The effect of crop rotation and fertilization on wheat and maize in the pedoclimatic conditions of the Banat Plain

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SUMMARY

The simplification of the plant cultures range and the yields in the last 10-15 years brings into the actuality the role of crop rotation and of fertilization on the yield level and stability for wheat and maize even on the soils with a high natural fertility. The results of the researches performed between the years 2006 – 2009 on a cambic low gleyed chernozem from the Banat Plain showed that the wheat cultivated in monoculture gives productions with 59-81% lower than that cultivated in crop rotation with other plants during 2-4 years. In maize, the yield obtained in monoculture is situated behind that obtained in crop rotation with 11-21%. The most favorable crop rotations for wheat were rape-wheat in a 4 years rotation and soybean-wheat in simple rotation of 2 years. In maize, the most favorable was the 2 years rotation (wheat-maize). The mineral fertilization was very efficient both in wheat (11-36%) and maize (9-31%). The organic fertilization with manure was very efficient for maize, the yields being superior with a mean value by 34% for a 60 t/ha dose and with 16% for 30t/ha. The fertilization compensates the negative effect expressed by the monocultivation only in a small measure.

INTRODUCTION

In the last 10-15 years it can be observed a reduction of the plant number that is cultivated in all countries of Europe and in an accentuated way in Romania (Borza and Coste, 2002; Borza et el., 2006; Marinca et al., 2009). The main cause is represented by the express demand for cereals (wheat and maize) required by the animal breeding complexes in relation with the continuing decreasing animal effectives from the household system (Borza and Coste, 2002; Marinca et al., 2009).

In the condition of a decreasing number of the plant cultures within the vegetal farms to only 3-4 plants, their rotation was simplified to an interval by 2-4 years and the monocultivation is performed on at least 25-30% surfaces for wheat and 30-40% for maize. In monocultivation, there is relying on the mineral fertilization contribution, in augmented amounts, and on the phytosanitary treatments, with much larger costs. The research results, as well as those found in production showed that even when the fertilization is increased, the monoculture is under crop rotation with up to 30-50% from yield in wheat and in a small measure in maize (Borlan et al., 1999; Borza et el., 2006).

On the soils with low natural fertility and in the years with less favorable climatic conditions for wheat crop, the yield results obtained in monocultivation are totally unsatisfactory.

The organic fertilization is performed on extremely reduced surfaces, and in many farms is excluded because of the orientation of the agriculture system to the animal breeding in large complexes by industrial type. The relinquishment to the organic fertilization of the agricultural lands puts in danger their fertility even in the condition of a well balanced mineral fertilization (Borlan et al., 1999; Borza et el., 2006; Marinca et al., 2009; Ţărău et al., 2008).

The climatic conditions with accentuated droughty tendency necessitate to adapt the tillage technologies to this specific feature (Marinca et al., 2009; Popa and Borza, 2008; Popa and Borza, 2007; Ţărău et al., 2008).

MATERIAL AND METHODS

The researches were carried out during the years 2006-2009 on a cambic low gleyed chernozem within the Didactic Station of the University of Agricultural Sciences and Veterinary Medicine of Banat (USAMVB) from Timişoara, Romania, the soil being representative for approx. 10-15% of Banat Plain.

The experiments, in number of two, are stationary, with the following factors and ranges: crop rotations and various doses of mineral fertilizers, respectively crop rotations and increasing doses of manure.

For wheat, there were cultivated autochthon kinds, and for maize there were cultivated Pioneer hybrids.

The mineral fertilization was realized with ammonium nitrate and complexes fertilizers 1:1:0 and 1:1:1, and the organic fertilization with semi-fermented manure from the bovine farm, applied before the maize cultivation.

The yield results are related to the STAS humidity, respectively 14% for wheat and 15% for maize, and the data processing was made by analysis of the variance with appropriate soft.

The researches continued in the year of 2010 and in the next years it is intended to be monitored not only the yields, but the soil fertility evolution too, as a consequence of the systematic application of the mineral and organic fertilizers.

RESULTS AND DISCUSSION

The characteristics of the cambic low gleyed chernozem from the Didactic Station of the (USAMVB) Timişoara, in the experimental location, were identified by opening a soil profile and can be found in the *table 1*.

