IMPACT OF AGROTECHNICAL AND ECOLOGICAL RISK FACTORS IN YIELD OF CEREALS

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Abstract

The study was carried out in the period between September 2010 and October 2013 at the experimental site of the University of Debrecen at Látókép (N: 47°33', E: 21°27') in the polyfactorial long-term experiment. The studied species were winter wheat and maize. The research focused on the effects of previous cropping and fertilizers, crop protection and irrigation on the amount of yield in three different cropyears. We wanted to find out how the yield were affected by the cropyear and agrotechnical factors.

In spite of the different years, the yields of maize and winter wheat were almost the same under the optimized agrotechnique. The maximum yields were 10.8 t ha^{-1} in 2011, 8.6 t ha^{-1} in 2012 and 9.1 t ha^{-1} in 2013 in winter wheat, while the maximum yields of maize ranged from 13.1 to 14.6 t ha^{-1} depending upon the year. The intensive crop production model results in better yield safety both in winter wheat and maize. From among the applied agrotechnical factors, fertilization had the strongest impact on the yield of winter wheat (59 %) and maize (45 %). However we found strong relationship between the crop rotation and the yield (winter wheat: 22 %, maize: 30 %).

Key words: cereals, yield, agrotechnical and ecological factors, variance component

INTRODUCTION

The productivity of field crops is determined primarily by the biological, genetic factors, secondly, by the ecological conditions and thirdly, by the agrotechnical factors. In the production technology of cereals, these factors should be harmonized.

Many aspects of agricultural production can be adversely affected by weather (Foxa et al., 1999). The importance of climate factors is decisive for wheat and maize yield. Crop fluctuations are principally caused by climate factors, especially the lack of precipitation (Radics 2003; Efeoğlu et al. 2009).

According to Pepó (2007) crop year and agrotechnical factors jointly determine the amount and stability of yield. The most important agrotechnical factors determining yield are crop rotation, fertilization, plant density and irrigation (Idikut and Kara, 2011). Higher yields can be reached in bicultures (soyabean – maize) than in monocultures (Qiang et al., 2010). Pepó (2006) found that the plant rotation has an outstanding importance amongst agricultural techniques. Although maize tolerates partial monocultures quite well, maize grown in a monoculture gave 1.3 t ha^{-1} less yield in an average crop year, and 3 to 4 t ha^{-1} less in a drought year compared to growing in plant rotation. Nitrogen supply is almost as important in crop production. Based on Németh and Kádár (1999), the yield of maize produced is significantly affected by nitrogen supply of the plant, however, unreasonable amount on nitrogen will result in yield depression and unfavorable nitrogen accumulation. According to Pepó (2002), fertilization is one of the major technological elements of wheat production too, because it has a direct or indirect impact on all other technological elements. Pepó (2009) found that the optimum fertilizer doses vary between $N_{150-200}$+PK in biculture and N_{50-150}+PK in triculture depending upon the year and the water supply. Montemurro et al. (2007) did not detect differences in yields of winter wheat between the fertilizer treatments N_{120}+PK and N_{180}+PK.

MATERIAL AND METHOD

The study was carried out in the period between September 2010 and October 2013 at the experimental site of the University of Debrecen at Látókép (N: 47º33', E: 21º27') in the polyfactorial long-term experiment set up by Prof. Dr. László Ruzsányi in 1983 and supervised by Prof. Dr. Péter Pepó. The meteorological data are presented in *Figure 1*. The studied species were winter wheat and maize. The experimental plots were set up in a randomized block design in four repetitions, the plot size was 9.2 m x 5 m (46 m^2).

