6th International Conference on Trends in Agricultural Engineering
7 - 9 September 2016, Prague, Czech Republic

INFLUENCE OF WEATHER CONDITIONS ON WASTE BIOMASS PRODUCTION IN THE VYSOČINA REGION OF THE CZECH REPUBLIC

O. Chotovinský[1], V. Altmann[2], M. Přikryl[1]

[1]Department of Technological Equipment of Buildings, Faculty of Engineering, Czech University of Life Sciences Prague, Czech Republic
[2]Department of Machinery Utilization, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Czech Republic

Abstract

The significant effect of change climatic and weather conditions on crop biomass yields is often observed in various regional production areas during the last decade. Starting with the Vysočina Region within the period of 2007–2011, the present article studies the relation between weather conditions and the volume of municipal residue biomass. A statistically significant impact of rainfall level on municipal residue biomass production has been demonstrated by simple regression. Available data for individual years confirm the regression compensation straight line of average monthly precipitation $\boldsymbol{p}$ and the average biodegradable municipal solid waste production per one collection $\boldsymbol{T}$ in the researched municipality of the Vysočina Region: $T = 0.542 + 0.659.p$. The development of biodegradable municipal solid waste collection in the researched municipality has also been described and evaluated.

Key words: biodegradable municipal solid waste, biodegradable municipal solid waste collection, municipal residue biomass, weather conditions.

INTRODUCTION

Residual Waste biomass (MRB), the source of which is biodegradable municipal solid waste (BMSW) or the biodegradable part of rest municipal solid waste (RMSW) is considered a potential source of perennial bioenergy (GREG, 2010). Most of the biomass of this kind is collected and aggregated in population centers with high energy demands. The availability of this energy source increases together with the population growth rate and energy consumption per capita (BOGNER ET AL., 2003). Implementation of equipment utilizing this potential requires significant investments (EIA, 2009). Nevertheless, technologies using this type of biomass are improving and gradually displacing fossil energy. As a consequence, the formation of methane during storage of biological biodegradable components of MSW at dump areas can be reduced (CONSONNI ET AL., 2005).

Biodegradable municipal waste means biodegradable waste from households, as well as other biodegradable waste, which because of its nature and composition is similar to biodegradable waste from households (EEA, 2002). Tab. 1 shows an overview of BMSW types according to legislation in the Czech Republic (MŽP, 2001).

Tab. 1. – Summary of biodegradable municipal solid waste

Code No.*	Name of the Type of Waste
20 01 01	Paper and cardboard with the exception of highly glossing paper and the wallpaper waste
20 01 08	Cafeteria biodegradable waste
20 01 10	Clothing
20 01 11	Textiles
20 01 38	Wood not included in 20 01 37
20 02 01	Biodegradable waste
20 03 01	Rest municipal solid waste
20 03 02	Marketplace waste
20 03 07	Bulky waste

The service of waste collection is defined as a combination of a certain technology and a human labor (Bilitewsky et al., 1997). The term ‘waste collection’ includes not only the collection itself, but also the transfer of waste to places where collecting vehicles are unloaded and loaded (Tchobanoglous et al., 1993). Typically, BMSW separated at the source are separated for reuse (recycled). The three principial methods now used for the collection of BMSW from residential sources include (Tchobanoglous et al., 2002):

1. Curbside collection using conventional and specially designed collection vehicles
2. Incidental curbside collection by charitable organizations
3. Delivery by residents to drop-off centers

The potential for the use of BMSW in the Czech Republic is based on an analysis of MSW potential. The potential of the remaining municipal waste (RMSW) and garden waste (including public green) in 2020 are forecasted to amount to 3.8 and 0.6 million tons respectively (MZe, 2012).

A number of recent studies have analyzed the role of climate effects and weather conditions on biomass production from the perspective of varying crop yields. The climate-biomass production relationships are documented and several examples of extremely/very low yields in the selected region and periods improve our understanding of the most important climatic factors and weather conditions. Understanding these causes and role of these events is critical for improving our ability to analyze chances both under present and, more importantly, expected conditions (e.g. Lobell et al., 2011; Olsen et al., 2012; Lavalle et al., 2009; Peltonen–Sainio et al., 2010; Kolař et al., 2013). However, the possible response of weather conditions on waste biomass production is not extensively observed today.

