EXAMINATION OF THE YIELD STABILITY OF WINTER WHEAT AFTER DIFFERENT FORECROPS

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Abstract

We analyzed the effect of sweet maize, sunflower and grain maize forecrop on the yield stability with four different winter wheat genotypes in three different crop years (2012-2015) in a long-term experiment. According to our results, with a favourable forecrop (sweet maize) a much higher yield stability was measured. As per our data, with unfavourable forecrop (grain maize) the difference between the varieties occurred more conspicuously, which showed the different adaptive ability of the varieties. During the examination of the response to fertilizers (in the average of three years) with sunflower and sweet maize forecrop, varieties GK Öthalom, GK Csillag and Mv Toldi belonged to the group of varieties with good nutrient utilization and good response to fertilizers. With grain maize forecrop most of the varieties (except genotype GK Csillag) belonged to the group of varieties with poor nutrient utilization and weak response to fertilizers, which draws attention to the importance of the choice of the forecrop in Hajdúság.

Key words: winter wheat, croprotation, yield, crop year, genotype

INTRODUCTION

According to Slafer et al. (1994), winter wheat is one of the most widely grown cereal plants, it is grown in all regions of the world. As per FAO (2013) data, sunflower is grown on 25.6 M ha, grain maize on 184.6 M ha and winter wheat on 218.4 M ha. In Hungary winter wheat is grown on 1.11 M ha, grain maize on 1.19 M ha, sunflower on 593.6 K ha and grain maize on 29.3 K ha [1]. Crop rotation in Hungary is has been concentrated on cereals and oilseeds. The effect of the crop year can influence the yield of cereal plants at a great extent. According to PEPÓ and CSAJBÓK (2014) the results of their 10-year long-term experiment on chernozem soil proved that evaluating even together the types of crop rotations, the effect of fertilization was the most obvious. Fertilization had a 26.74 – 75.54 % contribution to the increase of the yield. Due the effect of different forecrops the optimum fertilization also changes. According to VÁRNAI et al. (1985), in the average of fertilizer treatments, after maize forecrop, winter wheat produced a yield higher by 0.53 t ha^{-1}. According to LESZNYÁK (1997), after maize previous cropping, up to a N_{150} + PK fertilizer dose the yield of winter wheat is significantly growing, but a N_{200}+Pk fertilizer dose together with lack of water results in decrease in the yield. According to HORNOK and PEPÓ (2007), after maize forecrop a relatively close, positive correlation (0.705) was detected between fertilization and the yield results of wheat. According to PEPÓ (2014), in tests of 10-year periods, average yields decreased from 4.92 t ha^{-1} of the 80's to 4.03 t ha^{-1} of the 2000's, while the extent of fluctuation in the yield increased from 27% to 61%. In Hungary, in 2012 3.75 t ha^{-1}, in 2013 4.64 t ha^{-1}, in 2014 4.73 t ha^{-1}, in 2015 5.14 t ha^{-1} increase in the yield of of winter wheat was achieved, as per the data (2015) of the Central Statistical Agency. In the winter wheat production of Hungary, besides the ecological and agrotechnical factors, the genotype has a determinative role. In the national catalogue of varieties 168 varieties are available for farmers in Hungary NÉBIH (2015) [I3]. According to PEPÓ et al. (1989), the crop year, the forecrop and the variety considerably affects the realized yield result. According to KONDORA et al. (2002) many varieties with good adaptive ability are available which may have indifferent crop quality and yield results, but it is acceptable in a production area with weaker conditions.

MATERIAL AND METHOD

Our field tests took place on the test farm of KIT Látókép of University of Debrecen, Centre for Agricultural and Applied Economic Sciences, on calcareous chernozem soil, in long-term experiment, in growing seasons of years 2012-2015, after sweet maize, sunflower, grain maize forecrop, with varieties GK Öthalom, GK Csillag, Mv Csárdás, Mv Toldi arranged in 4 replicates in split bands. 100% of P and K fertilizer doses were spread in autumn, 50% of the N fertilizer doses were spread in autumn and the other 50% in spring. Fertilizer doses spread with the different nutrient levels are shown in *Table 1*. We applied Kang's stability analysis, where we calculated an environmental average annually from the average of the yield results of all the tested varieties. The yield results of the tested varieties gained with the different fertilizer treatments were averaged separately in each year, which has been demonstrated on diagram with the environmental average, applying linear regression. The different winter wheat species were characterized by the control and the optimum yields.

Table 1.

