ANALYSIS OF THE FERTILIZER AND YEAR EFFECTS ON THE MAIZE YIELD WITH NOVEL METHOD

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Abstract: As a result of climate change, spatial and temporal distribution of precipitation in Hungary changes, therefore appropriate nutrient supply becomes more and more important for both environmental protection and economic reasons. Monitoring of efficiency of fertiliser use requires field trials, where fertiliser utilization and specific effects of a given year are observable. A novel method was used for the investigation of the above.

The measurements were carried out at the Látókép Experimental Site of the University of Debrecen, in moderately warm, dry production zone, in years 2012-2014, on mid-heavy calcareous chernozem soil. The trial had two repetitions, and a split-strip-plot distribution.

Statistical evaluation and the interaction plot were performed in an R environment, with the RStudio graphical user interface. For the analysis of the fertilizer and year effect a repeated measurement model was created; comparison of multiple mean values was carried out by means of the Student-Newman-Keuls test.

Fertilization, and the specific annual factors had a significant ($p < 0.001$) effect on yield; however the interaction of the fertilizer and the year had no significant effect on the yield. We achieved the highest statistically verified yield, 13.3 tha^{-1} with the 120 kg Nha^{-1} base + 30kg Nha^{-1} additional fertilizer treatment. Each of the three examined years were significantly ($p < 0.001$) different from each other, we measured the highest yield 13.16 tha^{-1} in the year 2012.

Keywords: **maize, year effect, repeated measurement model, fertilisation**

Introduction

Due to increasing population of the need to increase the yield in the crop production, which can only ensured with intensive plant nutrition (*Ványiné et al*., 2012a). For the utilization of the nutrients is the soil moisture essential (*Ványiné et al*., 2012b). However as a result of climate change, spatial and temporal distribution of precipitation in Hungary changes, therefore appropriate nutrient supply becomes more and more important for both environmental protection and economic reasons. (*Ványiné and Nagy*, 2012). Determining the optimum fertilizer dosage depends on many factors, the most influencing factors on this are the soil water and nutrient supply capacity (*Al-Kaisi és Yin*, 2003; *Gehl et al.*, 2005.). Monitoring of efficiency of fertiliser use requires field trials, where fertiliser utilization and specific effects of a given year are observable. A novel method was used for the investigation of the above.

Materials and methods

The examinations were carried out at the Látókép Experimental Site of the Centre for Agricultural Sciences of the University of Debrecen (47° 33' N, 21° 26' E, 111 m), moderately warm, dry production zone, in the years 2012-2014. On mid-heavy calcareous chernozem soil, in a two replication split-strip-plot experiment. The main parcells are the hybrids, the split parcells are the irrigation variants and on the split-split plots the fertilizer treatments. In this research paper we used only the non irrigated parcells, because we wanted examine the effect of the year and the fertilizer doses on the yield

The fertilizer treatments are the following:

Basic: A_0= non treated control; A_{60}=60 kg N ha^{-1}; A_{120}= 120 kg N ha^{-1},
additional in V6 stage: $V6_{(90)}$=A_{60}+30 kg N ha^{-1}; $V6_{(150)}$=A_{120}+30 kg N ha^{-1},
additional in V12 stage: $V12_{(120)}$=$V6_{(90)}$+30 kg N ha^{-1}; $V12_{(180)}$=$V6_{(150)}$+30 kg N ha^{-1}.
The weather was evaluated on the data measured by the automatic weather station (*Figure 1.*)

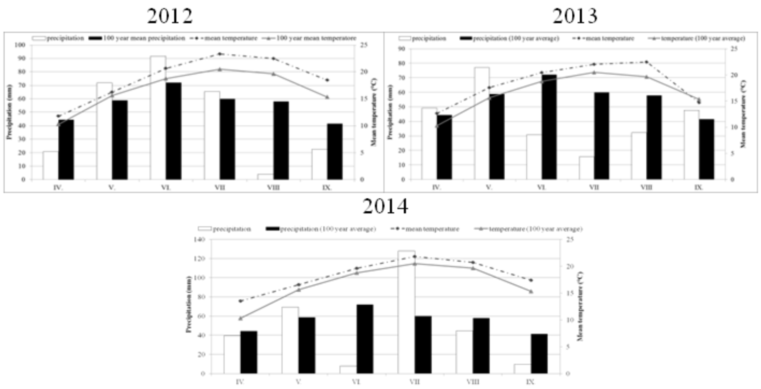

Figure 1. Precipitation and temperature during the growing season

(*Debrecen, 2012-2014*)

