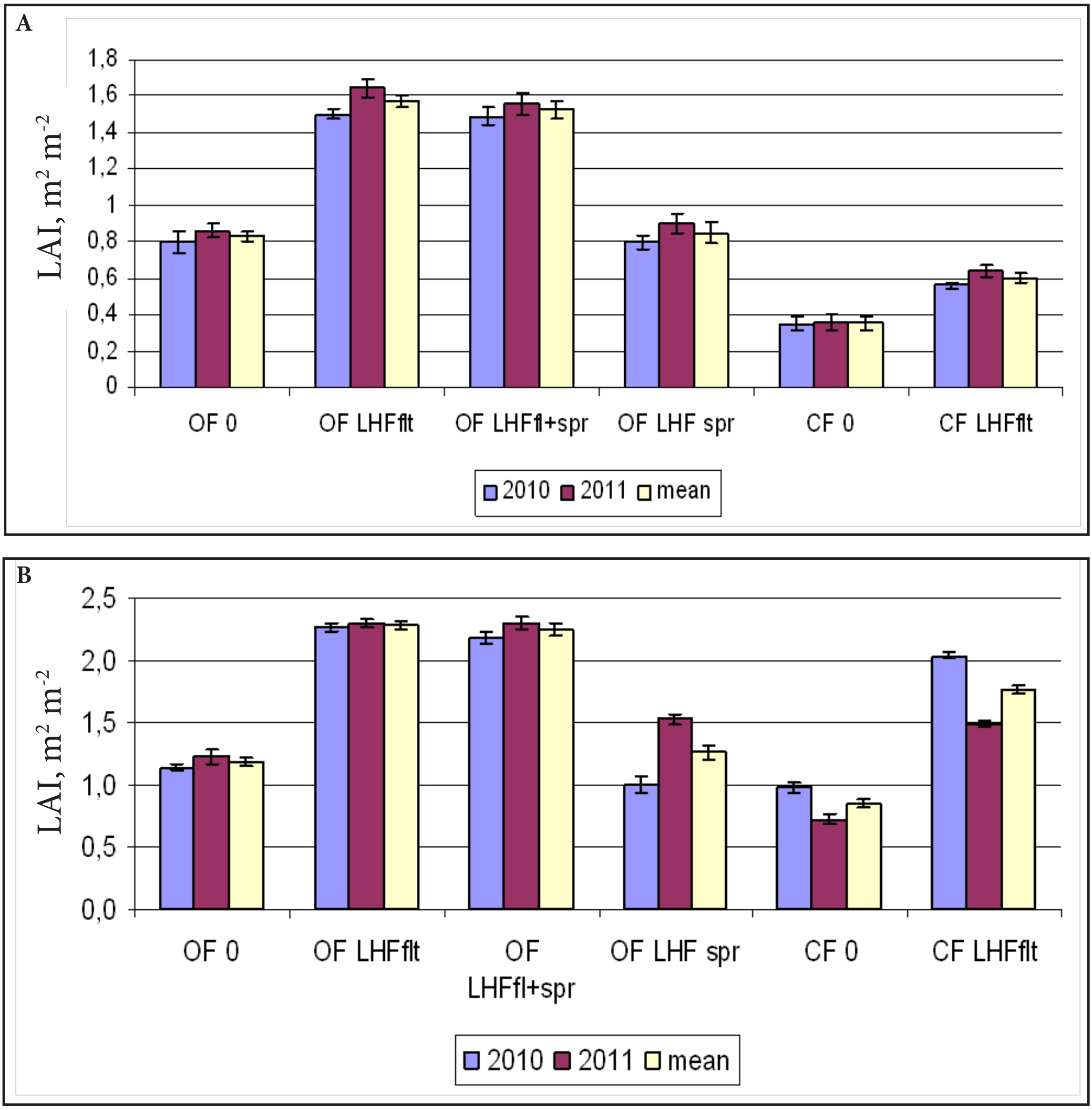

Fig. 1. LAI of winter wheat seedlings at tillering stage before (A) and after (B) LHF spraying (mean ± SE, $p < 0.05$).

wheat (*Triticum aestivum* L.) cv. «*Širvinta 1*» was grown in different rotation fields of conventional (CF, Albi-EpihypogleyicLuvisol, LVg-p-w-ab, 54°52'21»N23°51'40» E) and organic (OF, Hapli-EpihypogleyicLuvisol, LVg-p-w-ha, 54°52'28»N23°51'52»E) farming of Training Farm at Aleksandras Stulginskis University (ASU) during 2010–2011. Soil type was classified in accordance with FAO/UNESCO (1997).

