THE INFLUENCE OF THE CLIMATE CONDITIONS ON WHEAT YIELDS, CULTIVATED ON A LUVOSOL FROM ORADEA, CONTROLATED POLLUTED WITH OIL

INFLUENȚA CONDIȚIILOR CLIMATICE ASUPRA PRODUCȚIILOR DE GRÂU, CULTIVAT PE LUVOSOLUL DE LA ORADEA, POLUAT CONTROLAT CU ȚIȚEI

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***Abstract*: *The paper presents the results of the researches carried out at the Agricultural Research Station Oradea, between 1996 and 2002, regarding agricultural yield of spring wheat, cultivated on a luvosoil polluted under control with oil brought from the exploitation site at Suplacu de Barcău, Bihor County. The experimental device was made out of micro parcels of 1 m², set up in a randomized manner, in a Latin square, polluted with a concentration of: 0, 1, 3, 5 and 10 % (0, 3, 9, 15, and 30 l/m²), oil in the ploughed layer, in 4 repetitions. The experience was than cultivated with in the first three years with millet, a plant that is considered to be resistant to pollution, and than until 2002 with spring wheat. The analysis of the yield losses from the parcels polluted with oil in various concentrations, have shown that these decreases in time, becoming insignificant after 7 years in the concentration of 1 %, 8 years in the concentrations of 3 - 5 %, and 9 years for 10 %. This shows the biodegradation of the oil without any sort of agropedomeliorative measures. By analyzing the correlations between the wheat yields in the last 7 years of research and the climate factors (rainfall and air temperature) registered in the vegetation period, very significant square, spatial polynomial correlations were established for each oil concentration. The fact that correlation report decreases from 0.7458, for the parcels unpolluted (0 % oil), to 0,4170 for the parcels polluted 10 % oil points out the influence of the increase of the pollutive agent.*

***Rezumat*: *Lucrarea prezintă rezultate ale cercetărilor efectuate la Stațiunea Agricolă de Cercetare Dezvoltare Oradea, între 1996 şi 2002 privind producțiile agricole ale grâului de primăvară, cultivat pe luvosolul poluat controlat cu țiței adus din câmpul de extracție Suplacu de Barcău, Județul Bihor. Experiența este de tip pătrat latin cu microparcele de 1 m^2, aşezate randomizat în 4 repetiții, cu variante de poluare cu țiței, în concentrații de 0, 1, 3, 5 şi 10 % (0, 3, 9, 15, şi 30 l/m²), pe stratul arat. Suprafața experienței a fost cultivată apoi, în primii trei ani cu mei, plantă considerată mai tolerantă la condițiile de poluare şi apoi, până în anul 2002 cu grâu de primăvară. Analiza pierderilor de producție realizate de plantele cultivate pe parcelele poluate cu diferite concentrații de țiței a arătat că acestea se reduc în timp, devinind nesemnificative după 7 ani la concentrația de 1 %, 8 ani la concentrațiile de 3-5 % şi 9 ani pentru 10 %. Aceasta arată că țițeiul este biodegradat fără nici un fel de măsuri agropedoameliortive. Analizând corelațiile dintre producțiile de grâu din ultimii 7 ani de cercetări şi factorii climatici (precipitații şi temperaturi) înregistrați în perioada de vegetație au fost stabilite pentru fiecare concentrație de țiței, corelații polinomiale spațiale foarte semnificative statistic. Faptul că coeficienții de corelație se reduc de la 0,7458, pentru parcelele nepoluate (0% țiței) la 0,4170 pentru parcelele poluate cu 10 % țiței arată că influența agentului poluant creşte odată cu concentrația administrată.*

Key words: *oil pollution, luvosoil, biodegradation;*
Cuvinte cheie: *poluare cu țiței, luvosol, biodegradare;*

INTRODUCTION

The pollution of soil with oil residue is a very complex phenomenon that involves knowing the chemical nature and concentration of the pollutant and the soil conditions (COLIBAȘ I. et al 1995, SABĂU N et al., 2002).