Table 1

The chemical, physical and hydrophysical characteristics of the cambic low gleyed chernozem, medium clay-loamy (medium clay-loamy) from the Didactic Station of USAMVB Timişoara

Pedological horizon	Ap	Atp	Am	AB	BC	CCA g_1	CCA g_1	CCA g_2
Depth	0-20	20-35	35-50	50-65	65-85	85-110	110-130	130-200
pH in water	6.00	6.60	6.70	6.90	7.75	8.10	8.15	8.25
$CaCO_3$	-	-	-	-	0.60	15.50	17.70	10.80
Humus	2.97	2.79	2.42	2.23	1.73	0.93	-	-
Nitrogen index	2.58	2.48	2.20	2.11	1.73	-	-	-
P_{AL} (ppm)	35.0	7.2	6.7	-	-	-	-	-
K_{AL} (ppm)	322.0	262.3	259.8	-	-	100	-	-
V_{AH} (%)	87.0	89.0	91.2	94.9	100	41.0	100	100
Clay (< 0.002 mm)	44.1	43.1	45.4	45.0	45.3		39.0	44.9

The pH has values between 6 in the Ap horizon and 6,7 in the Am horizon, fact that indicates a low acid reaction in the first 50 cm topsoil, the humus supplying in the Ap horizon is good, the phosphorous supplying is middle to good (35 ppm), the potassium supplying is very good in the Ap horizon (322 ppm), the apparent density is 1,54 g/cm^3 which shows an advanced compaction degree, and the total porosity is by 38,65% which denotes a compacted soil. Generally, the soil has a high fertility potential.

After the capability classification was settled that the studied soil is framed in the class of 61-80 points, being favorable both for wheat and maize. As fertilization requirements it reclaims the periodical application of the manure and an annually chemical fertilization in moderate and balanced doses, with special attention to the nitrogen-phosphorous ratio.

Under climatic aspect, the researched area is characterized by a multiannual mean temperature by 10.9 °C and a precipitation sum by 623 mm (Meteorological Station Tiumişoara). In the experimental years 2006-2009 there were registered differences both regarding the multiannual means and for each year *(table 2).*

Table 2

The climatic characteristics of the years 2006-2010 related to the multiannual means (Meteorological Station Timişoara)

Agricultural year	T (°C)	Deviations	P (mm)	Deviations
2006	10.8	-0.1	705	+182
2007	13.1	+2.2	518	-105
2008	11.9	+1.0	730	+107
2009	12.0	+1.1	525	-98
Multiannual mean	10.9		623	

Under thermal aspect, in three consecutive years (2007, 2008, 2009), the annual mean temperature exceeded the normal value, and in one year (2006) it was near to the multiannual mean.

Under pluviometrical aspect, in two years (2006 and 2008) the normal value was exceeded, and the two others (2007 and 2009) were more droughty than usually.

Related to the climatic requirements of the two plant cultures, the year of 2006 was slightly favorable for wheat and favorable for maize, the year of 2007 was favorable for wheat and slightly favorable for maize, the year of 2008 was favorable for wheat and very favorable for maize, and the year of 2009 was very favorable both for wheat and maize. Statistically, it was found that in the four studied years there were slightly favorable conditions only in a single year for wheat (2006) and maize (2007) and very favorable conditions in one year for wheat (2009) and in two years for maize (2008 and 2009).

The analysis of the yield results depending on the experimental factors that were studied (crop rotation and fertilization) shows significant aspects which lead to valuable scientific and practical conclusions.

In *wheat*, the mean yields for four research years oscillated between 2083 and 5208 kg/ha, varying with the crop rotation and with the applied fertilization (*table 3*). Comparing to the monocultivation, the crop rotation by 2 and 4 years increased the wheat yiled with 1497-2076 kg/ha, respectively with 59-81%. The most favorable rotation was that of 4 years when the wheat followed after rape. In the 2 years rotation, the wheat behavior was the same after soybean and respectively after maize, excepting the unfertilized variant where the soybean proved that is superior to the maize as a precursory plant for wheat.

Table 3

The effect of the crop rotation and mineral fertilization on wheat (kg/ha) between the years 2006-2009

Crop rotation	Fertilization					
	$N_0P_0K_0$	$N_{60}P_0K_0$	$N_{60}P_{60}K_0$	$N_{120}P_{60}K_0$	$N_{120}P_{60}K_{60}$	Mean
Monocultivation	2083	2375	2660	2827	2920	2573
Wheat-maize	3276	3794	4025	4585	4673	4070
Wheat-soybean	3536	3820	4156	4588	4697	4159

