The course of soil temperature under oilseed rape canopy

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Abstract: The course of soil temperatures was determined under winter oilseed rape canopy of two varieties during the spring growth season in 2014. The first variety, Sherpa, was so called classic variety with typical height and canopy architecture for rape. The second variety was hybrid PX 104 with semi-dwarf height. Automatic sensors were positioned at two levels (50 and 100 mm) under the soil surface. The course of soil temperature varied under two tested varieties and their vegetation period. The regression between soil temperature in both depth and ground air temperature in the rape stand was established. The same relationships were determined between soil temperature under rape canopy and grass cover. These findings can be used in making more accurate prediction models of pathogens and pest occurrence on winter rape.

Key-Words: microclimate, soil temperature, air temperature, rape

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 [1]. The soil temperature under crop canopy can differ from ones recorded on standard meteorological station, also.

The knowledge of temperature course in different soil depth under crop canopy is important from the root growth point of view. The appropriate temperature and humidity are inevitable for development of several pathogens stages, too. E.g., important pathogen, *Sclerotinia sclerotiorum*, which causes Sclerotinia stem rot of rape, develops sexual ascospores in fruiting bodies apothecia which are formed on firm bodies of fungi mycelium, called sclerocia. Carpogenic germination of sclerocia (apothecia formation) occurs from 10 to 25°C with optimum 20°C. The high air or soil humidity is necessary for this process, also [2, 3, 4].

The ascospore dispersal is influenced by changing of temperatures and air humidity during the day [5]. The range of these parameters is used for prediction models of pathogen occurrence [6, 7, 8]. The data from climatological stations measured in 2m are usually used in these models.

Material and Methods

The measurement of soil temperature in and under oilseed rape canopy (variety Sherpa and PX 104) was carried out on Žabčice experimental station of Mendel University in Brno in 2014. This area 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 soil in experimental plot is heavy gleic fluvisol.

Data recording 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 soil temperatures under grass cover were also measured under grass cover on the near climatological stations by sensors T-107 (10TCRT) at the same depth as for oilseed rape. The spring vegetation period of rape was divided into four stages I. BBCH 30–59 (stem elongation to inflorescence emergence), II. BBCH 60–69 (flowering), III. BBCH 70–79 (development of fruit), IV. BBCH 80–89 (ripening). The regression analysis was carried out to evaluate interrelationships between soil temperatures measured under two types of plant covers (oilseed rape and grass, respectively). The same analysis was done for air temperature on the ground of oilseed rape and soil temperatures. As the course of temperatures in soil can be delayed, cross correlation were computed for this evaluation, also. These models were tested with the coefficient of determination (R^2).

Results and Discussion

The dependence of soil temperature under oilseed rape canopy on the temperature under grass cover in particular depth was high (Table 1) for the variety Sherpa in depth 50 mm, the coefficient of determination reached values from 0.462 to 0.713. For depths 100 mm determination coefficient for this variety was slightly lower and reached values from 0.135 to 0.465. The regression between course of temperature under grass and PX 104 was not proved, as determination coefficient did not reached value 0.1 in almost all cases, only with some exceptions.

Table 1 Regression relationships of dependence of soil temperature under rape canopy on temperature under grass cover in particular depth

Variety	STAGE	50mm	100mm
Sherpa	I.	y = 0.3408x + 6.9433	y = 0.1421x + 8.7135
		R² = 0.713	R² = 0.319
	II.	y = 0.2871x + 9.6418	y = 0.1085x + 11.669
		R² = 0.462	R² = 0.135
	III.	y = 0.5376x + 7.3181	y = 0.3667x + 9.5832
		R² = 0.659	R² = 0.465
	IV.	y = 0.438x + 12.76	y = 0.1499x + 17.362
		R² = 0.515	R² = 0.159
Px 104	I.	y = 0.08x + 8.2331	y = 0.0484x + 8.377
		R² = 0.147	R² = 0.070
	II.	y = 0.0713x + 10.547	y = 0.0416x + 10.669
		R² = 0.097	R² = 0.039
	III.	y = 0.2456x + 9.3809	y = 0.2144x + 9.5952
		R² = 0.406	R² = 0.352
	IV.	y = 0.0597x + 15.971	y = 0.0203x + 16.435
		R² = 0.095	R² = 0.016

Note: E.g. according to regression equations, 10°C under grass (independent value) means 12.5°C or 11.3°C under Sherpa or PX 104 varieties, respectively (dependent value); depth 50 mm, developmental period II.