The extraction, processing and transportation of the oil products in the conditions of Bihor County took place at the oil plants in Suplacu de Barcau, Marghita and Oradea, today OMV centers and in the SC Petrolsub SA Refinery, in Suplacu de Barcau, today in preservation. Because of these activities the soil is affected by historical pollution, approximately 200 ha are affected and are in need of measurements for ecological reconstruction (SABĂU N et al., 2006).

For the conditions of Western Romania, Colibas I., and coworkers published in 1995 the first partial results of researches regarding yield losses in millet, first year polluted with oil residue in controlled circumstances with various doses of oil. Later on Sabău N.C. and Șandor Maria – 2006, Sabău N.C. – 2007 and Șandor Maria, Sabău N.C. and coworkers – 2007 publish the results of researches regarding yield of oil polluted plots that took place at the Agricultural Research Station in Oradea, and correlations between yield and the concentration of oil residue n the soil (SABĂU N et al., 2006, 2007; ȘANDOR MARIA et al, 2007).

The researches carried out by Toti Mh and coworkers – 2003, on the effect of oil pollution on the agricultural land from the extraction locations form the Southern part of the country have shown that the plant's life is affected at a very mild pollution of 1 kg/m^2 (0,3 %) oil residue (TOTI M. et al., 2003). The authors consider that at higher concentrations - 1,5 - 3,0 kg/m^2 (0,5 - l,0 %) pollution is moderate, between 3 - 15 kg/m^2 pollution becomes strong, between 15 - 30 kg/m^2 pollution is very strong, the seeds of the plants no longer germinate, and over 30 kg/m^2 pollution is excessive.

MATERIAL AND METHODS

The researches carried out in Oradea had as an objective the study of the effects caused by oil residue from Suplacu de Barcau on agricultural yields, and on the time needed for biodegradation without any improvement measures.

Almost half the soils in Romania (49,397%) that are affected by pollution with oil are luvosoils, and that the soil from Suplacu de Barcău is also a luvosoil, the experience carried out was placed also on a luvosoil (COLIBAȘ I. et al 2000).

The experimental field was set up in 1993 and is made out of microparcels of 1 m^2, set up in latin square, randomized in four repetitions, polluted under control with oil from Suplacu de Barcău, with 0, 3, 9, 15 and 30 l/m^2, thus having the following concentrations with 0 in the ploughed layer (unpolluted witness), 1, 3, 5 and 10 %.

The field was cultivated with millet in the first three years (1993 – 1995), a plant that has an increased tolerance to pollution and that for the next seven years (1996-2002) with spring wheat, Speranța breed.

After analyzing the agricultural yields obtained in millet (hay) and spring wheat have shown that the yield differences decrease in time without applying any corrective measures. They become insignificant after 7 years in the variant polluted with 1% oil, after 8 years in concentration from 3 – 5 %, and after 9 years in the 10 % variant. This implies that the biodegradation of the oil residue took place.

Starting from this observation this paper is committed to evaluating the influence of the climate factors, rainfall and temperature, on the biodegradation process, through the accomplished spring wheat yields in the last seven years of research.

RESULTS AND DISCUSSIONS

The climate conditions characterized by annual rainfall and temperature show that the 7 year period studied had with 70,7 mm more rainfall than the annual average and was warmer with 0,5 ˚C (table 1).

Table 1

Climate characteristics from the research period\ Oradea Weather Station (1996-2002)

Nr. crt.	Year	Rainfall		Temperatures	
		mm	Differences	˚C	Differences
1	1996	886,0	+251,0	9,6	-0,9
2	1997	710,4	+75,4	11,4	+ 0,9
3	1998	786,6	+151,6	10,3	- 0,2
4	1999	827,7	+192,7	10,9	+0,4
5	2000	367,0	-268,0	12,0	+1,5
6	2001	830,6	+195,6	10,8	+0,3
7	2002	531,5	-103,5	11,9	+1,4
	Average 1996-2002	705,7	+70,7	11,0	+ 0,5
	Multiannual Average	635,0	-	10,5	-

The annual rainfall was between 367,0 mm in 200 and 886,0 mm in 1996, having diverted from the annual average with values between – 268,0 mm and + 251,0 mm. The values registered show that the period studied had rainy, wet, only two years having negative differences.