The basic objective of the study is an evaluation of BMSW separate collection data in the urban municipality of Náměšť nad Oslavou, covering the period of 2007–2011. Weather conditions of the same period and region are also analyzed and compared to their actual impact on waste biomass production. Description of the influence on waste biomass production including the impact of weather change as a possible limiting factor for continues reuse of biomass.

MATERIALS AND METHODS

Náměšť nad Oslavou – Biodegradable municipal solid waste production data

The urban municipality of Náměšť nad Oslavou (49.217°N, 16.150°E) is situated on the foot of the Czech-Moravian Highlands at an altitude of 365 metres. The urban municipality belongs to the Vysočina Region (Třebíč district); 20 km east of Trebic on the River Oslava. Its territory mostly constitutes agricultural and forest land (795 and 796 hectares respectively). The built-up area spans 48 hectares with 53 hectares of gardens. 4955 permanent residents live in 862 family houses and 52 blocks of flats in 2011 year. Gas is the most common heating medium. Separate collection of BMSW can be considered fully developed, with good access throughout the territory of municipality. Both drop-off and curbside collections are applied. 0.77 m^3 containers and 0.24 m^3 containers (previously used), as well as large volume containers (18 m^3) are placed in the municipality.

Tab. 2 and 3 specify, on a month-by-month basis, the BMSW production in Náměšť nad Oslavou in 2007 and 2011 (peripheral input data). These tables summarize also the real number of containers/month, available per collection drive.

Tab. 2. – Biodegradable municipal solid waste (20 02 01) in Náměšť nad Oslavou in 2007

Month	**Production [t]**		**Collected containers per month [pcs.month^{-1}]**		**Collections per month [drives.month^{-1}]**	
	C_{BMSW} 0.24 m^3	LSC 18 m^3	C_{BMSW} 0.24 m^3	LSC 18 m^3	C_{BMSW} 0.24 m^3	LSC 18 m^3
April	2.06	-	80	-	1	-
May	8.69	-	80	-	4	-
June	7.99	14.24	80	1	4	3
July	10.77	9.53	80	1	5	2
August	10.93	4.03	80	1	4	1
September	8.25	8.02	80	1	4	2
October	12.66	4.07	80	1	5	1
November	4.91	21.20	80	-	2	-

C_{BMSW} – adjusted BMSW containers; LSC – large-sized containers; Source: research ESKO-T s.r.o.

Tab. 3. – Biodegradable municipal solid waste (20 02 01) in Náměšť nad Oslavou in 2011

	Production [t]		**Collected containers per month [pcs.month^{-1}]**		**Collections per month [drives.month^{-1}]**	
Month	C_{BMSW} 0.77 m^3	LSC 18 m^3	C_{BMSW} 0.77 m^3	LSC 18 m^3	C_{BMSW} 0.77 m^3	LSC 18 m^3
April	7.96	3.57	34	1	3	3
May	16.07	3.84	34	1	5	3
June	13.84	3.59	34	1	4	2
July	12.44	-	34	-	4	-
August	16.20	-	34	-	4	-
September	19.16	-	34	-	5	-
October	11.62	-	34	-	3	-
November	3.93	-	34	-	1	-

C_{BMSW} – adjusted BMSW containers; LSC – large-sized containers; adjusted BMSW containers (volumes of 0.24 m^3) were changed for adjusted BMSW containers with volumes of 0.77 m^3 in 2009

Source: research ESKO-T s.r.o.

Náměšť nad Oslavou - Long-term climate data

The region is moderate warm. Favourable water regime ensures stable soil water content. The period annual average air temperature is 14–18°C in June and -3°C in January. The annual precipitation totals reach 350–400 mm in the vegetation period and 200–250 mm in winter.