Applied fertilizer doses (Debrecen, 2012-2015)

Applied fertilizer doses	*N*	*P_2O_5*	*K_2O*
	kg ha^{-1}		
0	*0*	*0*	*0*
1	*30.0*	*22.5*	*26.5*
2	*60.0*	*45.0*	*53.0*
3	*90.0*	*67.5*	*79.5*
4	*120.0*	*90.0*	*106.0*
5	*150.0*	*112.5*	*132.5*

Table 2.

Monthly values of precipitation (mm) and temperature (°C) in the vegetative period of winter wheat (Debrecen, 2012-2015)

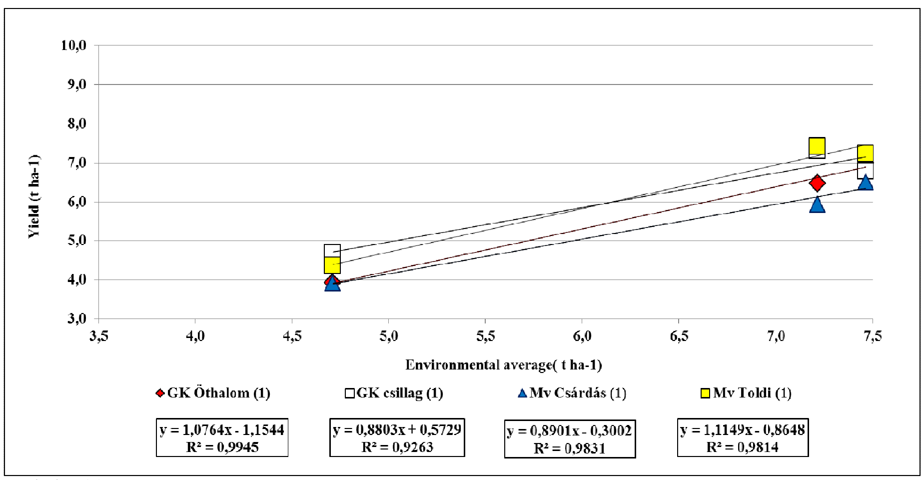
Year	Oct.	Nov.	Dec.	Jan.	Feb.	Marc.	Apr.	May	Jun.	Total
	Precipitation (mm)									
2012/2013	22,4	16,6	65,8	38,7	52,9	136,3	48	68,7	30,8	480,2
2013/2014	39,1	51,5	0	39,2	26	11,3	39,6	69,4	7,9	284,0
2014/2015	88,6	20,8	37,9	39,5	18,6	10,2	21,9	52,9	60,5	350,9
30 year average	30,8	45,2	43,5	37	30,2	33,5	42,4	58,8	79,5	400,9
	Precipitation (mm)									Average
2012/2013	11,1	7,2	-1,2	-1	2,3	2,9	12	16,6	19,6	7,72
2013/2014	11,8	7,6	0,5	2	7,8	8,9	12,3	15,4	19	9,48
2014/2015	11,2	6,4	2,4	1	1,5	6,2	10,1	15,8	19,9	8,28
30 year average	10,3	4,5	-0,2	-2,6	0,2	5	10,7	15,8	18,7	6,93

Our temperature and precipitation data measured in our field experiments are shown in *Table 2*. According to our measurements there were considerable differences between the years. The average of the average temperature of the tested years (7.72-9.48 ^{0}C) significantly exceeded the average of 30 years (6.93 ^{0}C). Both the distribution and the quantity of precipitation were unfavourable. With exception of the 2012/2013 growing season where the amount of rainfall was more by 79.3 mm, in growing seasons of 2013/2014 and 2014/2015 considerably less water (284.0-350.9 mm) was available for winter wheat stands, compared to the average of 30 years (400.9 mm), to which the different forecrop and varieties reacted differently.

RESULTS AND DISSCUSIONS

During our research done in long-term experiment we analysed the effect of sweet maize, grain maize and sunflower forecrop in the examined fertilizer treatments on the yield stability (Figure *1-3*). Average yield of winter wheat varieties after sweet maize forecrop changed between 3.9-7.2 t ha^{-1} in the average of the tested fertilizer treatments. The interval of the environmental average changed between 4.7-7.5 t ha^{-1}. It shows that in the average of the treatments there is a significant difference between the varieties compared to the values of the environmental average. GK Csillag and Mv Toldi were the best varieties in the average of the years (6.3 t ha^{-1}). The points shown were nearly in the same interval, which means that sweet maize forecrop has a favourable, positive effect on the yield.

Yield stability of winter wheat after sunflower forecrop is shown in *Figure 2*. According to our data, the environmental averages and the yield of the varieties changed in a smaller interval than with sweet maize forecrop.