Wheat-rape-maize-soybean	4013	4341	4713	4970	5208	4649
Mean	3227	3582	3888	4242	4374	
The effect of the crop rotation on the wheat yield						
Category	Yield (kg/ha)	Increment		Signification		
		kg/ha	%			
Monocultivation	2573	-	100			
Wheat-maize	4070	1497	159	***		
Wheat-soybean	4159	1586	162	***		
Wheat-rape-maize-soybean	4649	2076	181	***		
	DL 5% = 236	DL % = 430		DL 0,1% = 860		
The effect of the mineral fertilization on the wheat yield						
Category	$N_0P_0K_0$	$N_{60}P_0K_0$	$N_{60}P_{60}K_0$	$N_{120}P_{60}K_0$	$N_{120}P_{60}K_{60}$	
Yield (kg/ha)	3227	3582	3888	4242	4374	
Increment (kg/ha)	-	255	661	1015	1147	
Increment (%)	100	111	121	132	136	
Signification	-	*	***	***	***	
DL 5% = 188		DL 1% = 380		DL 0,1% = 520		

The yield results on years show that the wheat production in monocultivation decreased after the second cultivation year, even if this is appropriately fertilized (*figure 1*).

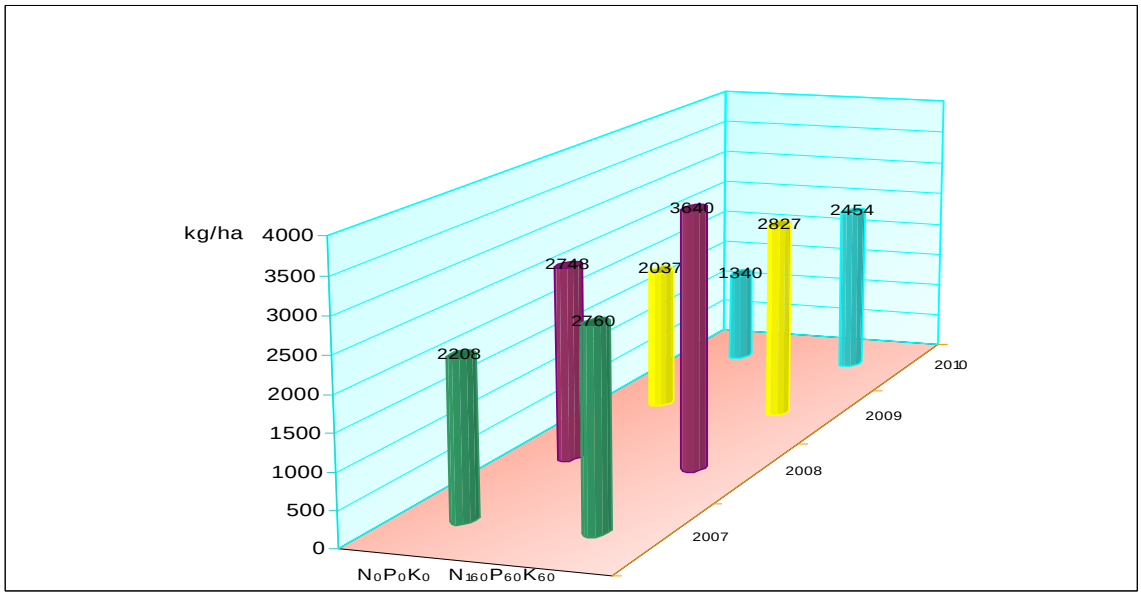

Figure 1: The evolution of the wheat yield in monocultivation

The effect of the mineral fertilization consisted of wheat yield increasing with 255-1147 kg/ha, respectively with 11-36%. The effect of the nitrogen applied all-alone was small (11%), but it was more significant in the presence of the phosphorous (2:1 ratio) and potassium (2:1:1). The optimal fertilization variant for wheat was $N_{120}P_{60}K_{60}$ for which there were registered a mean production in four years by 4585 kg/ha in the 2 years rotation after the maize, 4588 kg/ha in the 2 years rotation after the soybean and 4970 kg/ha in the 2 years rotation after the rape. In *maize*, it was found a positive influence on the yield both of the crop rotation and fertilization (*table 4*).

