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THE RELATION BETWEEN PRODUCTIVITY ELEMENTS AND MINERAL FERTILIZATION IN WHEAT

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ABSTRACT
The present research deals with the relation for determining productivity elements based on differentiated fertilization of wheat.
Ear length and spikelet number presented smaller variation amplitude, while grain number and the weight of the grains on the ear had greater variation under the influence of differentiated fertilization. The differences in the productivity elements under analysis have statistical assurance and high degree of certainty ($p<0.01$). Generally, nitrogen had a higher contribution to the formation of productivity elements ($R^2 = 0.853 – 0.946$) than phosphorus and potassium ($R^2 = 0.449 – 0.723$). Phosphorus and potassium played a more important part in the formation of the number of grains than in the other productivity elements. It is possible to predict with a high level of certainty ($p<0.01$) the productivity elements based on the doses of fertilizers applied. Nitrogen allows of better prediction than the PK complex.

Keywords: wheat, productivity elements, mineral fertilizers, prediction

INTRODUCTION

Wheat is one of the most important agricultural crops, and as such its biology and its relation with environmental factors have been the focus of a large number of studies, for the purpose of adapting agricultural technologies, (FISCHER 1985, SHEWRY 2009, DELCOUR ET AL. 2012).
Plant density, foliar area, nutrition state, ear length, spikelet number, number of grains, are individual morphological elements whose cumulated effect influences the formation of the agricultural crop, (HANSEN and SCHJOERRING 2003).
The productivity of wheat varieties is determined genetically, but at the same time it is influenced by soil and climate conditions, as well as by technological conditions, (STAPPER and HARRIS, 1989, AGGARWAL and KALRA 1994, ZHANG and OWEIS 1999).
Fertilization is one of the key factors that influence wheat productivity and yield, (JABLONSKYTĖ-RAŠČĖ ET AL. 2013). The differentiated state of nutrition given by fertilization ensures the different ways in which plants are formed and develop different values of productivity elements and finally different quality and quantity of the yield, (MULLA ET AL., 1992, TIMSINA and CONNOR 2001).
The present research deals with the relation between fertilization and productivity elements in wheat and also with the possibility to predict them based on the fertilizers applied.

MATERIAL AND METHOD

The research assessed the relations between mineral fertilization and productivity elements of winter wheat; ear length, spikelet number, number of grains and grain weight.

Fertilization was made with complex mineral fertilizers of the type NPK (S) + Zn and ammonium nitrate (35:0:0) in various combinations, which rendered the following variants: $P_0K_0N_0$, $P_0K_0N_{100}$, $P_0K_0N_{200}$, $P_{50}K_{50}N_{50}$, $P_{50}K_{50}N_{100}$, $P_{50}K_{50}N_{200}$, $P_{100}K_{100}N_{100}$, $P_{100}K_{100}N_{150}$, $P_{100}K_{100}N_{200}$, $P_{150}K_{150}N_{150}$ and $P_{150}K_{150}N_{200}$.

The research was set on slightly gleyed cambic chernozem with medium fertility: *p*H = 6.87, poor phosphorus supply (P = 24.3 ppm) and good potassium supply (K = 178.55 ppm), with a humus content of 2.87%:

The climate conditions in the crop years 2011 – 2013 were characterized by rainfall deficit as compared with the multiannual average, and by uneven distribution of rainfall throughout the year, with droughts and high temperatures especially in July and August. These climatic particularities of the experimental years did not have a significant influence over the wheat crop, as it was harvested at the beginning of July, and grain formation and maturation were finished in good conditions.

The biological material was represented by *Alex* cultivar, which has good productivity, stability and quality of the yield.

The experimental variants were set in randomized blocks, in three replicates. The area of a variant was 30 m^2. Complex fertilizers were applied in autumn, and nitrogen fertilizers were applied in spring. Both fertilizations were made manually, for better uniformity. General maintenance works were made uniformly within the general crop technology.

For determining the productivity elements, ear length, spikelet number, number of grains and the weight of grains on the ear, randomized plant samples were taken in each variant.

The experimental data were processed statistically through variance analysis, correlations, regressions, multivariate analysis using the statistic module from EXCEL 2007 and PAST software.