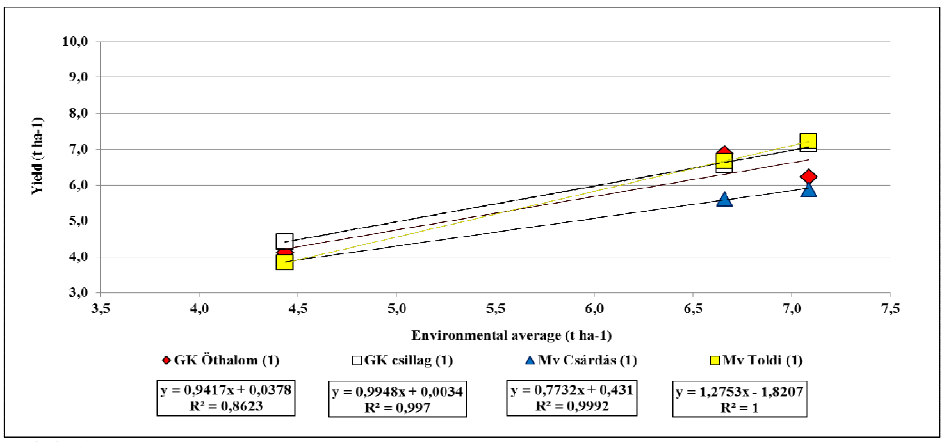


Varieties (1)

Fig. 1 Yield stability of different winter wheat varieties after sweet maize forecrop (Debrecen, 2012-2015)

Because of the robust root system of sunflower and its effect on the soil, the winter wheat stands produced a lower yield. Among the varieties, GK Öthalom and Mv Csárdás reached a lower yield stability. The environmental average was analysed in the average of the treatment and the years (*Table 3*). According to our data, it was 6.1 t ha^{-1} after sunflower and 6.5 t ha^{-1} after sweet maize forecrop. We assessed the yield stability of the different winter wheat varieties in the average of the treatments and the years. Based on our results gained in long-term experiment, we found small difference between the sweet maize (6.0 t ha^{-1}) and the sunflower (5.7 t ha^{-1}) forecrop, on which the favourable chernozem soil and nutrient intake could have a positive influence.

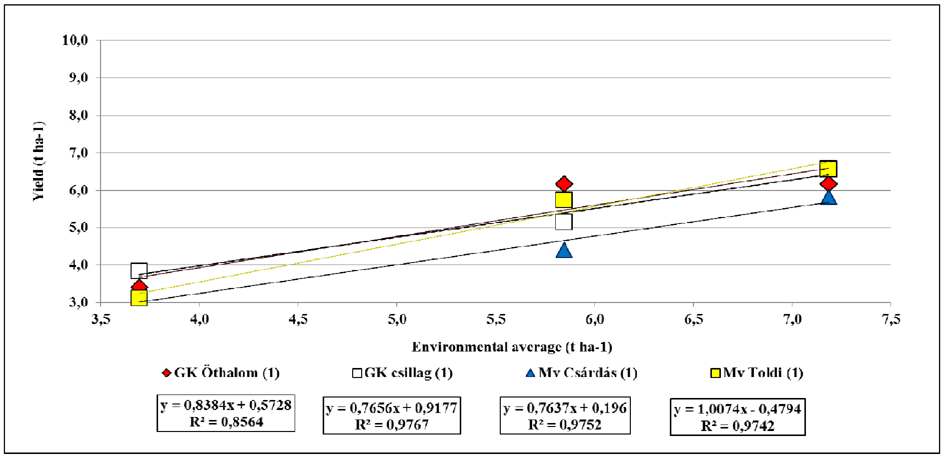
Efficiency of the adaptive ability of the varieties occurred more conspicuously after an unfavourable forecrop, with a lower yield. Decrease in the yield of the varieties after sunflower forecrop in the more unfavourable growing season of 2014/2015 was salient, which occurred due to the unfavourable effect of sunflower with high water consumption.



Varieties (1)

Fig. 2 Yield stability of different winter wheat varieties after sunflower forecrop (Debrecen, 2012-2015)

In our long-term field experiments we examined the effect of grain maize forecrop (Figure 3) on the yield stability of winter wheat. Accord to our results, after grain maize forecrop the lowest yield intervals were gained. Among the tested forecrops, the lowest environmental average (5.6 t ha^{-1}) in the average of the years was gained in this treatment. The very favourable crop year (2013/2014) could reduce the effect of the unfavourable forecrop.



Varieties (1)

Fig. 3 Yield stability of different winter wheat varieties after grain maize forecrop (Debrecen, 2012-2015)

Table 3.