Table 4

The effect of the crop rotation and mineral fertilization on maize (kg/ha) between the years 2006-2009

Crop rotation	Fertilization					
	$N_0P_0K_0$	$N_{60}P_0K_0$	$N_{60}P_{60}K_0$	$N_{120}P_{60}K_0$	$N_{120}P_{60}K_{60}$	Mean
Monocultivation	5408	5780	6006	6500	7050	6148
Maize-soybean	5920	6317	6674	7224	7900	6807
Maize-wheat	6460	7115	7295	7860	8250	7396
Maize-soybean-wheat-rape	5860	6360	7010	7290	7680	6840
Mean	5912	6393	6746	7218	7720	
The effect of the crop rotation on the maize yield						
Category	Yield (kg/ha)	Increment		Signification		
		kg/ha	%			

Monocultivation	6148	-	100	
Maize-soybean	6807	659	111	***
Maize-wheat	7396	1248	121	***
Maize-soybean-wheat-rape	6840	692	112	***
	DL 5% = 230	DL % = 356		DL 0,1% = 576

The effect of the mineral fertilization on the maize yield (means of the years 2006-2009)					
Category	$N_0P_0K_0$	$N_{60}P_0K_0$	$N_{60}P_{60}K_0$	$N_{120}P_{60}K_0$	$N_{120}P_{60}K_{60}$
Yield (kg/ha)	5912	6393	6746	7218	7720
Increment (kg/ha)	-	481	834	1306	1808
Increment (%)	100	109	115	122	131
Signification	-	*	***	***	***
DL 5% = 330		DL 1% = 495			DL 0,1% = 686

Related to the monocultivation, the rotations of 2 and 4 years proved to be more favorable, being obtained mean growths comprised between 659-1248 kg/ha, respectively by 11-21%. The most favorable proved to be the 2 years rotation which has as precursory plant the wheat. The soybean, as precursory for the wheat assured a production increase by 11-12% in the rotations of 2 years and respectively 4 years. It can be remarked that the maize production in monocultivation did not decreased, the yield differences between the researched years were determined by the climatic conditions (*figure 2*).

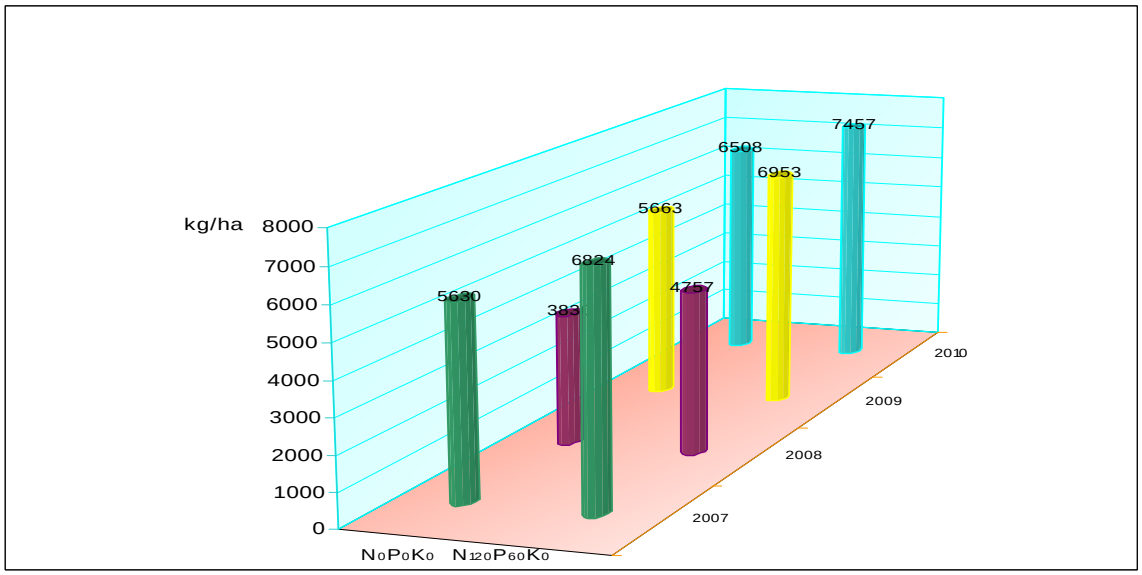

Figure 2: The evolution of the maize yield in monocultivation

The mineral fertilization led to the maize yield increasing with 481-1808 kg/ha (growth by 9-31%) related to the fertilization level. The nitrogen applied all-alone determined an increasing by 481 kg/ha (9%). Very significant yield growths were registered only at large doses of nitrogen in combination with phosphorous ($N_{120}P_{60}$) and with potassium ($N_{120}P_{60}K_{60}$) for which the increasing are by 22% and respectively 31%.

The organic fertilization with manure applied to the maize proved that it is very efficient, being obtained mean yield growths by 992 and 2064 kg/ha at 30 and 60 t manure/ha (*table 5*).