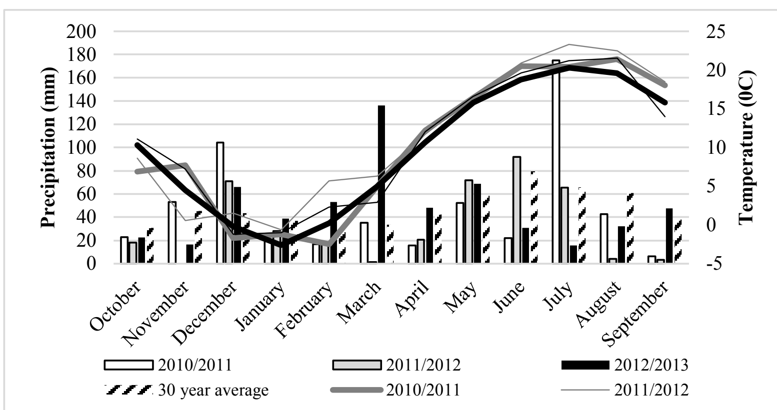

Figure 1.: Meteorological parameters in the vegetation period of winter wheat and maize (Debrecen; 10.2010.- 09.2013.)

The tested wheat variety was GK Csillag. The first production technology element tested was the crop rotation where triculture (pea-wheat-maize) and biculture (wheat-maize) were set up. The second agrotechnical element was the fertilization (control, $N_{50}P_{35}K_{40}$, $N_{100}P_{70}K_{80}$,

$N_{150}P_{105}K_{120}$, $N_{200}P_{140}K_{160}$). The third variable was the crop protection, where three models were set up (extensive, average, intensive).

The maize hybrid used in the experiment was Reseda (PR37M81; FAO 360). The first tested production technology element was the crop rotation where triculture (pea-wheat-maize), biculture (wheat-maize) and monoculture treatments were set up. The second agrotechnical element was the fertilization (control, $N_{60}P_{45}K_{45}$, $N_{120}P_{90}K_{90}$, $N_{180}P_{135}K_{135}$, $N_{240}P_{180}K_{180}$). The third variable was the irrigation where the treatments applied were non-irrigated (I1), irrigated to 50 % of the optimum water supply (I2) and irrigated to the optimum water supply (I3).

The statistical evaluation of the data was performed using the programs *Microsoft Excel 2013* and *SPPS for Windows 13.0*. The quantification of the agrotechnical elements' effects on the yield was done by variance component decomposition.

RESULTS AND DISSCUSIONS

Winter wheat

The yield of winter wheat was significantly influenced by the fertilization and the crop rotation in the years of 2011, 2012 and 2013, while crop protection did not have a significant effect.

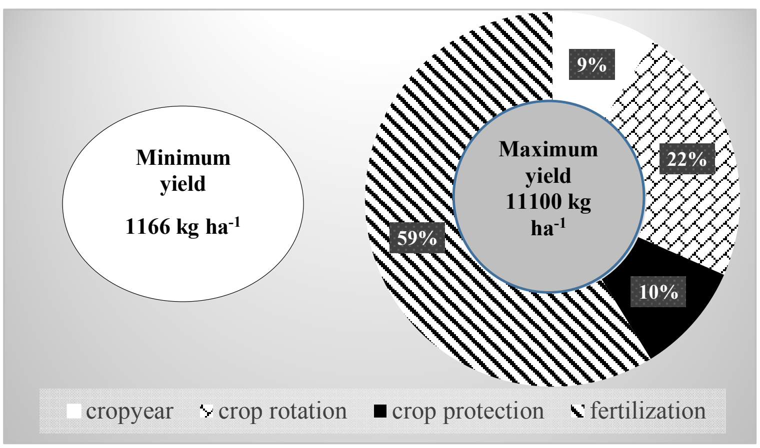

Figure 2. The roles of fertilization, crop rotation, crop protection and the year in the yield of winter wheat (Debrecen, 2011-2013)

By the decomposition of variance components, we determined the percentage share of agrotechnical factors (crop rotation, crop protection, fertilization) in the yield of winter wheat *(Figure 2.)*. As an average of the three years, the year, the crop rotation, the crop protection and the fertilization contributed to the yield by 9.04 %, 22.57 %, 9.62 % and 58.77 %, respectively.