Winter wheat was sown on 07–21 September at the rate of 200 kg ha^{-1} in accordance with autumn climatic conditions, namely soil humidity. Liquid humic fertilizer (LHF), 1 l ha^{-1} was applied in different ways in organic field (OF): 1) control (blank), 2) seed felt (flt) with LHF, 3) seed felt and sprayed (flt + spr) with LHF, 4) sprayed with LHF. LHF application in conventional field (CF) was carried out as fallows: 1) control (blank), 2) seed felt with LHF. All treatments were performed in 4 replications. LHF presents aqueous solution of 11 humic acid (humic and fulvis acids) based fertilizer with microelements (Fe, Zn, Mg, Mn, Mo, Co, B). Fertilizer (operation solution 200 l ha^{-1}) was once sprayed after a month after w. wheat sowing. Pre-sowing treatment of 10 l t^{-1} LHF aqueous solution (1:1) was applied for seed felting.

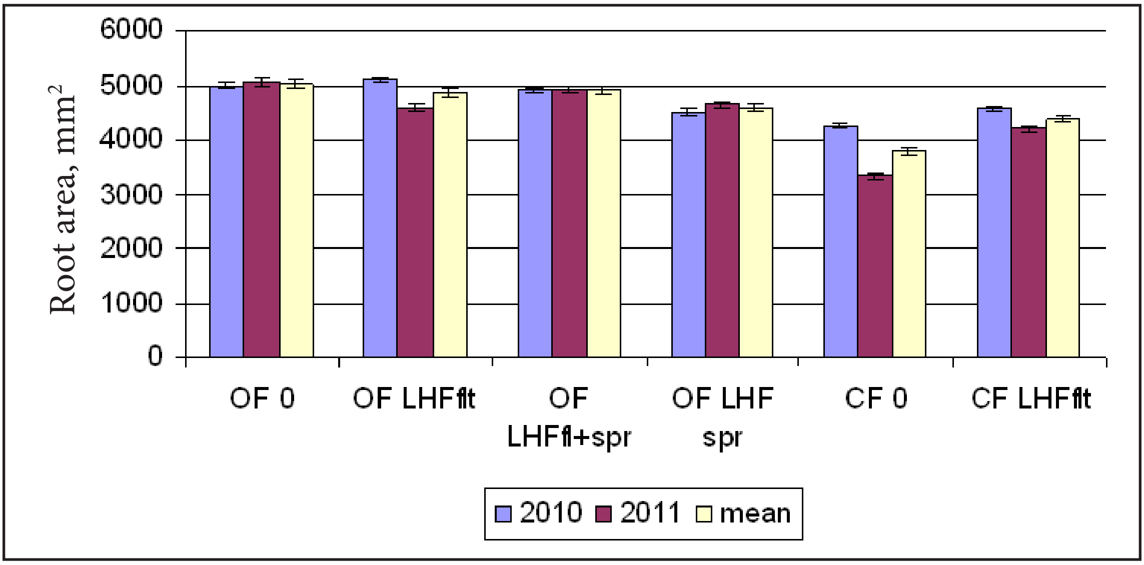

Fig. 2. LHF impact on root area (mean ± SE, $p < 0.05$).

Plant samplingand bioassessment. Biometric assessments were carried out at the Analytic laboratory of the Research Station of ASU. Crop biometric parameters were assessed from 0.036 m^2 samples in 4 replications at w. wheat tillering stage in two terms with 2 weeks gap between them. Measurements have been acquired at the end of vegetation season from the beginning of October after seedlings started tillering stage (21-25 BBCH scale; Meier 2001). Crop density was expressed via calculation of shoot number per plot unit (no. m^{-2}). Height (cm), biomass (g m^{-2}), and root system development were represented by indices of seedlings growth intensity. Finally, A3 light box was employed to scan the seedlings and Win DIAS programme was consequently applied to obtain seedling leaf area (cm^2), root total plot (mm^2), mean diameter (mm) and total length (mm). Green leaf area was used for calculation of leaf area index – LAI (m^2 m^{-2}) (Breda 2003).

Results and discussion

Results of this study showed, that the application of liquid humic fertilizer contributed to enhancing of growth and physiological indices during w. wheat autumn acclimation in both organic and conventional farming. Noticeably, the assessed biometrical indices were higher in OF than in CF possibly due to different fertilizer background application and delayed sowing term for 2 weeks due to high soil humidity of CF.