The variation interval of the average annual temperatures was between 9,6 – 12,0 ˚C, values that were registered in 1996 and 2000, with variations when compared to the multiannual average of -0,9 - 1,5 ˚C, showing warmer years than the annual average.

The annual average agricultural yield of the unpolluted plots vary due to the climate conditions in the 7 years of research; they decrease in the first five years of crop (from 21,8 q/ha in 1996 to 4,0 q/ha in 2000), and increase at 10,5 q/ha in the last year (figure 1).

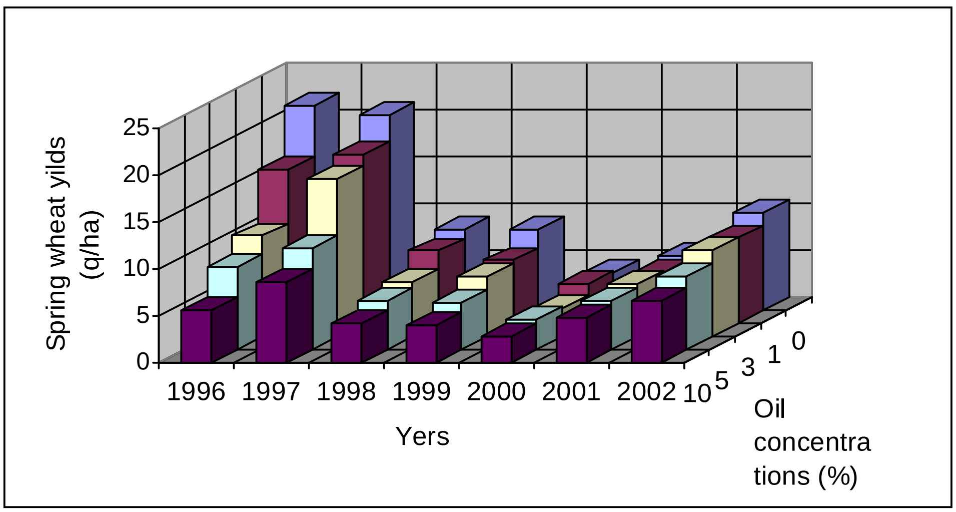

Figure 1. The influence of soil pollution with petroleum on wheat yields, q/ha (1996 – 2002)

The yields of the variants polluted under control with oil residue have the same tendency; a decrease of yields in correlations with the effect pollution it shows.

In order to highlight the effect of the climate conditions from the years the researches were carried out, the correlative links between spring wheat yield and the main climate elements that contribute to crop formation (rainfall and temperature) were tested.

The spring wheat (q/ha) – rainfall sum (mm) correlations from the vegetation period (February – August) are second degree polynomial, and look like $Y = aX^2 + bX + c$ (figure 2).

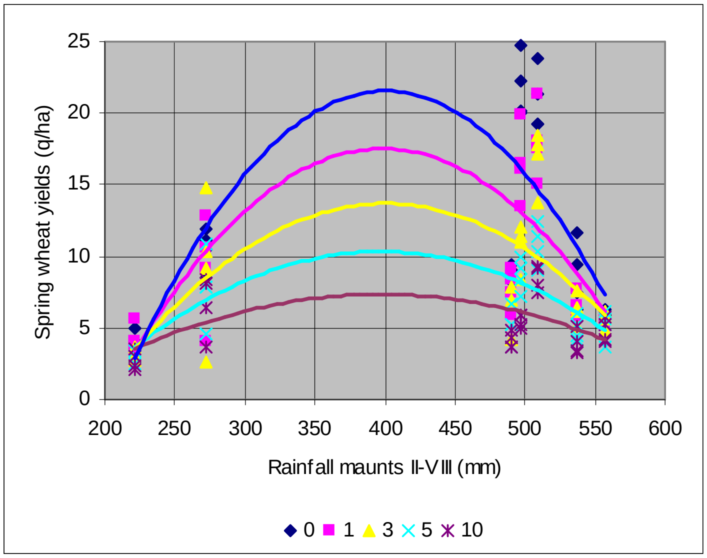

Figure 2. The correlation between the spring wheat yields and the total rainfall form the vegetation period

By analyzing the regression curve we notice that they have a convex shape for the all variants studied. The correlative links thus established are very significant for all the variants studied.