The Czech Hydrometeorological Institute (CHMI) conducts regular meteorological observations at more stations within the concerned region. Manually measured data used for this study cover long term monthly average air temperatures [°C], measured at the Sedlec station, and long term monthly total precipitation [mm] at Náměšť nad Oslavou, both for the period of 2007 to 2011 (see input, Tab. 4 and 5).

Tab. 4. – Monthly average air temperatures [°C]

Year	**Month**											
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
2010	3.0	2.6	5.7	11.5	15.0	19.2	19.4	19.0	12.2	7.7	1.3	-1.5
2011	0.7	2.3	3.4	8.9	14.7	18.8	19.1	18.9	13.0	8.9	5.2	0.8
2012	-3.3	-0.8	3.5	13.2	13.9	15.6	18.9	19.4	15.9	7.9	5.2	-0.8
2013	-4.2	-1.5	3.5	8.8	12.2	17.0	20.4	17.6	12.2	6.3	5.1	-4.8
2014	-1.2	-1.4	4.8	11.1	14.1	17.6	17.3	19.4	16.0	8.4	2.2	1.3

Source: CHMI

Tab. 5. – Monthly total precipitation [mm]

Year	**Month**											
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
2010	1.9	2.2	6.3	2.6	2.5	4.2	4.8	3.9	3.6	1.2	3.3	0.9
2011	1.0	1.5	2.3	2.8	2.4	4.2	2.9	3.1	2.5	1.0	1.8	1.6
2012	1.7	2.3	3.3	2.1	3.4	5.4	7.0	2.4	2.0	1.8	2.4	2.2
2013	2.6	1.4	1.0	5.0	5.7	10.7	8.0	6.7	5.6	1.3	1.9	1.9
2014	1.4	0.7	4.8	2.7	7.4	6.2	4.5	3.8	6.3	2.9	0.3	1.0

Partial correlation and regression model – Methodology

When working simultaneously with several variables, we need to assess the mutual dependence of their pairs without the influence of the others. The first option is to calculate correlation coefficients for all pairs of variables and establish the so-called correlation matrix. Calculation of correlation coefficients for the pairs, however, cannot capture higher-level interactions. To obtain these, we can use partial correlation coefficients. These express an interdependence of two variables, provided that other variable does not change. For example $r_{ij.k}$ expresses the interdependence of variables *Xi* and *Xj*, provided that *Xk* does not change (LEPŠ & ŠMILAUER, 2014).

The simplest regression method is the linear model of regression, i.e. a straight line, where the relation between two quantitatively measured characteristics (Y and X) is represented the equation the $Y = a + b * X + \varepsilon$. The parameters (regression coefficients) a and b have specific numerical values that we try to estimate based on the collected data (sample data); the symbol ε represents the stochastic (non-deterministic) part of the model (ŠMILAUER, 2007).

Analysis of variance is a part of regression analysis. Through this analysis, we determine the suitability of the selected regression model by using the *F*-test (ANOVA in regression). In this decomposition, we describe how a large part of the total variability in the values of the given variable can be explained by the chosen model and how significant is the remaining (unexplained) part. This analysis is based on the relation. A suitable regression model must contain a sum of explained squares which is greater than the residual sum of squares. When testing this assumption, we verify the null hypothesis H_0: The selected functional relation between the dependent and independent variable does not exist (LITSCHMANNOVÁ, 2011).

The program STATISTICA 8 was used to analyze the data and obtain the necessary characteristics of above-mentioned statistical methods.

Standard transformation for the regression model – Methodology

In order to obtain a more precise interpretation of the described data, a standardized transformation has been applied. This eliminates possible interruptions in the continuous measurement conducted by CHMI (unmeasured precipitation). This model, which is also more suitable for handling winter months without BMSW (20 02 01) collection in the municipality, is depicted in Tab. 6.

