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# Nutritional and energy value of two wheat varieties

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## Abstract

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Field experiment was conducted in the years 2014-2016 in the experimental field of Faculty of Agriculture, Trakia University, Stara Zagora. In an attempt included two varieties of common wheat – Diamond and Ingenio. Variants of the study are: 1. Control – Fertilizing with N 140 kg.ha$^{-1}$; 2. Fertilizing with N 140 kg.ha$^{-1}$ + Laktofol base (1.0 l/ha). 3. Fertilizing with N 140 kg.ha$^{-1}$ + Wuxal Grano (400 ml/ha). 4. Fertilizing with N 140 kg.ha$^{-1}$ + Wuxal Grano (400 ml/ha) + Wuxal Grano (200 ml/ha). The applied liquid fertilizers for feeding during the growing season are enriched with micro elements. The leaf fertilizers used increase the CP content but have no effect on the PDI content of both varieties. An increase in the crude protein content of variants treated with liquid fertilizers has been reported. The calculated correlation coefficient in two varieties, which measures the strength of the relationship is r = 0.909 at Diamond and r = 0.82 ie there are a strong correlation. The applied products for fertilization the crops and the variety do not effect of the nutrition value of wheat for ruminants and non-ruminants.

*Keywords:* common wheat; energy digestibility; protein digestibility; digestible energy; metabolizable energy
*Abbreviations:* CF – crude fibre, CP – crude protein, DCF– digestible crude fibre, DEE – digestible ether extract, DEp – digestible energy for poultry, DEpg – digestible energy for pigs, Deg – degradability of dietary protein in the rumen, DNFE – digestible nitrogen free extract, DOM – digestible organic matter, DP – digestible protein, Dsi – digestibility in small Intestine, EE – ether extract, FOM – fermentable organic matter, FP – silage fermentable products, FUM – feed unit for milk, FUG – feed unit for growth, GE – gross energy, ME – metabolizable energy, MEp – metabolizable energy for poultry, MEpg – metabolizable energy for pigs, NFE – nitrogen free extract, PDI – protein digestible in (small) intestine

## Introduction

Cereals have a historical and strategic importance for meeting the food needs of the country, the growth of the national economy and our foreign trade. Many factors influence the formation of crop yields in common wheat. Besides genotype of the variety they have influence and weather conditions that can`t be controlled. Levers that can be used to unleash the potential genetic traits of culture are optimizing technological elements – balanced fertilization, crop density, high level of applied agricultural equipment and more. Yields and their structural elements are strongly influenced by the conditions of the year and plasticity of variety, considered Georgieva et al. (2004). Combined fertilization $N_6P_5K_4$ leads to an increase in the content of crude protein, crude fat and minerals 5.9%, 5.8% and 4-3% found Mihailova et al. (2012), exploring the impact of tillage and fertilization on the nutritional value of grain in cereals.

Climatic characteristics of each region are leading to the selection of varieties grown. During the years of the study,

displayed 20 varieties of wheat Samodova (2008) demonstrate the impact of climate change and the coincidence of phases of plant growth conditions change now.

The study of the productive potential of wheat is related to exploration and enhanced tolerance to abiotic stress, according Tzenov et al. (2009).

Proper varietal structure depending on the specific agro-ecological conditions of the region can significantly increase yields and product quality Ilieva, D. (2011). The selection of winter wheat is aimed primarily to obtain high and stable yields (Stoeva et al. 2009).

The main objective of this study is to analyze the effects of feeding with fertilizers in wheat on productivity, quality and nutritional value of the grain.

## Materials and Methods

Field experiment was conducted in the years 2014-2016 in the experimental field of Faculty of Agriculture, Trakia University, Stara Zagora. In an attempt included two varieties of common wheat – Diamond, which is a catalog of varieties of IASAS and Ingenio – introduced a variety of catalog of Syngenta. In cultivation is applied technology, traditional for the region. The experiment was based on the method of fractional plots in four replicates with the size of the experimental plot of 15 $m^2$.

Variants of the study are: 1. Control – Fertilizing with N 140 $kg.ha^{-1}$; 2. Fertilizing with N + Laktofol base (1.0 l/ha). 3. Fertilizing with N 140 $kg.ha^{-1}$ + Wuxal Grano (40 ml/ha). 4. Fertilizing with N 140 $kg.ha^{-1}$ + Wuxal Grano (400 ml/ha) + Wuxal Grano (200 ml/ha). The applied liquid fertilizers for feeding during the growing season are enriched with micro elements.