We can also notice that for the variants under controlled pollution the correlation coefficient that show the intensity of the bonds decrease with the increase of oil dose administered (table 2).

For the variants that have second-degree polynomial equations with convex shape the value of the maximum yield and the optimum amount of rainfall needed was determined**.** The maximum yields are: in the unpolluted variant 18,99 q/ha for a optimum rainfall value of 389,3 mm and in the variant polluted with 1 % oil residue of 10,64 q/ha, corresponding to the rainfall value 359,9mm. In the next variant, with 3, 5 and 10 % pollutant the yields are 16.79, 13.12 and 11.84 q/ha for 424.7, 429.8 and 489.0 mm rainfall.

Table 2

Polynomial second-degree regression equation
Spring wheat yield (Y) – Rainfall during vegetation period (X)

Nr. crt.	Oil concentration (%)	Regression equation	Correlation coefficient	Meaning
1.	0 (witness)	$Y = - 0,0006 X^2 + 0,4672 X - 71,954$	0,6971	***
2.	1	$Y = - 0,0005 X^2 + 0,3599 X - 54,125$	0,6525	***
3.	3	$Y = - 0,0003 X^2 + 0,2548 X - 37,313$	0,5452	***
4.	5	$Y = - 0,0002 X^2 + 0,1719 X - 23,814$	0,6016	***
5.	10	$Y = -0,0001 X^2 + 0,0978 X - 12,076$	0,4696	***

The optimum rainfall increases with the concentration of the pollutive agent and the technical maximum of the yields is reduced with the growth of the concentration.

The spring wheat (q/ha) – average temperature (ºC) of the months in the vegetation period (February – August) correlations are of the same type, polynomial of the second degree, but they are different significant (table 3).

Table 3

Polynomial second-degree regressions equation
Spring wheat yield (Y) – Temperature during vegetation period (X)

Nr. crt.	Oil concentration (%)	Regression equation	Correlation coefficient	Meaning
1.	0	$Y = 2,0262 X^2 - 61,185 X + 469,35$	0,7308	***
2.	1	$Y = 1,3625 X^2 - 41,213 X + 318,52$	0,6247	***
3.	3	$Y = 0,5416 X^2 - 16,618 X +134,30$	0,3300	**
4.	5	$Y = 0,6644 X^2 - 19,512 X + 148,9$	0,4211	***
5.	10	$Y = 0,2743 X^2 - 7,8475 X + 61,021$	0,1778	*

The shapes of the curves obtained for the witness variant and for the variants polluted with various forms of oil residue are concave. The spring wheat yield reduces as the average temperature rises. (Figure 3)

For the variants with concave shapes of the curves the minimum of the yields and the correspondent average temperature we can calculate. These are: witness variant Y_{min} = 7,5 q/ha for t_c = 15,1 ºC; variant polluted with concentration 1 % Y_{min} = 7,0 q/ha and t_c = 15,1 ºC; variant polluted with concentration 3 % Y_{min} = 6,9 q/ha for t_c = 15,3 ºC; variant polluted with concentration 5 % Y_{min} = 5,7 q/ha for t_c = 14,7 ºC and respectively variant polluted with concentration 10 % Y_{min} = 4,9 q/ha for t_c = 14,3 ºC.

We can also notice the decrease of the minimum yields and of the correspondent temperature with the increase of the concentration of pollution.

The second-degree polynomial correlations with two factors and dependence between the factors studied. Seeing that the yields of variants polluted under control are in direct correlation with the sum of rainfall and the average temperature in the vegetation period, we tried to emphasize their influence on yields.