Tab. 6. – Standard transformation

Quater of Years	**Average BMSW production per one drive of collection [t]**	**Average Monthly temperature [°C]**	**Average Monthly precipitation [mm]**
1Q	$\frac{1}{3}(\frac{1}{n}\sum_{i=1}^{n} x_i + \frac{1}{n}\sum_{i=1}^{n} x_i + \frac{1}{n}\sum_{i=1}^{n} x_i)$	$\frac{t_1 + t_2 + t_3}{3}$	$\frac{p_1 + p_2 + p_3}{3}$
2Q	- „ -	- „ -	- „ -
3Q	- „ -	- „ -	- „ -
4Q	- „ -	- „ -	- „ -

$x_{i(0.12;\,0.23)}$ – amount of biodegradable municipal solid waste in C_{BMSW} – adjusted BMSW containers in C_{BMSW} containers (0.12 and 0.24 m^3)/drive of collection; n – number of collection (drive of collection); t_1, t_2, t_3 – monthly average air temperatures of the relevant quarter; p_1 , p_2 , p_3 – monthly total precipitation of the relevant quarter

RESULTS

The Municipality placed three types of BMSW containers in the built-up area already in recently time. Their usage is as follows:

- C_{BMSW} containers 0.24 m^3 and 0.77 m^3 – BMSW from residences,
- LSC containers 18 m^3 – BMSW from public green areas.

The year-by-year development of the number of BMSW containers and their collection is presented in Tab. 7 below.

The number of C_{bmsw} 0.24 m^3 containers and the number of C_{bmsw} 0.77 m^3 containers (and the associated change of the number of participating residences) influenced the total volume of collected BMSW between 2007 and 2011. This trend, recalculated to

BMSW production per one collection drive, is presented in Tab. 8 below. This table also represents the standard data transformation for the regression model.

Tab. 7. – Number of biodegradable municipal solid waste containers and number of collected containers per month in the municipality of Náměšť nad Oslavou

Year	**C_{BMSW} 0.24 m^3** (total containers/ collected containers per month)	**C_{BMSW} 0.77 m^3** (total containers/ collected containers per month)	**LSC 18 m^3** (total containers/ collected containers per month)
2007	88/330	-	1/2.7
2008	88/310	-	1/3.8
2009	-	33/137	1/1.5
2010	-	34/123	1/2.3
2011	-	34/123	1/2.6

C_{BMSW} – adjusted BMSW containers; LSC – large-sized containers

Tab. 8. – Average values from data obtained for individual quarters of the years 2007 – 2011 (Standard transformation)

Quarter and year	**Average BMSW production per one collection drive [t]***	**Average Monthly temperature [°C]**	**Average Monthly precipitation [mm]**
1Q 2007	0	0	0
1Q 2008	0	0	0
1Q 2009	0	0	0
1Q 2010	0	0	0
1Q 2011	0	0	0
2Q 2007	2.07	13.82	2.56
2Q 2008	2.98	14.12	3.13
2Q 2009	2.48	14.21	3.64
2Q 2010	3.78	12.65	7.15**
2Q 2011	3.11	14.29	5.42
3Q 2007	2.31	16.85	4.12
3Q 2008	4.03	17.00	2.80
3Q 2009	4.59	18.08	3.78
3Q 2010	4.32	16.76	6.76
3Q 2011	3.66	17.56	4.87
4Q 2007	1.66	3.85	2.24
4Q 2008	1.96	4.97	1.44
4Q 2009	2.58	4.11	2.13
4Q 2010	2.74	2.18	1.68
4Q 2011	2.06	3.94	1.38

* - collection of C_{BMSW} containers (0.24 and 0.77 m^3)

** - high leverage point, extreme precipitation in June

The results of the analysis, presented in the Tab. 8, first focused on determining the correlation coefficient (the Correlations matrices function) between the average BMSW production per one collection drive in the given quarter [t] and other variables, namely the average monthly temperature [°C] and the average monthly precipitation [mm]. The results, presented in Tab. 9, confirm an individual linear dependence. The partial coefficient 0.5707 demonstrated a correlation between the average daily temperatures and average daily precipitation (Tab. 10). Therefore only the more significant variable (average monthly precipitation) has been used for the next calculation.