Table 1.

Effect of agrotechnical factors on winter wheat yield (Debrecen, 2011-2013)

Crop protection	Crop rotation	Fertilization	2011	2012	2013
Extensive	Biculture	control	1976	2274	1462
		N_{50}+PK	3808	5078	3752
		N_{100}+PK	5913	7005	5890
		N_{150}+PK	7175	7634	7528
		N_{200}+PK	**7749**	**7703**	**8019**
	Triculture	control	6363	4683	4602
		N_{50}+PK	8297	6094	6427
		N_{100}+PK	**9352**	7133	7901
		N_{150}+PK	9163	**7622**	**8118**
		N_{200}+PK	8900	7321	7907
Average	Biculture	control	2046	2429	1558
		N_{50}+PK	4197	5490	3960
		N_{100}+PK	6520	7283	6205
		N_{150}+PK	7742	8109	7910
		N_{200}+PK	**8423**	**8179**	**8317**
	Triculture	control	6570	5015	4811
		N_{50}+PK	8812	6554	6954
		N_{100}+PK	**10050**	7553	8465
		N_{150}+PK	9830	**8203**	**8660**
		N_{200}+PK	9642	8015	8241
Intesive	Biculture	control	2270	2515	1608
		N_{50}+PK	4624	5662	4185
		N_{100}+PK	6876	7665	6671
		N_{150}+PK	8100	8478	8363
		N_{200}+PK	**8850**	**8680**	**8779**
	Triculture	control	6616	5219	4888
		N_{50}+PK	9263	6819	7215
		N_{100}+PK	**10852**	7780	8751
		N_{150}+PK	10468	**8685**	**9196**
		N_{200}+PK	10209	8287	8722
$LSD_{5\%}$ crop rotation			*505*	*660*	*776*
$LSD_{5\%}$ fertilization			*1051*	*461*	*689*
$LSD_{5\%}$ crop protection			*1113*	*816*	*1026*

In the different crop protection treatments, we found that higher yields were obtained in the stands treated once and twice than in the extensive model. In the biculture treatment, the maximum yields were obtained at the highest fertilization level (N_{200}+PK) in all three experimental years. In triculture, however, the maximum yield was obtained at lower fertilization levels, at the dosages of N_{100}+PK in 2011 and N_{150}+PK in 2012 and 2013. By applying the intensive crop protection model, the yield of winter wheat can be kept in the interval of 8.5-10.5 t ha^{-1}. In the extensive model, the yields varied between 1.5 and 2.5 t ha^{-1} (bi) and between 4.5 and 6.5 t ha^{-1} (tri), consequently, they were considerably lower than in the case of the intensive technology (*Table 1.*).

Maize

The yield of maize was significantly influenced by the fertilization and the crop rotation. As an average of the three years, the year, the crop rotation, the irrigation and the fertilization had a 3.5 %, 29.8 %, 21.5 % and 45.2 % share in the yield, respectively (*Figure 3*).

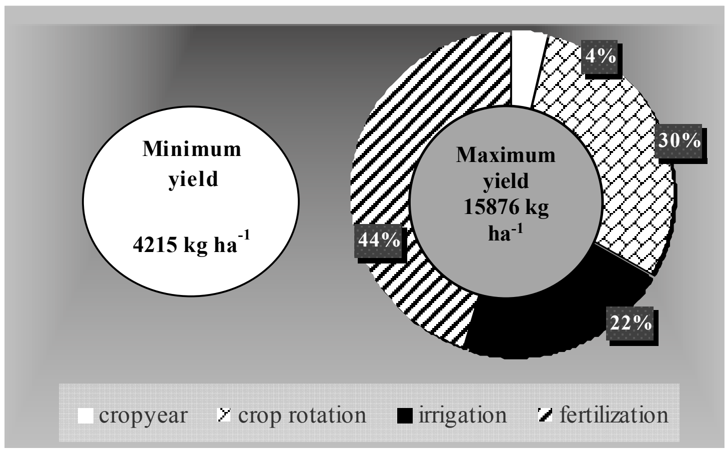

Figure 3. The roles of fertilization, crop rotation, irrigation and the year in the yield of maize (Debrecen, 2011-2013)