For the witness variant and the variants polluted in a controlled manner with oil residue second degree polynomial correlations were established, with two factors, and an interaction between the two factors, between average yield (Y) on one side and between the rainfall average sum (X_1) and average temperatures (X_2) from the vegetation period on the other side (table 4).

Table 4.

Second-degree regression equations, with two factors, with factor interaction
Spring wheat yield (Y) – Rainfall (X_1) and average temperature (X_2)

Nr. crt.	Oil concentration (%)	Regression equation	Correlation coefficient	Meaning
1.	0	$Y=-0,00011 X_1^2 +1,594799 X_2^2+1,06239 X_1-18,6527 X_2-0,06537 X_1X_2-89,5684$	0,7458	***
2.	1	$Y=-0,00018 X_1^2+0,783747 X_2^2+0,69184 X_1-7,50944 X_2-0,03698 X_1X_2 -81,9603$	0,8685	***
3.	3	$Y=-0,00013 X_1^2+0,352309 X_2^2+ 0,88766 X_1+13,61616 X_2-0,05229 X_1X_2-298,446$	0,4453	***
4.	5	$Y=-0,00012 X_1^2+0,668324 X_2^2+0,38049 X_1-10,0424 X_2-0,01869 X1X2-13,4396$	0,6177	***
5.	10	$Y=-0,00011 X_1^2+ 0,377763 X_2^2+0,21577 X_1-6,03783 X_2-0,00795 X_1X_2-7,74181$	0,4170	**

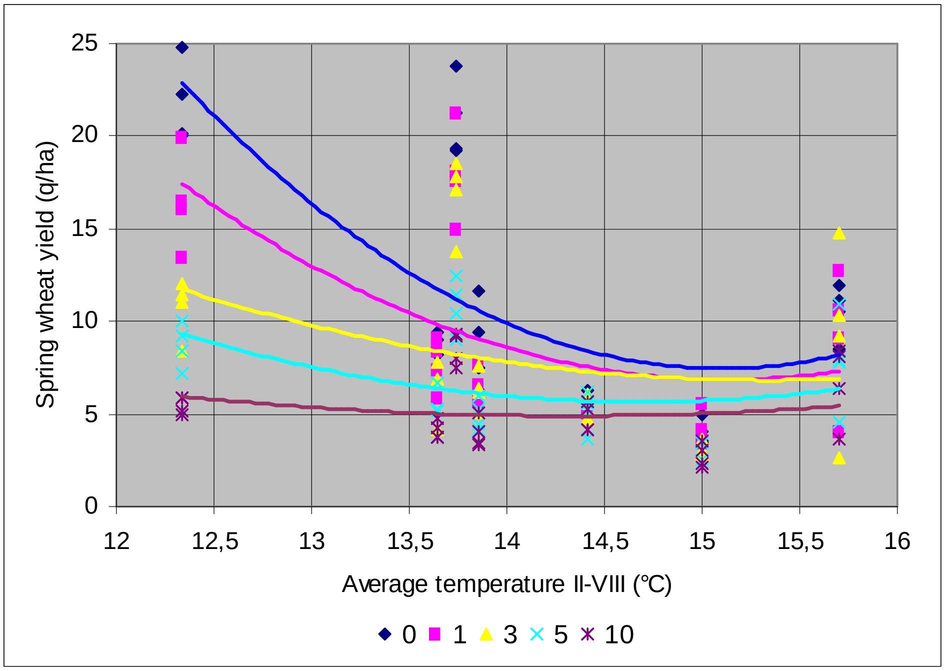

Figure 3. Correlations between the spring wheat yield and average temperature during the vegetation period

The links between the spring wheat yield and the 2 factors taken into consideration is very significant (R = 0.8685 – 0.4453), except the last variant (10 %) where the link is only distinct significant (R = 0,4170)

The general shape of the response equation of the yields determined by rainfall and temperature in 3D presentation is $Y = a_0 + a_{11}X_1 + a_{12}X_1^2 + a_{21}X_2 + a_{22}X_2^2 + a_{1121}X_1X_2$.