‘*F* statistics’, resulting from the analysis of the variance regression model, was carried out as an intermediate step of the selected regression function (Tab. 11).

Tab. 9. – Result of correlation values

	Correlations (Tab. 8) Marked correlations are significant at $p < 0.05000$ N=20 (Case deletion of missing data)	
Variable	[°C]	[mm]
[t]	0.8475	0.8518
	p=0.000	p=0.000

Tab. 10. – Result of partial correlations

	Partial correlations (Tab. 8) Marked correlations are significant at $p < 0.05000$ N=20 (Case deletion of missing data)	
Variable	[°C]	[mm]
[°C]	1.0000	0.5707
	p= ---	p=0.011
[mm]	0.5707	1.0000
	p=0.011	p= ---

Tab. 11. – ANOVA results

	Analysis of Variance; *DV*: [t] (Tab. 8)				
N=20	Sums of Squares	*df*	Mean Squares	*F*	*p*-level
Regress	34.02646	1	34.02646	47.57438	0.000002
Residual	12.87408	18	0.71523		
Total	46.90053				

Values of the Mean Squares in Tab. 12 were used for testing the significance of the regression model, whereas the key value used was the ratio of the model mean square and the residual mean square. In the case of the null hypothesis, the value of this ratio should be relatively close to 1 (i.e., the explained and unexplained variability should be of a similar size). More precisely (for this particular model), it should originate from the F disturbance with a parameter value of 1.18 (for the presented model). Nevertheless, the probability that the true value of this ratio, i.e. the *F* statistic (with a value of 47.57438), originates from this F disturbance is less than 0.000001 or equal to 0^6, as confirmed by the values in the '*p*-level' column. Hence H_0 can be rejected with this probability of a Type I error (at the concerned level of significance).

We present below a graphical representation of the regression line, (Fig. 1).

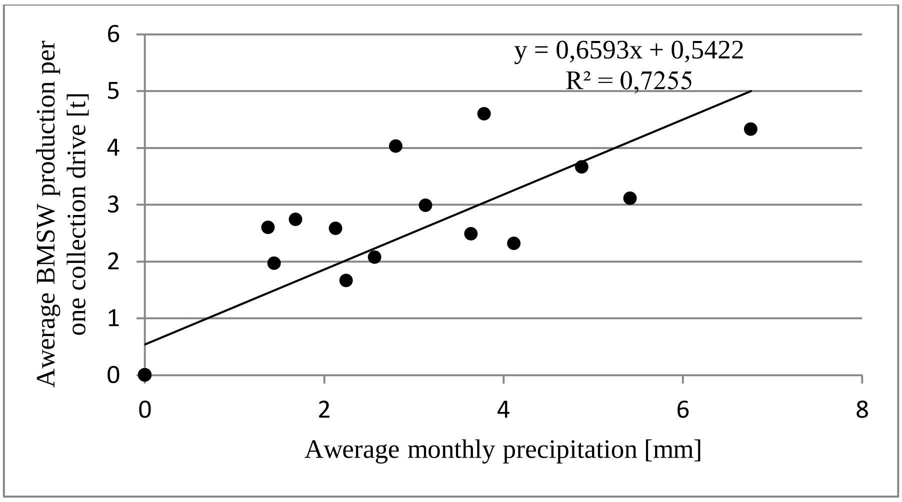

Fig. 1. – Graphical representation of regression

DISCUSSION

An assessment of the mean values of weather conditions proves a statistically significant relation between the average BMSW production per collection and the average monthly precipitation ($r = 0.8518$, $\alpha = 0.05$, $n = 20$), as well as between the BMSW production and the average monthly temperature ($r = 0.8475$, $\alpha = 0.05$, $n = 20$). SIDLAUSKAS (2003) has shown a very similar that seed yield of spring oilseed rape correlated well with the duration of vegetative growth period, precipitation rate and mean daily temperature. In other words, the biomass waste production in the municipality of Náměšť nad Oslavou could depend on weather conditions of the growing season. The positive relationship was furthermore enriched by regression analysis; however this does not necessarily reflect a causal relation (in fact, only non-manipulated areas have been observed). Together with some other factors, the yield of biomass is considerably dependent on the weather condition. For instance, these factors generaly include the onset of the spring, moisture and temperature conditions for emergence and tillering and the content of the available soil nitrogen (PETR & MIČÁK, 2009). Furthermore, as the distribution of regression residuals around the x-axis shows, there exist some differences between real (observed) and predicted (fitted by the regression model) values of the variables in the regression equation. Thus, BMSW production could have been influenced by others non-measured factors.

