THE COURSE OF SOIL TEMPERATURE UNDER WHEAT STAND

Krčmářová J.[1], Pokorný R.[1], Středa T.[1], Středová H.[2], Brotan J.[3]

[1]Department of Crop Science, Breeding and Plant Medicine, Faculty of Agronomy, Mendel University in Brno, Zemedelska 1, 613 00 Brno, Czech Republic

[2]Department of Applied and Landscape Ecology, Faculty of Agronomy, Mendel University in Brno, Zemedelska 1, 613 00 Brno, Czech Republic

[3]Department of Agrosystems and Bioclimatology, Faculty of Agronomy, Mendel University in Brno, Zemedelska 1, 613 00 Brno, Czech Republic

E-mail: xkrcmar2@mendelu.cz

ABSTRACT

The course of soil temperature was determined under the wheat stand during the main growth season in 2010 and 2011years. Automatic sensors were positioned at two levels (50 and 100 mm) under the soil surface. The range of temperatures was more pronounced in the depth 50 mm in comparison with 100 mm. The distinct differences were not obvious between two evaluated years. The dependence of soil temperature under wheat canopy on the temperature under grass cover in particular depth was high in the first two stages of wheat development (tillering till the end of flowering) in both years evaluated, the coefficient of determination reaches values from 0.80 to 0.96.The regression between soil temperature and air temperature in the wheat stand was established, also. As it was found out by cross correlation analysis, the best interrelationships between these two variables were achieved in 3 hours delay for the soil temperature in 50 mm and 5 hour delay for 100 mm. After the time correction the determination coefficient reached values from 0.76 to 0.88 for 50 mm and 0.61 to 0.74 for 100 mm. These findings can be used in making more accurate prediction models of pathogens and pest occurrence on winter wheat.

Key words: wheat, soil, temperatures

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INTRODUCTION

Specific microclimate develops in different plant species stands. Vertical distribution of air temperature and humidity are fluctuating and there are differences in these data recorded on the climatological station and in the different heights of canopy (Krédl et al., 2012, Středa et al., 2012). The soil temperature under crop canopy can differ from ones recorded on standard station, also.

The knowledge of temperature course in different soil depth under crop canopy is important from the root growth point of view. Several developmental stages of pathogens and pests can be also influenced. According to Chungu et al. (2001) optimal temperature for development of fungi *Mycosphaerella graminicola* pycnidia is 18-22°C during the day and 15°C in the night. Immature females of nematode *Heterodera latipons* were first evident on roots with soil temperatures of 11.8-13.3°C and the mature females containing eggs with embryo when the soil temperature was 14.2-15.3°C (Hajihassan et al., 2011). The viability of pathogens in the soil can be affected as well. Singh et al. (2009) explored displacement of *Fusarium psedograminearum* from stubble by other fungi. This was very poor at the lowest temperatures and water potentials.

The aim of this study was to evaluate the course of soil temperature under the wheat canopy and to determine relationships between soils temperatures measured under different plant cover. The correlation between soil and air temperatures was also evaluated.

MATERIAL AND METHODS

The measurement of soil temperature in and under wheat canopy (variety Sultan) was carried out on Zabcice experimental station (GPS Loc. 49°C1´18.656´´N, 16°36´56.150´´E) of Mendel University in Brno in 2010 and 2011 years. This station is located in the floodplain of the river Svratka in altitude of about 184 m in maize production area. The average annual air temperature is 9.2°C and average annual precipitation total is 483 mm. The locality belongs to the warm macro area, predominantly warm area, predominantly dry sub area, region with either mild winter. The soil in experimental plot is heavy clayey-loam gleyic fluvisol.

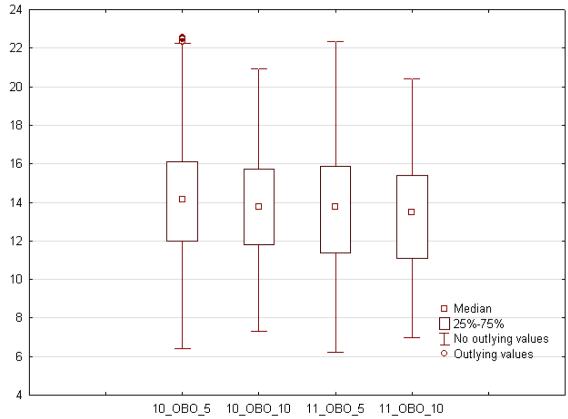
Data recording for wheat was conducted by means of a mobile meteo station equipped by digital temperature sensors (Dallas semiconductor, DS18B20 type). The recorders were positioned at two depths (50 and 100 mm under the soil surface). The air temperature on the ground of wheat canopy was monitored by Dallas semiconductor, DS18B20 type. The soil temperature under grass cover was also measured on the near climatological stations by sensors T-107 (10TCRT) at the same depth as for wheat. The spring vegetation period of wheat was divided into three stages: I. BBCH 23-32 (tillering to beginning of stem elongation), II. BBCH 33-69 (stem elongation to the end of flowering) and III. BBCH 70-89 (development of fruit and ripening).

The range of soil temperature was plotted as box figure. The regression analysis was carried out to evaluate interrelationships between soil temperatures measured under two types of plant covers (wheat and grass, respectively). The same analysis was done for air temperature on the ground of wheat and soil temperatures. As the course of temperatures in soil can be delayed, cross correlations were computed for this evaluation. These models were tested with the coefficient of determination (R^2).