In growing season of 2012 the temperature was 2,13°C higher than the multiple-year average, the precipitation was 71 mm less than the a multiple-year average. The growing season of the next year (2013) was warmer (+1,6°C) and precipitation was 84mm lower than the average. In the year 2014 in the season the temperature was 1,58°C warmer and precipitation was 35,6 mm lower than the average.
Statistical evaulation: The evaulation and the interaction plot were performed by R 3.2.0. (*R Core Team*, 2015) and RStudio 0.98.1103 graphical interface. We used the packages "gplots" (*Gregory et. al*., 2015), "car" (*Fox és Weisberg*, 2011) és "agricolae" (*de Mendiburu*, 2014). For the analysis of the fertilizer and year effect a repeated measurement model was created; comparison of multiple mean values was carried out by means of the Student-Newman-Keuls test (*Huzsvai and Balogh*, 2015). We used 10% (alpha=0.1) as limit for significant difference.

The script for repeated measurement model in RStudio:

```
model<- aov(yield~fertilizer_treatment*year+Error(parcell_id/year), data=database))
summary(modell)
```

The script for the Student-Newman-Keuls test in RStudio:

```
df=df.residual(model$"parcell_id")
mse=deviance(model$"parcell_id")/df
treatment <- with(database, SNK.test(yield, treatment, df, mse, alpha=0.1, console = T))
```

Results and discussions

We created an interaction plot, to demonstrate the fertilization and the year effect on the yield (Figure 2.).

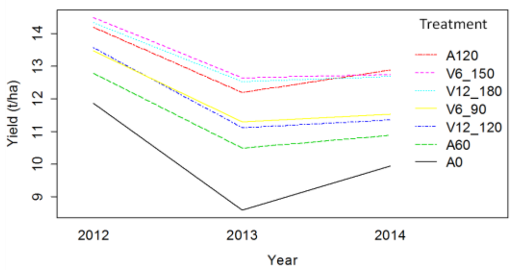

Figure 2. Fertilization and year effect on yield

On the interaction plot it is visible that all treatments are different from the non fertilized control parcels, with the created repeated measurement model we examined the connection between the fertilizer, year effect and the yield. As the result, the year and the fertilizer has a significant ($p<0{,}001$) effect on the yield, but the fertilizer and the year interaction has no effect on the yield (*Table 1*.).

Table 1. Analysis of variance table for the repeated measurement model

Error: parcell_id					
	Df	Sum Sq	Mean Sq	F value	Pr (>F)
Treatment	6	431,5	71,91	8,304	$4{,}72*10^{-7}$ ***
Residuals	83	718,8	8,66		
Error: parcell_id * year					
Year	2	299	149,5	110,844	$<2*10^{-16}$ ***
Treatment * Year	12	19,94	1,66	1,232	0,265
Residuals	166	223,89	1,35		
Significance codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1					

Each of the three examined years was significantly ($p<0{,}001$) different from each other, we measured the highest yield 13,16 tha^{-1} as experiment average in the year 2012. This was a droughty season, but the precipitation in april, may, june and july was higher than the average, and because of this the yield was the highest of the three examined vinages. The second highest yield was in the year 2014 with 11,33 tha^{-1}, as experiment average. In 2014 July was more than two times more precipitation than the multiple year average, and therefore the droghtly June was offset slightly in the terms of yield. We measured the lowest yield in the year 2013 which was 10,68 tha^{-1}, because in May it fall nearly 30% more rain, but in the following moths were severe droughtly, and it strongly negatively affected the crop.

Each of the 6 treatments in three-year average was significantly ($p<0{,}001$) different from the non fertilized control treatment (*Figure 3*.)

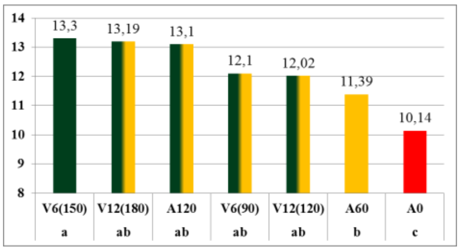

Figure 3. Effect of fertilizer on the yield (tha^{-1}) in dry farming

We achieved the highest statistically verified yield, 13.3 tha^{-1} with the 120 kg Nha^{-1} base + 30kg Nha^{-1} additional fertilizer treatment. It was significantly different from the 60 kg Nha-1 base fertilizer treatment. The V12(180), A120, V6(90) and V12(120) treatments are not statistically different from the V6(150) or the A60 treatment.

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