Maize grown in monoculture gave 2003-2090 kg ha^{-1} lower yields as an average of three years than maize grown in crop rotation. According to our studies, the optimum N+PK amount is influenced by several factors, on the one hand, by the year, on the other hand, by the applied agrotechnique (crop rotation, irrigation). Based on the three-year results, the highest yields were obtained at the fertilization levels of $N_{180-240}$+PK in monoculture, $N_{120-180}$+PK in biculture and N_{60-120}+PK in triculture. The yield increment due to irrigation was determined by the nature of the year. In all three experimental years, maize was irrigated several times, therefore, we could quantify the impact of irrigation, which resulted in a yield increment of 434-994 kg ha^{-1} in 2011, 994-653 kg ha^{-1} in 2012 and 1874-2664 kg ha^{-1} in 2013. In the intensive model, the yield of maize was between 12.5-14.5 t ha^{-1}. In the extensive crop production model, the yield of maize varied between 4.5 and 7.0 t ha^{-1} (in monoculture), 9.0 and 11.5 t ha^{-1} (in biculture) and 9.0 and 11.0 t ha^{-1} (in triculture), it was considerably lower than that in the intensive technology (*Table 2.*).

Table 2.

Effect of agrotechnical factors on maize yield (Debrecen, 2011-2013)

Irrigation	Fertilization	2011			2012			2013		
		Monoculture	Biculture	Triculture	Monoculture	Biculture	Triculture	Monoculture	Biculture	Triculture
I1	control	6226	8769	9602	6715	9389	9656	4862	9208	9029
	N_{60}+PK	8237	10143	11692	9571	10970	10932	7751	10812	10276
	N_{120}+PK	10619	12428	**12388**	10297	11481	**11955**	9216	11046	**10812**
	N_{180}+PK	11362	**12670**	12020	10641	**11886**	11710	**9386**	**11947**	10203
	N_{240}+PK	**11515**	12271	11751	**11289**	11470	11303	9217	11719	9675
I2	control	6370	8805	9961	6881	9820	9827	5488	10963	10219
	N_{60}+PK	8324	10842	11712	9742	11182	11427	8070	12527	12336
	N_{120}+PK	11050	**13304**	**12990**	11043	11674	12504	10545	13469	**13387**
	N_{180}+PK	11927	12990	12782	11284	**12406**	**11670**	**11825**	**13942**	13005
	N_{240}+PK	**12351**	12180	12617	**11910**	11669	11347	11283	13176	13029
I3	control	6741	9075	10652	7028	10126	10140	5725	11614	10971
	N_{60}+PK	8659	12093	**13420**	9852	11980	12736	8667	13292	13492
	N_{120}+PK	11887	**14117**	13086	11235	12996	**13170**	11974	13906	**14676**
	N_{180}+PK	**12704**	13586	13148	11669	**13083**	12848	**12821**	**14689**	13750
	N_{240}+PK	12035	12775	12621	**12569**	12610	12132	12648	14174	12719
LSD $_{5\%}$ crop rotation			*678*			*531*			*738*	
LSD $_{5\%}$ irrigation			*737*			*565*			*790*	
LSD 5% fertilization			*636*			*522*			*956*	

CONCLUSIONS

The different agrotechnical factors (crop rotation, fertilization, crop rotation, irrigation) have a different efficacy in the production technology of winter wheat and maize which should be taken into consideration at their application in the practice. We have determined the capacity of the extensive and intensive crop production models of winter wheat and maize on chernozem soil in the Hajdúság. By applying the intensive crop model, the yields of winter wheat and maize can be kept at 8.5-10.5 t ha^{-1} and 12.5-14.5 t ha^{-1}, respectively.

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