RESULTS AND DISCUSSIONS

The experimental variants obtained by fertilization caused different development of the wheat plants. For the same reason, specific variations were recorded in the productivity elements analysed, namely ear length, spikelet number, number of grains and the weight of the grains on the ear. These specific variations are presented in *Table 1*.

Table 1. Values of productivity elements of wheat, *Alex* cultivar, depending on fertilization

Parameter / Variant	Variant number	Ear length (cm)	Spikelet number	Grain number	Grain weight (g)
$P_0K_0N_0$	V_1 (Mt)	6.82±0.26	13.65±0.45	35.30±2.37	1.66±0.11
$P_0K_0N_{100}$	V_2	7.17±0.19	15.05±0.40	38.60±2.12	1.72±0.14
$P_0K_0N_{200}$	V_3	7.97±0.15	16.50±0.39	45.75±1.75	2.12±0.08
$P_{50}K_{50}N_{50}$	V_4	6.99±0.13	14.70±0.43	41.50±1.61	1.54±0.09
$P_{50}K_{50}N_{100}$	V_5	7.11±0.19	14.95±0.40	44.95±2.34	1.95±0.05
$P_{50}K_{50}N_{200}$	V_6	7.83±0.12	16.20±0.29	46.40±1.31	2.10±0.68
$P_{100}K_{100}N_{100}$	V_7	7.23±0.15	15.40±0.29	41.35±1.55	1.68±0.07
$P_{100}K_{100}N_{150}$	V_8	7.80±0.20	15.90±0.35	46.80±2.00	1.91±0.09
$P_{100}K_{100}N_{200}$	V_9	8.47±0.14	16.65±0.23	52.85±1.64	2.12±0.08
$P_{150}K_{150}N_{150}$	V_{10}	7.86±0.17	16.40±0.28	48.75±1.66	1.97±0.07
$P_{150}K_{150}N_{200}$	V_{11}	8.81±0.19	17.45±0.30	53.15±1.85	2.46±0.09

Ear length is the morphological and productivity element on which the other elements are

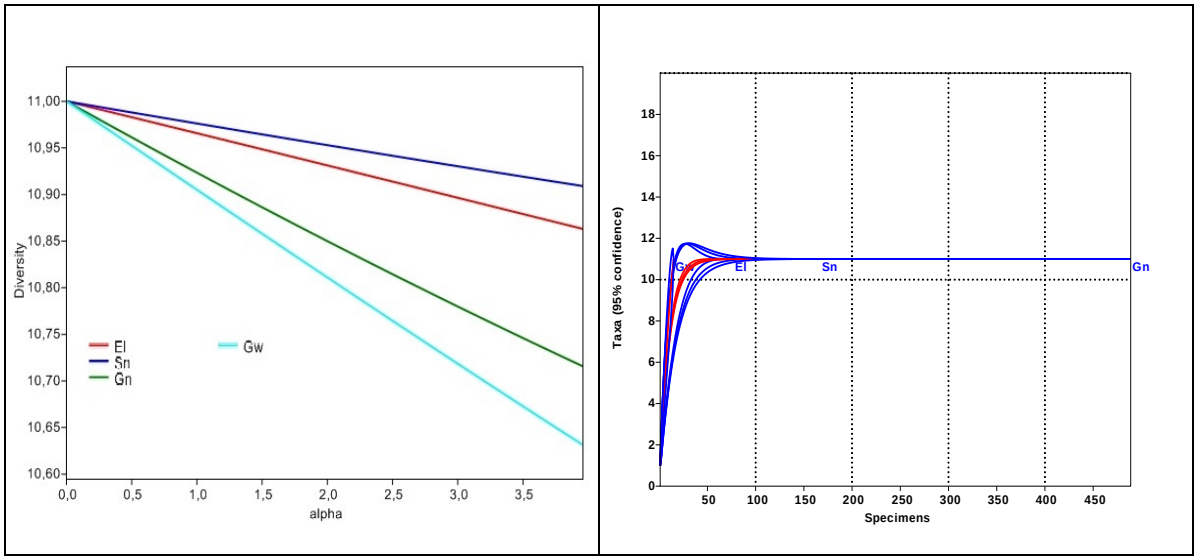
formed and develop: spikelet number, grain number and grain weight. As a result of differentiated fertilization, ear length varied between 6.99±0.13 cm in variant V_4 and 8.81±0.19 cm in variant V_{11}. In the control variant V_1, ear length was 6.82±0.26 cm. The values recorded for spikelet number ranged from 14.70±0.43 in variant V_4 to 17.45±0.30 in variant V_{11}, while the control variant gave 13.65±0.45 spikelets.
The number of grains on an ear had values between 38.60±2.12 in variant V_2 and 53.15±1.85 in variant V_{11}. In the same experimental conditions, the control variant V_1 gave 35.30±2.37 grains/ear. Grain weight on the ear gave values between 1.54±0.09 g in variant V_4 and 2.46±0.09 g in variant V_{11}. In the control variant, V_1 we recorded 1.66±0.11 g/ear grain weight.
The differences recorded about the productivity elements, generated by differentiated fertilization, are statistically assured, with a high confidence level ($p < 0.01$), *Table 2*.