For all the variants, the polynomial second degree equation has the rainfall coefficient of the first order, a_{11} positive and the temperature first order coefficient negative, the yields achieved grow in direct proportional with the rainfall and inverse proportional with the average temperature in the vegetation period.

The influence of the interaction between the sum of rainfall and the average temperature on yield, described by the a_{1121} is little and has a negative value, from -0,06537 for witness variant to -0,00795 for the variant polluted with 10 % oil.

The interaction of the two factors studied is to reduce the level of yields, inverse proportional with concentrations of the pollutant.

The witness variant shows a maximum yield over 20 q/ha, for the rainfall sum close to 550 mm and an average temperature close to 13 ºC (figure 4).

The maximum yields of over 10 q/ha form polluted variant with 1 and 3 % oil residue are obtained for similar conditions, an average temperature to 13 ˚C and for the rainfall sum of 550 mm. In these case we can observe a second zone, with yields over 10 q/ha from maximum of temperature (16˚C) and minimum of rainfall (350 mm).

The behavior of the yields obtained is very similar to that of the witness variant is which yield gain is due to the balanced soil moisture, generated by rainfall and moderate potential evapotranspiration, determined by the lowest average temperature possible.

The second category of response surfaces of the yields to the factors studied is specific to the variants with concentrations of 5 % or 10 % (figure 5).

In this case the maximum of yield, over 10 q/ha is obtained for the maximum of average temperature, in both variants and for minimum rainfall sum (350 mm) in variant polluted with 5 % oil residue and respectively for the rainfall sum of 400 mm in variant with 10% oil residue concentration.

We can say that the level of the yield is smaller because a large quantity of oil residue is in course of being decomposed and the environment toxicity is very high.

Achieving maximum yields for high values of the average temperature and minimum or moderate rainfall sum can be explained that high temperatures and moderate humidity ensures a good soil aeration and stimulate the activity of the microorganism in the soil that are responsible for the biodegradation of the oil residue.

The increase of the value of the rainfall sum determines the increase of yields, in the first category of variant (0 – 3%) and the increase of average temperature, in the second category of variants (5-10%) determines an increase of the microorganisms activity in the soil responsible for the oil residue decomposing, the increase of the organic matter found in various stages of humification and the increase of the soil humus content.

CONCLUSIONS

Earlier researches have shown that the yield losses in an experience with polluted microparcels in concentrations of 1, 3, 5, 10% become insignificant after many years of cultivation even if no agricultural measures have been applied, that is sign that the oil residue is biodegraded.

The second degree correlations very significant established from the spring wheat yield (q/ha), for seven years and the rainfall sum and the average temperature in the vegetation period show that they are dependant on the climate conditions of the period studied.

The expressions of the equations obtained show that the maximum yields for the variants studied are realized for values of the rainfall sum of 359.9 – 489.0 mm. The minimum values of yields are resulted for values of the average temperatures of 14.3-15.1˚C.

The second-degree polynomial correlations with the interaction of two climate factors very significant show that the product between rainfall x temperature has a negative influence on the yields by determining the yield decrease inverse proportional with the increase of concentration's pollutant.

For the witness variant and the variants with smaller pollutant concentrations (1 and 3%) the maximum yields are accomplished at maximum values of rainfall sum (550 mm) and minimum values of average temperature (13˚C)

For the variants with high pollutant concentration (5 and 10%) maximum yields are obtained for maximum values of average temperature (16ºC), that stimulate the activity of the microorganisms responsible for soil oil degradation and for minimum and moderate values of rainfall sum (350 and respectively 400 mm) that ensure balanced humidity and aeration in the polluted soil.