As can be seen from the Table 2, the prediction of soil temperature cannot be done from the air temperature in the ground of rape canopy recorded at the same time, because coefficients of determination were usually very low. As it was found out by cross correlation analysis, the best interrelationships between these two variables were achieved in 2 hours delay for the soil temperature in 50 mm and 4 hour delay for 100 mm in variety Sherpa and 6 hours delay for the soil temperature in 50 mm and 7 hour delay for 100 mm in variety PX 104. After the time correction the determination coefficient reached values from 0.85 to 0.89 for 50 mm and 0.66 to 0.79 for 100 mm in variety Sherpa. For variety PX 104 this coefficient reached values from 0.51 to 0.72 in 50 mm depth and from 0.39 to 0.67 in 100 mm depth.

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. From our results is evident, the relationships between temperatures measured in soil can be influenced by architecture of particular variety of the same crop. Plant architectural traits have been reported to impact pest and disease occurrence and development, because spatial distribution of leaves in space can determines the within plant microclimate and the shoot distribution, topological connections which influence the within plant propagation of attackers [9, 10, 11]. From this point of view, the type of varieties should be included in prediction models.

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

Variety	Stage	50mm (non)	50mm (corr)	100mm (non)	100mm (corr)
Sherpa	I.	y = 0.3096x + 7.3078	y = 0.3787x + 6.6993	y = 0.1036x + 9,1157	y = 0.2177x + 8.0333
		R^2 = 0.586	R^2 = 0.851	R^2 = 0.169	R^2 = 0.713
	II.	y = 0.3742x + 8.5843	y = 0.4434x + 7.6644	y = 0.1507x + 11.145	y = 0.2687x + 9.5759
		R^2 = 0.611	R^2 = 0.865	R^2 = 0.202	R^2 = 0.657
	III.	y = 0.6965x + 5.1382	y = 0.7257x + 4.8217	y = 0.4888x + 7.8786	y = 0.5554x + 6.9424
		R^2 = 0.824	R^2 = 0.893	R^2 = 0.613	R^2 = 0.790
	IV.	y = 0.572x + 9.8985	y = 0.6173x + 9.1475	y = 0.2224x + 15.882	y = 0.3569x + 13.389
		R^2 = 0.729	R^2 = 0.886	R^2 = 0.290	R^2 = 0.789
Px 104	I.	y = 0.0762x + 8.3578	y = 0.1823x + 7.4192	y = 0.0455x + 8.4571	y = 0.1432x + 7.5964
		R^2 = 0.103	R^2 = 0.586	R^2 = 0.048	R^2 = 0.477
	II.	y = 0.1136x + 10.184	y = 0.2376x + 8.7536	y = 0.0698x + 10.414	y = 0.1897x + 9.0369
		R^2 = 0.110	R^2 = 0.514	R^2 = 0.049	R^2 = 0,393
	III.	y = 0.3479x + 8.3266	y = 0.4063x + 7.5293	y = 0.3103x + 8.577	y = 0.3675x + 7.8021
		R^2 = 0.530	R^2 = 0.719	R^2 = 0.480	R^2 = 0.667
	IV.	y = 0.0432x + 16.278	y = 0.1483x + 14.36	y = 0.0082x + 16.66	y = 0.1109x + 14.783
		R^2 = 0.052	R^2 = 0.634	R^2 = 0.003	R^2 = 0.512

Note: E.g. according to regression equations, ground air temperature 15°C (independent value) means 9.1°C in real time and 14.3°C with 2 hours delay under Sherpa variety (dependent value); depth 50 mm, developmental period II.

Conclusion

As is evident from regression analyses, the course of temperatures can significantly differ in soil under various plant cover and from ones measured in plant stand. The 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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