Table 2. ANOVA: Single Factor

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	12112.71	3	4037.571	497.0652	1.11E-31	6.59454
Within Groups	324.9128	40	8.12282			
Total	12437.63	43				

Alpha = 0.001

Of all productivity elements under analysis, the lowest variation amplitude generated by differentiated fertilization was recorded in spikelet number and ear length, and the highest was recorded in grain number and grain weight on an ear, as shown in *Figure 1*. This proves the greater dependence of grain formation (in terms of number and quality) on the nutrition state of plants than on the genetic factor.



a - Diversity profile b - Rarefaction curve

Figure 1. Variation amplitude of the productivity elements in relation with fertilizer doses (El – ear length; Sn – spikelet number; Gn – grain number; Gw – grain weight)

Between the two categories of variables analysed, i.e. fertilizers as an independent variable and productivity elements as dependent variables, we identified the relations of interdependence with different levels of significance, as shown in *Table 3*.
Under the climate and soil conditions specific for the research period, nitrogen had overall

a higher contribution to the formation of productivity elements than phosphorus and potassium. Analysis of the individual correlation values of the productivity elements with the fertilizer (*Table 3*) showed closer dependence of spikelet number and ear length to nitrogen. Phosphorus and potassium had a higher contribution to the formation of grain number than to any other productivity element.

Table 3. Correlation matrices (r) among the parameters determined

	N	PK	Length (cm)	Spikelet number	Grain number	Grain weight
N	1.000					
PK	0.423	1.000				
Length (cm)	0.888	0.607	1.000			
Spikelet number	**0.946**	0.628	**0.952**	1.000		
Grain number	0.853	**0.723**	**0.919**	**0.912**	1.000	
Grain weight	0.855	0.449	**0.906**	0.868	0.844	1.000

Based on the high values of the determined correlations, which express the interdependence between the two categories of variables, we studied the possibility to predict productivity elements by using the fertilizers applied. In the predictions presented below, the correlation given by R^2 was calculated on the predicted values.
Ear length prediction was possible with high certainty based on the two categories of nutrients, i.e. nitrogen and the phosphorus:potassium complex (R^2 = 0.854; r = 0.924; $p<0.01$), equation (1).

$$L_{ear} = 6.47384 + 0.00719N + 0.0016PK \quad (1)$$

Of the two categories of nutrients, nitrogen allows prediction with a higher certainty degree (R^2 = 0.930) *Figure 2*, than the PK complex, where potassium and phosphorus are considered together (R^2 = 0.432).
Spikelet number can be predicted with high certainty based on the fertilizer doses applied (R^2 = 0.957; r = 0.978; $p<0.01$), equation (2).

$$N_{spikelets} = 13.6176 + 0.01313N + 0.00268PK \quad (2)$$

Of the two categories of nutrients, nitrogen allows prediction with a higher certainty degree (R^2 = 0.939) *Figure 3*, than the potassium and phosphorus taken together (R^2 = 0.412).
Grain number can be predicted with high certainty based on the fertilizer doses applied (R^2 = 0.887; r = 0.942; $p<0.01$), equation (3).