Table 5

The effect of the crop rotation and organic fertilization on maize (kg/ha) between the years 2006-2009

Crop rotation	Manure (t/ha)			
	0	30	60	Mean
Monocultivation	5970	6720	7460	6716
Maize-soybean	6476	7458	8520	7484
Maize-wheat	6732	7840	8858	7810
Maize-soybean-wheat-rape	5614	6742	8213	6856
Mean	6198	7190	8262	

The effect of the crop rotation on the maize yield (means of the years 2006-2009)				
Category	Yield (kg/ha)	Increment		Signification
		kg/ha	%	
Monocultivation	6716	-	100	-
Maize-soybean	7484	768	112	***
Maize-wheat	7810	1094	117	***
Maize-soybean-wheat-rape	6856	140	102	***
	DL 5% = 266	DL 1% = 470		DL 0,1% = 722

The effect of the organic fertilization on the maize yield (means of the years 2006-2009)			
Category	0	30	60
Yield (kg/ha)	6198	7190	8262
Increment (kg/ha)	-	992	2064
Increment (%)	100	116	134
Signification	-	***	***
	DL 5% = 305	DL 1% = 512	DL 0,1% = 786

Although the maize monoculture does not represent a favorable technological solution, it can be remarked that, even in these conditions, the mineral and organic fertilization lead to yield increasing. The fertilizers efficacy is superior in the rotations of 2 and 4 years comparing to the monocultivation and it is preferable because the maize yields are much higher.

CONCLUSIONS

1. The climatic conditions from the Banat Plain between the years 2006-2007 were slightly favorable for wheat in the year of 2006 and for maize in the year of 2007, and in the rest of the years these were favorable and very favorable.
2. In conditions of the simplification of the range plant that are cultivated, the crop rotation becomes an extremely important production factor, especially for the wheat culture.
3. The wheat monoculture practiced for four years proved to be un-recommendable, although it was sustained by an appropriate fertilization, because the yield started to decrease from a year to another.
4. The maize monoculture, although it did not register yield decreasing, similarly to the wheat, is situated under the levels given by the rotation of 2 and 4 years.
5. The effect of the mineral fertilizers applied in the wheat or maize monoculture is attenuated comparing to the variant where the maize and the wheat are enclosed into a crop rotation.
6. All rotation variants that had been studied were superior to the monocultivation and determined very significant yield growths, both for wheat and maize.
7. The mineral and organic fertilization contributes to the yield increasing with 11-36% for wheat and with 9-34% for maize. The optimal variant of mineral fertilizer application is $N_{120}P_{60}K_0$, and there is required the introduction of a dose of 60 kg K_2O/ha in order to maximize the yield.
8. The periodical organic fertilization applied to the maize represents a safe solution to increase the yield and the soil fertility.

REFERENCES

1. Borlan Z.-Ştefănescu Daniela-Alexandrescu Adriana-Nebunelea Dobrița (1999): Fertilizarea în cadrul unor sisteme de producție vegetală durabilă, Revue Ştiința solului, vol. 33, no. 2.
2. Borza I.-Coste I. (2002): Agroecologie şi dezvoltare agricolă durabilă, Eurobit Publishing House, Timişoara, Romania.
3. Borza I.-Puşcă I.-Ţărău D. (2006): Calitatea solurilor din vestul României şi rezultate ale aplicării îngrăşămintelor chimice pe soluri şi la plante diferite, Proceedings of the International Symposium CIEC, Bacău, Romania, Agris Publishing House, Bucharest.
4. Marinca C.-Dumitru M.-Borza I.-Ţărău D. (2009): Solul şi fertilitatea, relația cu sistemele agricole din Banat, Mirton Publishing House, Timişoara, Romania.
5. Popa Veronica-Borza I. (2008): Results of the studies on the causes favoring the desertification risk in the Banat Plain, Proceedings of the International Symposium of USAMVB Timişoara, Faculty of Agriculture, vol. 40 (1), Agroprint Publishing House, Timişoara, Romania.
6. Popa Veronica-Borza I. (2007): The analysis of multiannual variation of temperature and precipitation related to the desertification risk in the Banat Plain, Proceedings of the International Symposium of USAMVB Timişoara, Faculty of Agriculture, vol. 39, Agroprint Publishing House, Timişoara, Romania.
7. Ţărău D.-Borza I.-Iordache Mădălina-Dicu D., 2008 – The influence of agrometeorological conditions on some agroecosystems components from the Vinga Plain in no-till cultivation system, Proceedings of the International Symposium of USAMVB Timişoara, Faculty of Agriculture, vol. 40, Agroprint Publishing House, Timişoara, Romania.