Nitrogen fertilization analysis on small plot winter wheat (*Triticum aestivum* L.) experiments

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Abstract: Our research at the Institute of Crop Production of the Faculty of Agricultural and Environmental Sciences at Szent István University was comparative tests of nitrogen fertilization analysis on small plot winter wheat experiments in which production was examined with a view to the different volume of used N fertilisation in the period of four years (2008, 2009, 2010, 2011). The comparative small plot winter wheat we have arranged is a split-plot experiment. In this case, the cultivar represented the main parcel factor and the various fertiliser treatments represented the sub-parcel factors. In our experiment the effects of 6 nitrogen doses (one control and 5 treatments as top-dressing) were examined for 5 cultivars (Mv Csárdás, Mv Magdaléna, Mv Suba, Mv Toborzó, Alföld 90) in 4 repetitions. Three years (2008, 2009 and 2011) of the experiment showed significant differences among the yields as a result of the applied different level of N. According to the comparative study of the vintages, there were statistically proved differences between the yields every year which proves that the weather has a huge impact on the harvest.

Keywords: winter wheat, N-fertilization, top-dressing, small-plot experiment, yield

Introduction

Biological agents such as variety and it's nutrient reactions in winter wheat fertilization are commanding affects. High differences appear in variety's nitrogen demand and usage which are affected by agro-ecological (vintage soil) and agro technical (forecrop plant protection etc.) factors (*Harmati*, 1975; *Pepó*, 1995). Adverse weather effects can be moderated by appropriate nutrient replenishment (*Fowle*r, 2003).

Various authors – especially from the international literature – are suggesting different amount of fertilizer as well as different fertilizing time depending on the soil and ecological situation of the field they are working on. Most authors agree that the quality development caused by nitrogen application on winter wheat is very high (Ragasits, 1998), however there is a limit on applied amount of fertilizers (*Neményi,* 2008).

Nitrogen (N) fertilization is one of the most important agronomic management practices, yet the amount and timing of N remains a management challenge. Crops growing with N deficiency lose greenness, they are usually smaller with less biomass, and have reduced photosynthetic capacity resulting in poor yield and low protein content (*Basso et al.*, 2013).

Materials and methods

Location: The experimental agricultural plot of the Institute of Crop Production is approx. 5 ha in size. The location of the small plot experiment is in the outer area of the municipality of Hatvan-Nagygombos.

Weather in the examined years: The annual average temperature of the area is 10.3 °C and annual precipitation varies between 560-580 mm. In the first year of the experiment (2008), in the period from August to July, the region's overall precipitation was 695.7 mm which is 120-140 mm more than the long term average. Overall precipitation in the

2nd year of the experiment (480.3 mm, in 2009) was 200 mm less in comparison to the previous year. 2010 was an extremely rainy year in Hungary with respect to the long term average, as the total precipitation (799.2 mm) was well above it. The large quantities of rainfall resulted in inland water over a large part of the experimental area, having a depressive effect on its flora. In 2011, total precipitation was 665.8 mm, which is above the average, just as it was during the preceding year.

Soil: The experimental area's soil is chernozem-brown forest soil, its most important average soil test result are shown below (5 August 2007): organic matter content:
2.65%; CaCO3:1.86%; pH (KCl):7.30; KA: 45; P2O5 (mg kg^{-1}):463 (AL-soluble); K2O (mg kg^{-1}):293 (AL-soluble); N (mg kg^{-1}):0.9 (total mineral cont.)

From the measurement results of the soil samples, that the area has a satisfactory supply of phosphorus and potassium, therefore basic fertilisation only plays a sustaining role. As for feeding the flora, nitrogen is of exceptional significance, as this is the only macro element in limited supply for the plants.

Setting and sustaining the experimental conditions and the applied treatments

Layout: The comparative small plot winter wheat we have arranged is a split-plot experiment. In this case, the cultivar represented the main parcel factor and the various fertiliser treatments represented the sub-parcel factors. In out experiment the effects of 6 nitrogen doses (one control and 5 treatments) were examined for 5 cultivars in 4 repetitions.

Cultivars: The varieties set in the experiment were selected with the aim of picking those with high yields as well as high protein and gluten contents as these react easier to the doses of active ingredients delivered. Four of the five selected cultivars were Martonvásár wheat (Mv Csárdás, Mv Magdaléna, Mv Suba, Mv Toborzó) and an older, but well-performing cultivar which had received state recognition back in 1987, the Alföld-90 (later known as Alföld).

Plant nutrition: As a basic fertiliser, one unit (300 kg ha^{-1} total amount of fertilizer) of complex (N:P:K=15:15:15) fertiliser was delivered using a splash plate broadcast spreader. The various single N doses (0, 40, 80, 120 kg ha^{-1}) were delivered in spring as top-dressing, at the time of tillering. In the case of double and triple N doses (split top-dressing: 80+40, 80+40+30 kg ha^{-1}), the first application was delivered at the time of tillering, the second at stem elongation, and the third nitrogen dose was delivered upon the appearance of the flag leaves. Top-dressing was performed manually in each case, given the small size of the plots, after doses had been precisely measured.