$$N_{grains} = 34.8909 + 0.05431N + 0.0219PK \quad (3)$$

Of the two categories of nutrients, the prediction based on nitrogen is more certain (R^2 = 0.834) *Figure 4*, than the one made on phosphorus and potassium taken together (R^2 = 0.590). The PK complex ensures greater certainty for the prediction of this productivity parameter than for ear length and spikelet number.
Ear grain weight can also be predicted based on the fertilizer doses applied, but the certainty in this case is lower than for the other productivity elements under study (R^2 = 0.740; r = 0.860 ; $p<0.01$), equation (4).

$$G_{grains} = 1.4717 + 0.00319N + 0.00026PK \quad (4)$$

Analysis of the individual contribution of nutrients revealed that nitrogen gives a more certain prediction (R^2 = 0.988) *Figure 5*, than the phosphorus and potassium taken together (R^2 = 0.274).

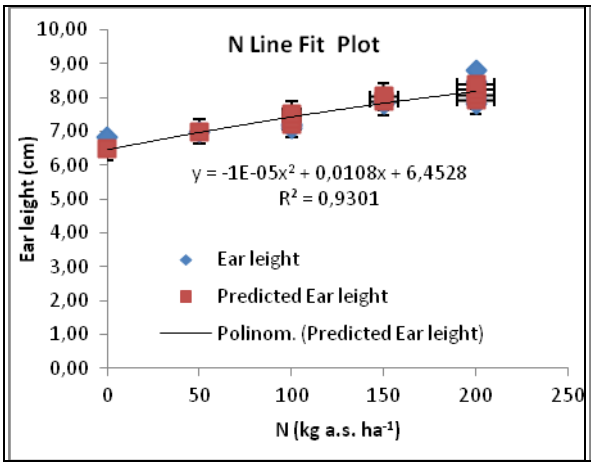


Figure 2. Prediction of ear length based on the nitrogen in the fertilizers

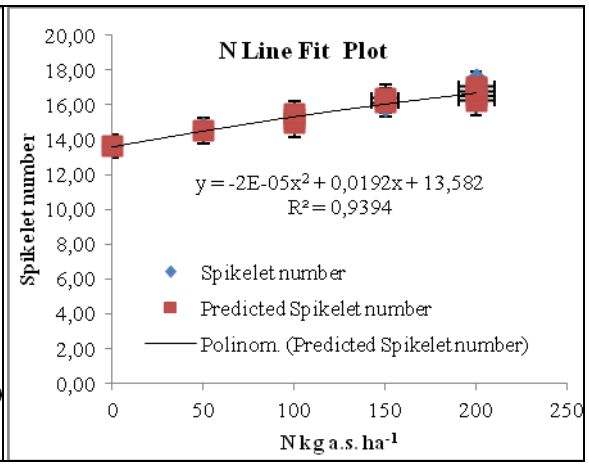


Figure 3. Prediction of spikelet number based on the nitrogen in the fertilizers

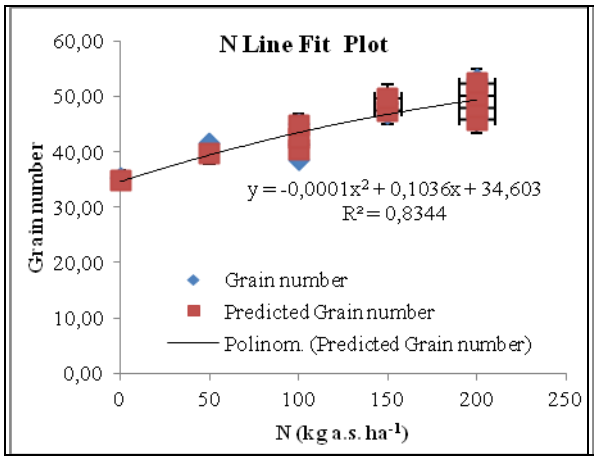


Figure 4. Prediction of grain number based on the nitrogen in fertilizers

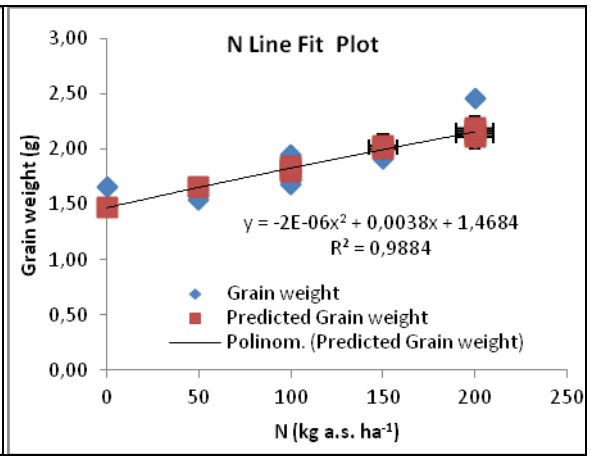


Figure 5. Prediction of ear grain weight based on the nitrogen in fertilizers

CONCLUSIONS

The productivity elements of wheat had specific variation induced by differentiated fertilization with nitrogen, phosphorus and potassium. The largest variation amplitude was recorded in grain number and grain weight, while the smallest variation appeared in ear length and number of spikelets.

Overall, nitrogen had a greater influence on the values and variation of productivity elements than phosphorus and potassium. The PK complex had a greater effect on the number of grains on an ear and a smaller effect on the other productivity elements.

Prediction of productivity elements based on the fertilizers applied is possible with higher certainty in the case of nitrogen.

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REFERENCES