RESULT AND DISCUSSION

As can be seen in the Figure 1, range of temperatures was more pronounced in the depth 50 mm in comparison with 100 mm. The distinct differences were not obvious between two evaluated years.

Figure 1 The range of temperatures under wheat canopy in depth -50mm and -100mm in 2010 and 2011 years



Notes: 10_OBO_5: -50 mm in 2010; 10_OBO_10: -100 mm in 2010; 11_OBO_5: -50 mm in 2011; 10_OBO_10:100 mm in 2011

The dependence of soil temperature under wheat canopy on the temperature under grass cover in particular depth was high in the first two stages (tillering till the end of flowering) in both years evaluated, the coefficient of determination reaches values from 0.80 to 0.96 (Table 1). This coefficient differs slightly in the third stage (ripening) in particular year. From this point of view, it is possible to predict soil temperatures under wheat canopy from data recorded in standard climatological station near the field in dependence on wheat developmental stage.

Table 1 Regression analysis of dependence of soil temperature under wheat canopy on temperature under grass cover in particular depth

YEAR	STAGE	50mm	100mm
2010	I.	$y = 0.8788x + 0.6888$ $R^2 = 0.90$	$y = 0.8978x + 0.3729$ $R^2 = 0.96$
	II.	$y = 0.5475x + 4.2454$ $R^2 = 0.89$	$y = 0.5984x + 3.4245$ $R^2 = 0.93$
	III.	$y = 0.4719x + 6.4011$ $R^2 = 0.78$	$y = 0.5732x + 4.2543$ $R^2 = 0.87$
2011	I.	$y = 0.669x + 2.2624$ $R^2 = 0.83$	$y = 0.6819x + 1.9434$ $R^2 = 0.80$
	II.	$y = 0.4545x + 4.8947$ $R^2 = 0.84$	$y = 0.5307x + 3.4319$ $R^2 = 0.92$
	III.	$y = 0.3915x + 7.5426$ $R^2 = 0.61$	$y = 0.4429x + 6.2511$ $R^2 = 0.61$

As can be seen from the Table 2, the prediction of soil temperature can not be done from the air temperature in the ground of wheat canopy recorded at the same time, because coefficients of determination were very low. As it was found out by cross correlation analysis, the best interrelationships between these two variables were achieved in 3 hours delay for the soil temperature in 50 mm and 5 hour delay for 100 mm. After the time correction the determination coefficient reached values from 0.76 to 0.88 for 50 mm and 0.61 to 0.74 for 100 mm.

Table 2 Regression analysis of dependence of soil temperatures in different depth on air temperatures from non-corrected (non) and corrected (corr) data

YEAR	STAGE	50 mm (non)	50 mm (corr)	100 mm (non)	100 mm (corr)
2010	I.	y = 0.4499x + 6.4706 $R^2 = 0.59$	y = 0.5348x + 5.5539 $R^2 = 0.83$	y = 0.2523x + 8.2858 $R^2 = 0.30$	y = 0.3772x + 6.9439 $R^2 = 0.67$
	II.	y = 0.5324x + 6.0649 $R^2 = 0.67$	y = 0.5971x + 5.2177 $R^2 = 0.84$	y = 0.3547x + 8.1985 $R^2 = 0.45$	y = 0.452x + 6.923 $R^2 = 0.72$
	III.	y = 0.5076x + 8.043 $R^2 = 0.71$	y = 0.5649x + 7.0587 $R^2 = 0.88$	y = 0.3119x + 11.086 $R^2 = 0.43$	y = 0.4104x + 9.3943 $R^2 = 0.74$
2011	I.	y = 0.2681x + 7.7316 $R^2 = 0.44$	y = 0.3526x + 6.8404 $R^2 = 0.76$	y = 0.1399x + 8.7943 $R^2 = 0.19$	y = 0.2512x + 7.6228 $R^2 = 0.61$
	II.	y = 0.3715x + 7.9594 $R^2 = 0.54$	y = 0.4522x + 6.872 $R^2 = 0.81$	y = 0.2324x + 9.4364 $R^2 = 0.30$	y = 0.3426x + 7.9506 $R^2 = 0.66$
	III.	y = 0.2904x + 11.016 $R^2 = 0.51$	y = 0.3678x + 9.7235 $R^2 = 0.81$	y = 0.146x + 13.005 $R^2 = 0.23$	y = 0.2538x + 11.21 $R^2 = 0.68$

The knowledge concerning soil temperature is inevitable for modelling of some plant growth and development models and it is sometimes used for the prediction of pathogens and pest occurrence. Bergjofrd and Skljevag (2011) reported that daily global radiation at plant level and soil temperature (20 mm) were the only two climatic factors found to have significant effects on periodic changes in fructan concentration in wheat seed. Different tillage systems can also influence the temperature of soil and the growth of wheat (He Jing Li 2012).

For these purposes the data recorded in standard climatological stations are usually used. As mentioned above, they can differ from actual temperatures in or under the crop stands. For these reason the comparison of data recorded should be made in different crop stands and soil management systems as well.

CONCLUSIONS

As is evident from analyses, the course of temperatures can significantly differ in soil under various plant cover and from ones measured in plant stand. The regression lines describing relationship between soil temperature under grass cover and the temperature under wheat canopy was dependent on the wheat developmental stage and year. The best interrelationships between air temperature measured in the ground of wheat stand and soil temperature were achieved in 3 hours delay for the soil temperature in 50 mm and 5 hour delay for 100 mm. These results must be taken in account to precision of prediction models of some harmful agent’s occurrence, in models of crop and yield development etc.

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