Tillage: The area managed according to the sequencing requirements of crop rotation was selected so that the preceding crop should be the same in each year examined and in our case it was dried beans.

Sowing: Sowing was performed every year with the institute's 8 row, sliding coulter Wintersteiger Plotman plot seeder (Wintersteiger GmbH., Ried, Austria).

Cultivation routes: The cultivation routes across the tillering winter wheat field sowed using the split-plot system were created during the spring with the help of a rotary tiller.

Plant protection: The plant protection treatments (weed control, application of fungicides,

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etc.) was carried out in each case with a knapsack-type portable sprayer, therefore no wider access routes than created for sowing were necessary.

Harvesting: Harvesting was performed using the Wintersteiger Nurserymaster (Wintersteiger GmbH., Ried, Austria) plot harvester owned by the Institute of Crop Production.

Statistical data analysis

Statistical analysis (two variable analysis of variance /ANOVA/) of yield was carried out with the help of the GenStat programme. Variance analysis only shows whether significant difference exists among the results evaluated, but it doesn't indicate the groups among which the difference emerged. In order to identify this data, a Duncan multiple range post hoc test was carried out. The reason was the creation of homogeneous groups.

Results and discussion

Table 1 Results of the variance analysis of the four years (2008-2011)

Source of Variance	Degree of freedom	F-values			
		2008	2009	2010	2011
Repetition	3				
Varieties (A)	4	11.11***	112.3***	60.1***	78.03***
Fault (A)	12				
Nutrition (B)	5	84.6***	150.55***	63.93***	130.77***
A x B	20	1.48^{ns}	2.12*	1.16^{ns}	1.19^{ns}
Fault (B)	75				
All	119				

Table 1 shows the results of two-factor analysis of variance that was performed in each year of the study. From the results obtained it is obvious that each year there was a significant difference between the cultivars already on 0.1% significance level. The effect of - nutrient treatment (0.1%) was also significant in all years of our study. In case of the cultivar x nutrient interactions there was a significant difference only in 2009 on 5% level.

2008: After having done the Duncan-test (***Figure 1***) significant differences were observed in three types (Alföld, Csárdás, Magdaléna) however the yields of Suba and Toborzó varieties didn't differ significantly either from each other or from the yields of Csárdás and Magdaléna. The comparison of the different N data showed a significant difference in all level of N. The only exceptions were seen in the case of the single 120 kg N application and in the case of the divided N doses (80+40 kg) where there was no significant difference in yields.

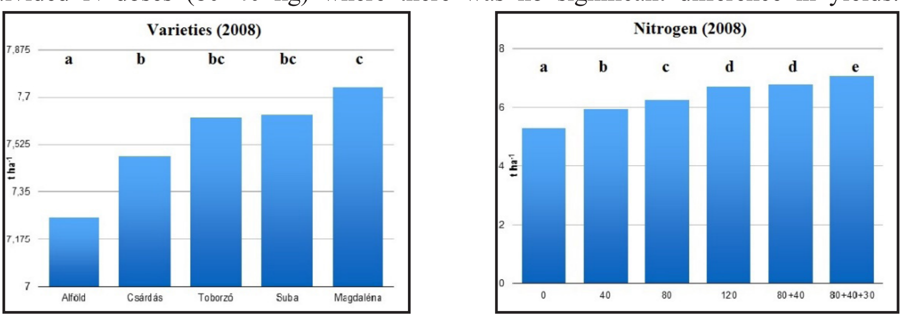

Figure 1 Comparision of varieties and applied N doses, Duncan-test (2008)

2009: According to the Duncan-test (***Figure 2***) there was a significant difference in yields between the Csárdás and Magdaléna wheats and in the other 3 varieties (Alföld, Toborzó, Suba). The Duncan-test didn't show significant difference among the yields of Alföld, Toborzó and Suba types. Differences in the doses of N were compared by the Duncan test as well. The result of the test falls in with the previous year's result as significant differences were measured in the applied doses of fertilizer. In 2009 the exception was again the divided and the single applications of the 120 kg N as there was no significant difference between the yields.

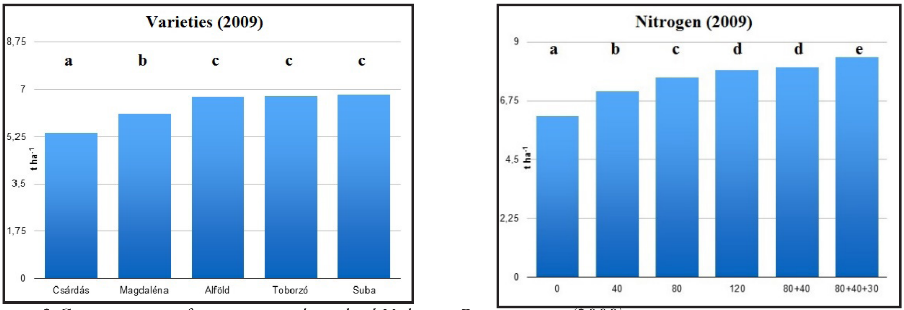

Figure 2 Comparision of varieties and applied N doses, Duncan-test (2009)

2010: Duncan-test (***Figure 3***) showed that there were significant differences among all types of wheats. Significant difference was shown among the 0, 40, 80, 120kg N, the 80+40kg N doses and the 80+40+30kg N doses. However, there were no significant differences among the 80 and 120 kg, and 80+40 kg and 80+40+30 kg N-doses.