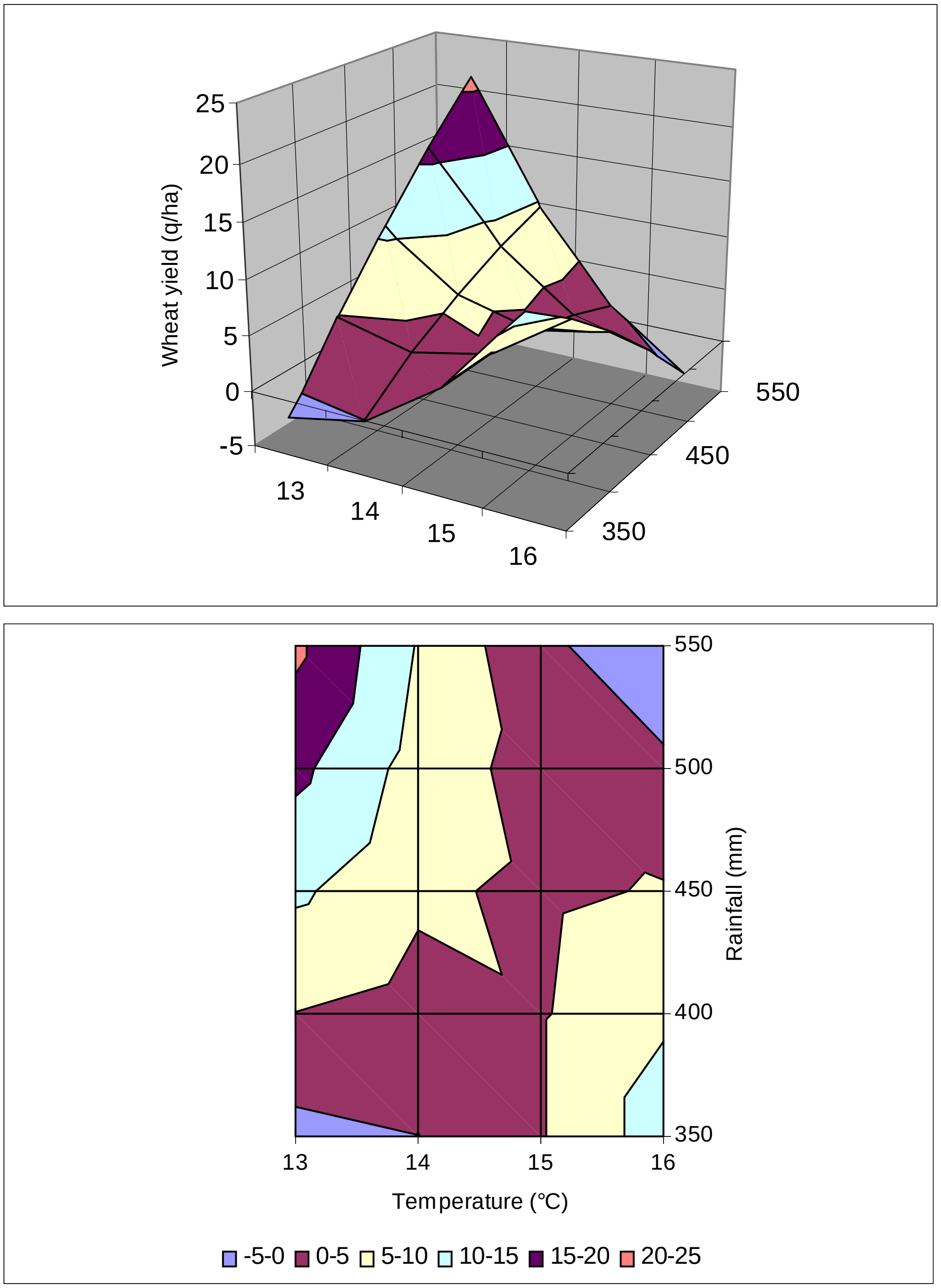

Figure 4. Polynomial correlation with two factors of the second degree, spring wheat yield (q/ha) of the witness variant (Y) – Rainfall (R) and Temperature (T)