AGGARWAL P.K., NAVEEN KALRA (1994): Analyzing the limitations set by climatic factors, genotype, and water and nitrogen availability on productivity of wheat II. Climatically potential yields and management strategies, Field Crops Research, Volume 38, Issue 2, p. 93–103.

DELCOUR J.A., JOYE I.J., PAREYT B., WILDERJANS E., BRIJS K., LAGRAIN B. (2012): Wheat gluten functionality as a quality determinant in cereal-based food products, Annu Rev Food Sci Techno. 3:469-92. doi: 10.1146/annurev-food-022811-101303.

FISCHER R.A. (1985): Number of kernels in wheat crops and the influence of solar radiation and temperature, The Journal of Agricultural Science, Volume 105 / Issue 02, p. 447 – 461, DOI: http://dx.doi.org/10.1017/S0021859600056495.

HANSEN P.M., SCHJOERRING J.K. (2003): Reflectance measurement of canopy biomass and nitrogen status in wheat crops using normalized difference vegetation indices and partial least squares regression, Remote Sensing of Environment, Volume 86, Issue 4, p. 542–553.

JABLONSKYTĖ-RAŠČĖ, D., STANISLAVA MAIKŠTĖNIENĖ, AUDRONĖ MANKEVIČIENĖ (2013): Evaluation of productivity and quality of common wheat (*Triticum aestivum* L.) and spelt (*Triticum spelta* L.) in relation to nutrition conditions, Zemdirbyste-Agriculture, vol. 100, No. 1, p. 45–56, UDK 633.111:631.47:631.8 / DOI 10.13080/z-a.2013.100.007.

MULLA D.J., BHATTI A.U., HAMMOND M.W., BENSON J.A. (1992): A comparison of winter wheat yield and quality under uniform versus spatially variable fertilizer management, Agriculture, Ecosystems & Environment, Volume 38, Issue 4, p. 301–311.

SHEWRY P.R. (2009): Wheat, Journal of Experimental Botany, Vol. 60, No. 6, p. 1537–1553, doi:10.1093/jxb/erp058.

STAPPER M., HARRIS H.C. (1989): Assessing the productivity of wheat genotypes in a Mediterranean climate, using a crop-simulation model, Field Crops Research, Volume 20, Issue 2, March 1989, p. 129–152.

TIMSINA J., CONNOR D.J., (2001): Productivity and management of rice–wheat cropping systems: issues and challenges, Field Crops Research, Volume 69, Issue 2, p. 93–132.

ZHANG H., OWEIS T. (1999): Water–yield relations and optimal irrigation scheduling of wheat in the Mediterranean region, Agricultural Water Management, Volume 38, (3), p. 195–211.