The change of technological parameters, respectively the associated change of volumes of C_{BMSW} 0.24 m^3 containers for C_{BMSW} 0.77 m^3 containers may influence unexplained points of analyzed components; additionally, fluctuations of both analyzed climate data could also played a role.

MUŽÍKOVÁ ET AL. (2013) describe similar statistically conclusive results concerning the influence of weather conditions; they proved a close relation between the values of available water capacity and biomass production of selected crops in the Czech Republic (in 1976–2007). STŘEDOVÁ ET AL. (2011) published an analysis of several temperature and precipitation indexes and their changes, with an emphasis on the increase of above-normal temperature months and the loss of normal rainfall months. MUŽÍKOVÁ ET AL. (2011) have also documented the future increase of extremities in the weather conditions across the Czech Republic.

CONCLUSIONS

The principal objective of the present study was an evaluation of BMSW collection in the municipality of Náměšť nad Oslavou in the period of 2007–2011. The authors also studied the influence of selected climatic factors on BMSW production of an urban municipality.

The study proves that weather conditions influence BMSW production and mathematically defines this dependence. Available data for individual quarters of 2007–2014 confirm the following regression compensation straight line of average monthly precipitation $\boldsymbol{p}$ and the average BMSW production per one collection $\boldsymbol{T}$ in the municipality of Náměšť nad Oslavou: $T = 0.542 + 0.659.p$.

A perspective BMSW separete collection that includes full cost accounting of separete collection of waste, handling, and processing must incorporate marketing, distributing, and recycling in a life cycle analysis that reflects external costs and societal benefits. In this view of systems perspective, the influence of weather conditions may become a new, complementary, approach to flowing the costs of separate collection of BMSW, including the limiting impact on the balance of input converting matter for reuse. This should be taken into consideration when developing BMSW collection processes. The well-chosen technological parameters of BMSW separate collection play an important role too.

ACKNOWLEDGEMENTS

The work has been supported by the Internal Grant Agency of Czech University of Life Sciences Prague, Project No. 2014: 31180/1312/3132.

REFERENCES

1. BILITEWSKY, B., HARDTLE, G., MAREK, K.: Waste Manegement . 1st ed. Verlag Berlin Heidelberg, DEA, Springer 1997.
2. BOGNER, J., MATTHEWS. E.: Global methane emissions from landfills: new methodology and annual estimates 1980–1996. Global Biogeochemical Cycles, 17, 2003: 1–18.
3. CONSONNI, S., GIUGLIANO, M., GROSSO, M.: Alternative strategies for energy recovery from municipal solid waste, Part B, emission and cost estimates. Waste Management, 25, 2005: 137–148.
4. GREG, J. S.: National and regional generation of municipal residue biomass and the future potential for waste-to-energy implementation. Biomass & Bioenergy, 34, 2010: 379–388.
5. KOLÁŘ, P., TRNKA, M., BRÁZDIL, R. HLAVINKA, P.: Influence of climatic factors on the low yields of spring barley and winter wheat in Southern Moravia (Czech Republic) during the 1961–2007 period. Theoretical and applied Climatology, 117, 2014: 707–721.
6. LAVALLE, C., MICALE, F., HOUSTON, TD., CAMIA, A., HIEDERER, R., LAZAR, C., CONTE, C., AMATULLI, G.,

GENOVESE, G.: Climate change in Europe. 3. Impact on agriculture and forestry. A review. Agronomy for Sustainable Development, 29, 2009: 433–446.