$$Y = -0,00011R^2 + 1,594799T^2 + 1,06239R - 18,6527T - 0,06537RT - 89,5684;$$

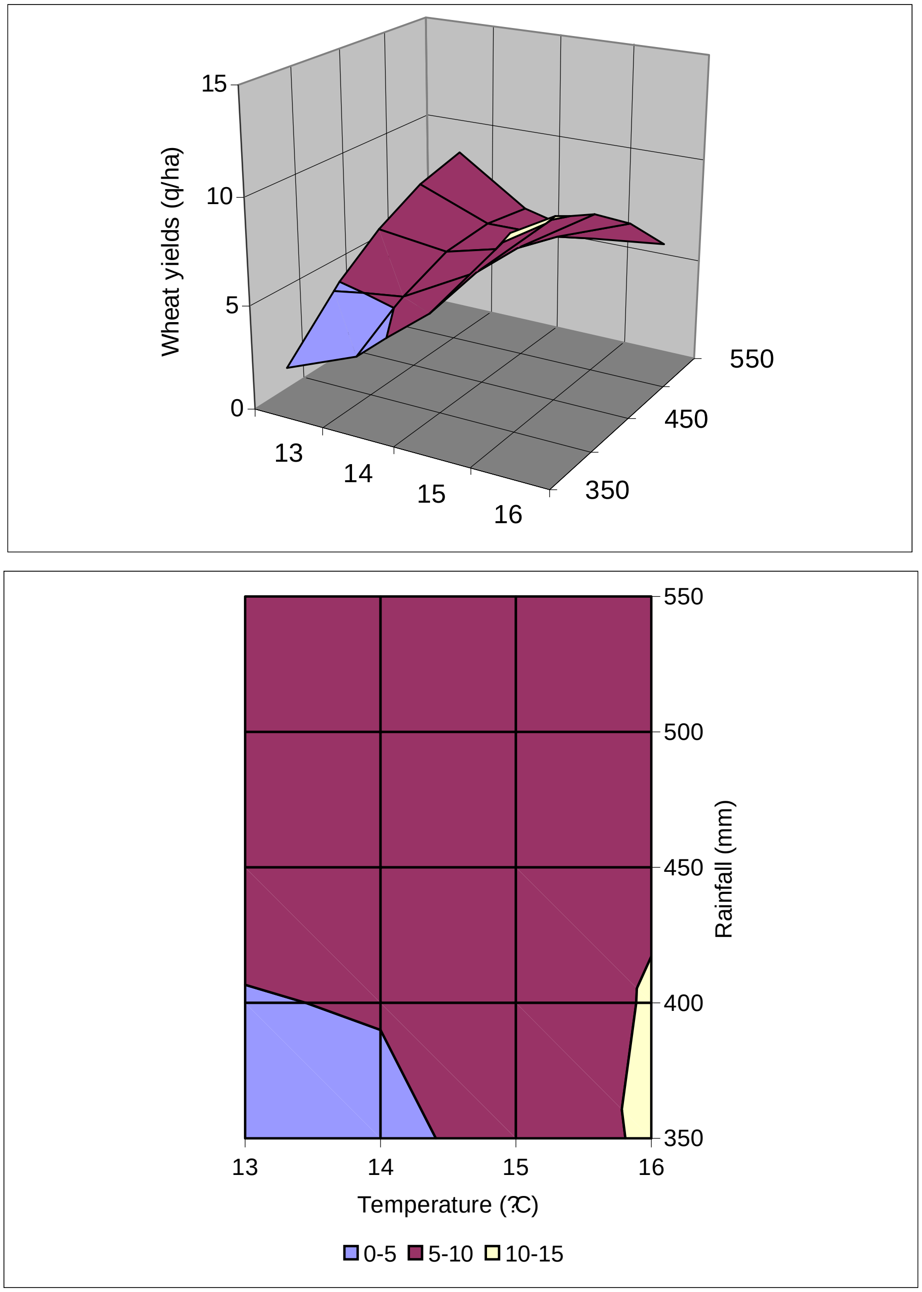

Figure 5. Figure 4. Polynomial correlation with two factors of the second degree, spring wheat yield (q/ha) of the 5 % variant (Y) – Rainfall (R) and Temperature (T)

$$Y = -0,00012\, R^2 + 0,668324\, T^2 + 0,38049\, R - 10,0424\, T - 0,01869\, RT - 13,4396;$$

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