After germination mean LAI of w. wheat seedlings varied significantly and ranged between 0.35 (CF 0) and 1.57 m^2 m^{-2} (OF LHF flt) in different treatments (Fig. 1 A). This green leaf area index characterizes carbon assimilation and organic material synthesis in plants (Viña *et al.* 2011). Seed felting with LHF caused LAI increase by 0.74 and 0.25 m^2 m^{-2} in OF and CF, respectively, as compared to control or only LHF spraying. Consequently, LHF felt contributed to formation of seedlings with higher LAI which is essential in plant organics synthesis and guarantees growth process supplementation with proper constitutional materials in low temperatures stress during autumn acclimation. These issues of LHF impact on acclimation correspond with the results obtained when applying nitrogen fertilizers (Bahrman *et al.* 2004; Houlès *et al.* 2007).

Two weeks later and after LHF spray photosynthetically functional LAI geminated and approached between 1.2-2.3 m^2 m^{-2} in OF and 0.8-1.5 m^2 m^{-2} in CF (Fig. 1 B). Notwithstanding, LHF spray applied in OF had not enhanced LAI, possibly due to low temperatures and short vegetation period during autumn acclimation.

We observed, that root mean area ranged between 4900.4 mm^2 (OF LHF flt + spr) and 3787.5 mm^2 (CF 0). Due to later sowing term lower values of root area and diameter (Fig. 2) were observed in CF than in OF. Across the two seasons, LHF application resulted in significant increase in root mean area only in CF LHF flt (4376.2 mm^2) if compared to control. In accordance with Kosová *et*