Yield stability after different forecrops in the tested years

(Debrecen, 2012-2015)

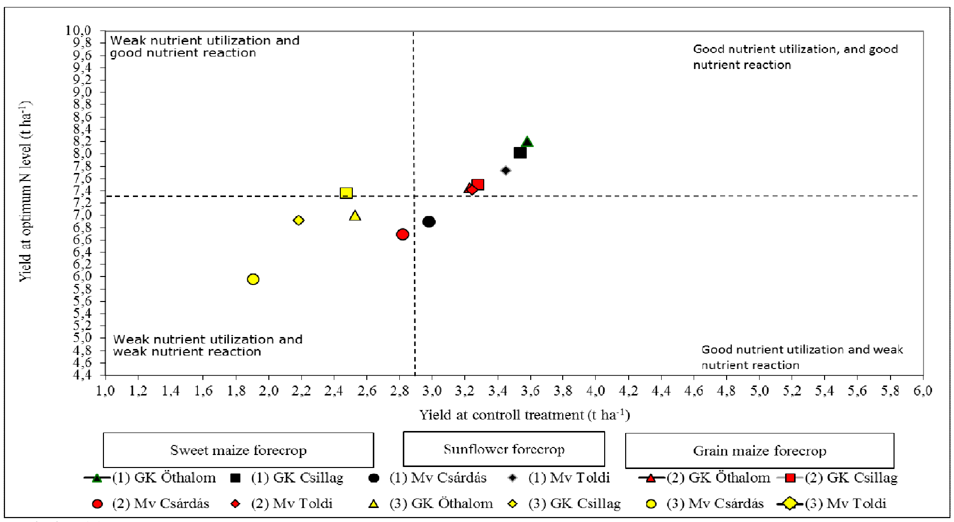
Cropyear	Environmental average	GK Öthalom (1)	GK csillag (1)	Mv Császdás (1)	Mv Toldi (1)
	Yield (t ha^{-1})				
Sweet maize forecrop					
2012-2013	4.7	3.9	4.7	3.9	4.4
2013-2014	7.2	6.5	7.3	5.9	7.4
2014-2015	7.4	7.0	6.8	6.5	7.2
Average	**6.5**	**5.8**	**6.3**	**5.5**	**6.3**
Main average:	-	**6.0**			
Sunflower forecrop					
2012-2013	4.4	4.1	4.4	3.9	3.8
2013-2014	7.1	6.2	7.1	5.9	7.2
2014-2015	6.7	6.9	6.5	5.6	6.7
Average	**6.1**	**5.7**	**6.0**	**5.1**	**5.9**
Main average:	-	**5.7**			
Grain maize forecrop					
2012-2013	3.7	3.4	3.8	3.1	3.1
2013-2014	7.2	6.2	6.6	5.8	6.6
2014-2015	5.8	6.2	5.2	4.4	5.7
Average	**5.6**	**5.2**	**5.2**	**4.5**	**5.1**
Main average:	-	**5.0**			

Varieties (1)

We analysed yield stability, and in the average of the treatments, the years and the varieties we measured 5 t ha^{-1} after grain maize forecrop, after sunflower and sweet maize forecrops higher yields (+0.7 t ha^{-1} and 1.0 t ha-

^{1}) were gained (*Table 3*). Our data shows that on chernozem soil, even with increased fertilization, after grain maize forecrop winter wheat was not able to reach the yield interval that it produced after sunflower forecrop.

We evaluated the yield potential of the varieties in the average of the treatments and the years after the tested forecrops (*Table 4*). Our results revealed that GK Öthalom, GK Csillag and Mv Toldi can be classified as varieties with good nutrient utilization and good nutrient reaction after sweet maize and sunflower forecrops. Among winter wheat genotypes sown after unfavourable forecrop (grain maize) Mv Csárdás, Mv Toldi and GK Öthalom had been classified as varieties with weak nutrient utilization and weak nutrient reaction. GK Csillag with its good adaptive ability had been classified as a variety with weak nutrient utilization but with good nutrient reaction, which shows that the variety has a better adaptive ability.



Varieties (1)

Fig. 4 Yield reaction of different winter wheat varieties after different forecrops in the average of the treatments and the years (Debrecen, 2012-2015)

CONCLUSIONS

In Hajdúság, we carried out Kang's stability analysis with winter wheat in long-term field experiment, in three different crop years with four different varieties. According to our results, small difference has been observed with winter wheat sown after sunflower and sweet maize forecrops. The lowest yield stability was measured with grain maize forecrop, with the application of the same agrotechnique. We detected how the adaptive ability of the varieties changed, which, with “favourable forecrops”, fell in nearly the same interval. During testing the three forecrops, we observed that Mv Csárdás was the variety with the lowest yield stability. With an unfavourable forecrop (grain maize), nutrient reaction of the varieties was significantly different.

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