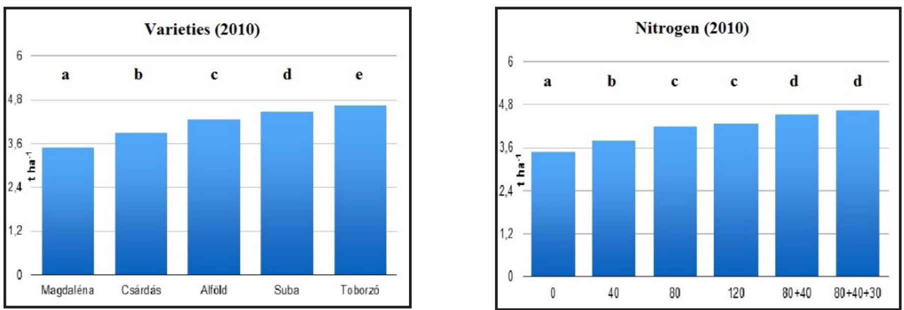

Figure 3 Comparision of varieties and applied N doses, Duncan-test (2010)

2011: Duncan-test (***Figure 4***), aimed to compare the different types, identified significant differences among the Csárdás, Magdaléna and Alföld types and between the mentioned types and the pair of Suba and Toborzó varieties. Significant difference was not shown between Suba and Toborzó types. The Duncan-test for N treatment showed the same result as it was in the first two years of experiment (2008-2009). The test didn't show significant difference between the use of single and divided use of the 120kg N however, apart from this result there was significant difference in all other nutrition levels.

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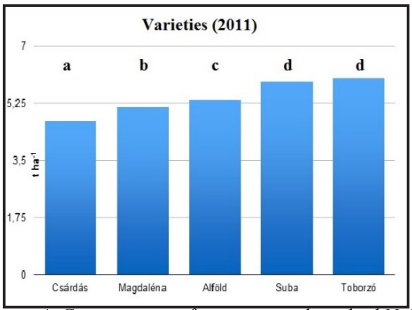

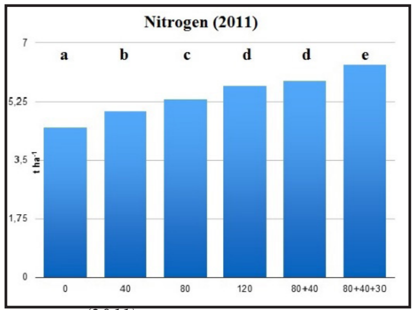

Figure 4 Comparision of varieties and applied N doses, Duncan-test (2011)

2008-2011:The follow-up of the the avarage yield per year was carried out by the Duncan-test as well. In all four years of the test period the yearly yield differed significantly (***Table 2***) from the other three years' results. As a result of the experiment we came to the conclusion that vintage has the greatest impact on the winter wheat yield that is followed by N fertilisation and the variety affect. The impact of the N fertilisation was two times as important as the variety impact however the interaction of the vintage and N fertilisation and vintage and variety were also significant.

Table 2 Results of combined variance analysis

Source of Varrience	Repe-tition	Variety (A)	Fault (A)	Nutri-tion (B)	A x B	Fault (B)	Year (C)	A x C	B x C	A x B x C	Fault	All
Degreeof freedom		4	12	5	20	75	3	12	15	60	270	479
Calculated F-volume		125.26 ***		357.18 ***	1.58 ns		2998.85 ***	33.56 ***	7.5 ***	1.43 *		

Conclusions

Based on comparison of the examined four years of small plot winter wheat varieties and the N fertilisation trial we came to the conclusion that increased use of N doses resulted in yield increase in the case of all varieties. Three years (2008, 2009 and 2011) of the experiment show significant differences among the yields as a result of the applied different level of N. The yield of the tested winter wheat varieties increased as a result of the increased doses of N fertilisation. Exceptions are the utilization of the single and divided uses of the 120kg N, as there was no significant difference between the two N levels (method of application) in the mentioned three years. It means that the division of the top dressing's dose increased the yields but it can't be verified statistically. According to the comparative study of the vintages, there were statistically proved differences between the yields every year which proves that the weather has a huge impact on the harvest. Based on the combined analysis of variance test, done in the mentioned four years it is proved that greatest impact on winter wheat yield was the vintages, followed by the effects of N fertilization and the variety. The effect of the N fertilization was double of the varieties' effect though there were significant interactions between the vintages and N fertilisation and between the vintage and the variety.

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