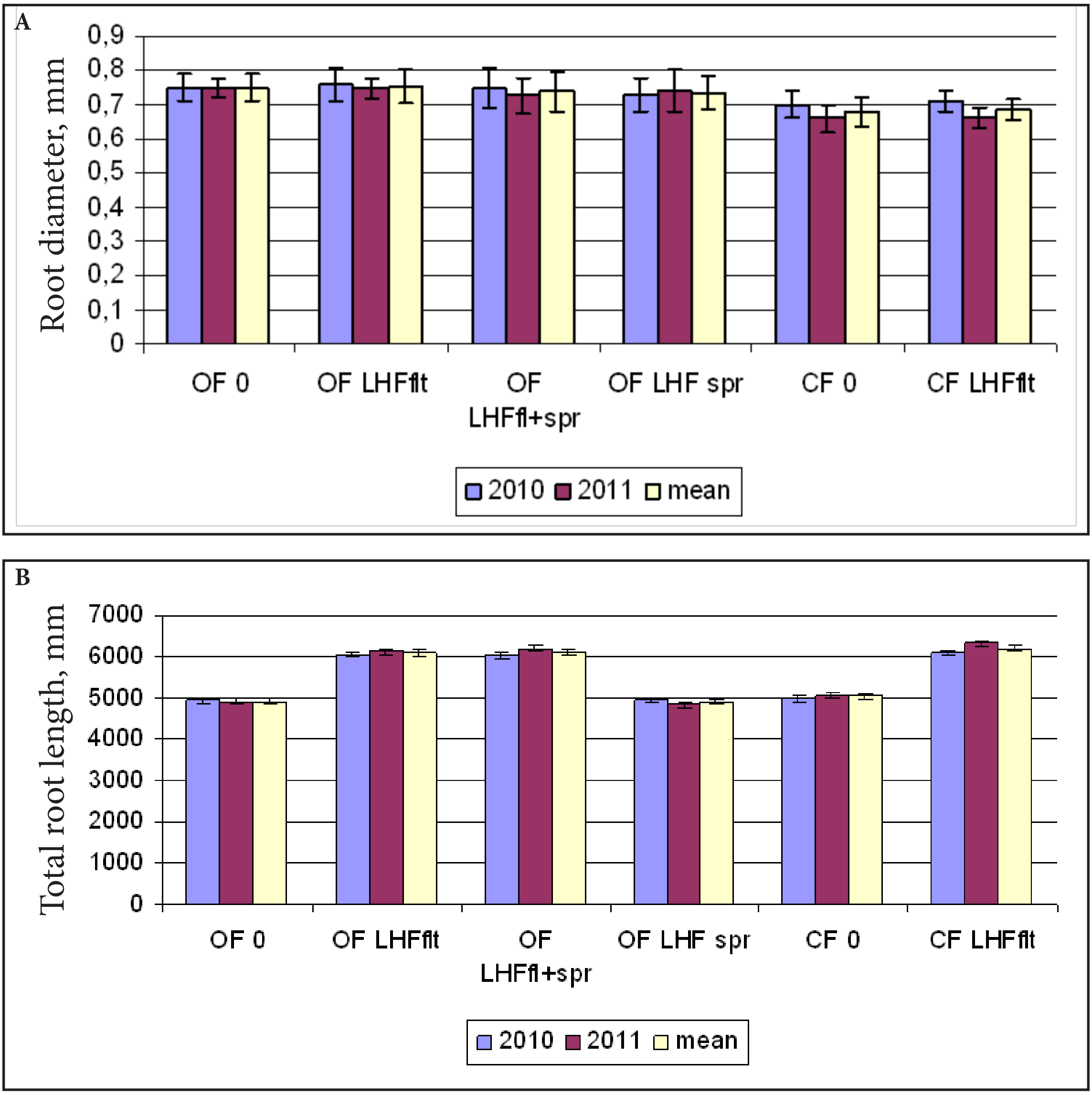

Fig. 3. LHF impact on root diameter (A) and root total length (B) (mean ± SE, $p < 0.05$).

al. (2011) reference that sufficient root area increase wheat cold tolerance, consequently applied LHF flt contributes adaptation of wheat seedlings to autumn low temperature stress. Root area was lower in 2011 than in 2010 possibly due to lower precipitation rate.

The minimal LHF effect scale was observed on root diameter (Fig. 3 A). Variation in root mean diameter was insignificant across OF (0.74-0.75 mm) or CF treatments (0.68-0.69 mm). As referred by Liu *et al.* (2004), vegetative organs usually act as a temporary sink for nutritional materials storage. Moreover, this process is greatly altered by fertilizers (N) level. Nonetheless, the application of LHF has not enhanced root diameter and thus prospective temporary sink of seedling organic materials. Moreover, it is due to Jackson *et al.* (1997) that LHF encourages fine root (<2 mm in diameter) formation for water and nutrient uptake by plants, and thus fostering seedlings acclimation.

Root length ranged between 4926.15-4904.65 in OF 0-LHF spr and 6118.75 in CF LHF flt + spr (Fig. 3 B). The higher LHF impact on root length was observed in CF if compared to that in OF, and thus enhanced better seedlings capacity for water uptake (Equiza *et al.* 2001). Total root length was equated 6207.6 mm in CF LHF flt treatment. Summarizing, LHF efficiently stimulate wheat root growth and formation of the optimal seedling root system during autumn period. As root growth is environmentally controlled (Saidi *et al.* 2010), LHF flt application contributes to appropriate management techniques inducing balance between root water uptake and leaf transpiration (Jackson *et al.* 1997). Consequently, formation of optimal root system guarantees satisfactorily seedlings autumn acclimation (Raven *et al.* 2005).

Given the root systems of crop plants may be unnecessarily large; however their optimal rate may result in more photosynthates being available for shoots and higher grain production (Liu *et al.* 2004; Streck *et al.* 2003). As for the discussed case, the observed normal root length values suggest LHF flt could be considered as an appropriate measure to growth stimulation of seedlings root system. As referred Saidi *et al.* (2010), developed root system improves seedlings capacity for water uptake, enhances their resistance to heaving during frosts and thus better adaptation to low-temperature stress.

Conclusion

This study demonstrated positive impact of LHF on biometric characteristics, namely LAI and root development in different farming background during cold acclimation. Nonetheless, LHF application technique: seed felting or spraying has different stimulation affect during cold acclimation. Seed felting exhibited stronger effect on LAI (increase by 0.7-1.1 g m^{-1} day^{-1} in OF and 0.25-0.7 g m^{-1} day^{-1} in CF), *Chl a* (increased by 2.35 mg g^{-1} in Of and 1.01 mg g^{-1} in CF) and carotenes content (increased by 0.36 mg g^{-1} in OF and 0.54 mg g^{-1} in CF), root length (increased by 1166 mm in OF and 1182.55 in CF) and area (increased by 72.45 mm^2 in OF and 588.7 in CF) during autumn acclimation than seedling spraying did. Consequently, winter wheat seed felting with LHF could be considered as an appropriate measure leading to LAI, and root development stimulation, and thus increasing resistance to low temperature stress.

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