7. LEPŠ, J., ŠMILAUER, P.: Biostatistika. České Budějovice, the Czech Republic, Univerzity of South Bohemia in České Budějovice 2014.
8. LITSCHMANNOVÁ, M.: Úvod do statistiky. Ostrava, the Czech Republic, VŠB – Technical University of Ostrava 2011.
9. LOBEL, D. B., SCHLENKER, W. , COSTA-ROBERTS, J.: Climate trends and global crop production since 1980. Science, 29, 2011: 616–620.
10. EEA: Biodegradable municipal waste management in Europe. European Environment Agency, Copenhagen, DKA. Available at: www.eea.europa.eu. Accessed 21 March 2002.
11. EIA: Methodology for allocating municipal solid waste to biogenic and non-biogenic energy. US. Energy Information Administration, Washington DC, USA. Available at: www.eia.gov. Accessed 1 May 2007.
12. MŽP: Katalog odpadů. Ministry of the Environment of the Czech Republic, Prague, CZA. Available at: www..mzp.cz. Accessed 17 October 2001.
13. MZE: Akční plan pro biomasu v ČR na období (2012–2020). The Ministry of Agriculture of the Czech Republic, Prague, CZA, 2012. Available at: www.eagri.cz. Accessed 12 September 2012.
14. MUŽÍKOVÁ, B., VLČEK, V., STŘEDA, T.: Tendencies of climatic extremes occurrence in different Moravian regions and landscape types. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 5, 2011: 169–178.
15. MUŽÍKOVÁ, B., STŘEDA, T., KRMELOVÁ P.: Výnosy ječmene setého v klimatických podmínkách České republiky. Kvasný průmysl, 59, 2013: 352–357.
16. OLESEN, JE., BORGENSEN, CD., ELSGAARD, L., PALOSUO, T., ROTTER, R., SKJELVAG, AO., PELTONEN-SAINIO, P., BORJESSON, T., TRNKA, M., EWERT, F., SIEBERT, S., BRISSON, N., EITZINGER, J., VAN DERFELS-KLERX, HJ., VAN ASSELT, E.: Changes in time of sowing, flowering and maturity of cereals in Europe under climate change. Food Additives & Contaminants, 29, 2012: 1527–1542.
17. PELTONEN-SAINIO, P., JAUHIAINEN, L., TRNKA, M., OLESEN, JE., CALANC, PL., ECKERSTEN, H., EITZINGER, J., GOBIN, A., KERSEBAUN, KC., KOZYRA, J., KUMAR, S., MART, AD., MICALE, F., SCHAAP, B., SEGUIN, B., SKJELVAG, AO., ORLANDINI, S.: Coincidence of variation in yield and climate in Europe. Agriculture, Ecosystems Environment, 139, 2010: 483–489.
18. PETR, J., MIČÁK, L.: Yield formation in the spring barley in organic farming. Scientia Agriculturae Bohemica, 10, 2009: 110–114.
19. SIDLAUSKAS, G., BERNOTAS, S.: Some factors affecting seed yield of spring oilseed rape (Brassica napus L.). Agronomy Researched, 1, 2003: 229-243.
20. STŘEDOVÁ, H., STŘEDA, T., MUŽIKOVÁ, B.: Trend teplotních a srážkových podmínek v zemědělsky intenzivních oblastech. Úroda, vědecká příloha, 10, 2011: 590–596.
21. ŠMILAUER, P.: Moderní regresní metody. České Budějovice, the Czech Republic, Univerzity of South Bohemia in České Budějovice 2007.
22. TCHOBANOGLOUS, G., THEISEN, H., VIGIL AS.: Integrated Solid Waste Management.1st ed. New York, USA, McGraw-Hill 1993.
23. TCHOBANOGLOUS, G., KREITH, F.: Handbook of solid waste management. 2nd ed. New York, USA, McGraw-Hill 2002.

Corresponding author:

Ing. Ondřej Chotovinský, Department of Technological Equipment of Buildings, Faculty of Engineering, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6, Prague, 16521, Czech Republic, e-mail: chotovinsky@tf.czu.cz