Laktofol major contain: N – 101.7 $gL^{-1}$; $P_2O_5$ – 29.4 $gL^{-1}$; $K_2O$ – 50.9 $gL^{-1}$; $SO_3$ – 1.356 $gL^{-1}$. От микроелементите B – 305.0 $mgL^{-1}$; Cu – 203.0 $mgL^{-1}$; Fe – 226.0 $mgL^{-1}$; Mn – 226.0 $mgL^{-1}$; Mo – 23.0 $mgL^{-1}$; Zn – 452.0 $mgL^{-1}$.

Wuxal Grano contains the following macro- and micronutrients: N – 219.0 $gL^{-1}$; $SO_3$ – 365.0 $gL^{-1}$; MgO – 29.0 $gL^{-1}$; Cu – 0.0043 $mgL^{-1}$; Mn – 0.0043 $mgL^{-1}$; Zn – 0.0146 $mgL^{-1}$.

The soil type in the experimental field is meadow-cinnamic soil. Characterized by powerful humus horizon that is highly expressed in the range of 0-50 cm. According to the humus content of the soil is an average stock (3.93%).

Agrochemical characteristics of soil is made by fixing on the reserve that the availability of nutrients. The soil type in the experimental field is characterized by the average availability of mineral nitrogen – 33.2 mg/1000g, weak stocks with flexible phosphor – 3.9 mg/1000g, and a well-stocked with available potassium – 44 mg/1000g. According to its mechanical composition, the soil type is sandy-clay.

The chemical composition of the two varieties of common wheat was analyzed by the Weende method.

To calculate the content of digestible nutrients in wheat, we used data on digestibility coefficients for ruminants, pigs and poultry (Todorov et al., 2007).

The contents of FUM, FUG and PDI for ruminants are calculated by using the formulas (Todorov et al., 2007):

GE = 0.0242 CP + 0.0366 EE + 0.0209 CF + 0.017 NFE
ME = 0.0152 DP + 0.0342 DEE + 0.0128 DCF + 0.0159 DNFE
FUM = ME (0.075 + 0.039q)
q = ME/GE
FUG = ME (0.04 + 0.1q)
PDI = 1.11CP (1 – Deg) Dsi + 0.093 FOM
FOM = DOM – DEE – FP – CP (1 – РП)
FP = 250 – 0.5 DM

The content of DE and ME for pigs and poultry are calculated using the formulas (Todorov et al., 2004):

DEpg = 0.0242 DP + 0.0394 DEE+0.0184 DCF + 0.0170 DNFE
MEpg = 0.0210 DP + 0.0374 DEE+0.0144 DCF + 0.0171 DNFE
DEp = 0.0239 DP + 0.0398 DEE+0.0177 DCF + 0.0177 DNFE
MEp = 0.0178 DP + 0.0397 DEE+0.0177 DCF + 0.0177 DNFE

## Results and Discussion

***Agro-climatic conditions***

The period of the field study covers the years with different voltage meteorological factors (Table 1). The first business year of the experiment are characterized by nearly 62% rainfall over climate norm. For the months of April-May rainfall is less by 15.6% than the average for the multiannual period (106.1 mm). In the second year of the experience accumulated amount of precipitation was close to normal. The amount of rainfall that fell during April-May is 26.3% higher than the norm for this period. Security of the two business years in terms of precipitation is as follows – 95.8 and 66.0% for the period of April-May, when the flow of stem pheno-

**Table 1. Agro-meteorological conditions in the survey years, 2014-2016**

| Common wheat | Variant | DEp | MEp | DEpg | MEpg |
|---|---|---|---|---|---|
| Diamond | 1 | 15.87 | 15.22 | 16.45 | 16.15 |
| | 2 | 15.95 | 15.25 | 16.55 | 16.21 |
| | 3 | 15.85 | 15.17 | 16.45 | 16.12 |
| Ingenio | 1 | 15.9 | 15.22 | 16.5 | 16.18 |
| | 2 | 15.87 | 15.18 | 16.5 | 16.16 |
| | 3 | 15.99 | 15.27 | 16.51 | 16.2 |

phase to flowering wheat, collateralization is as follows – 36.3 and 79.7%.

In terms of daily average temperatures during the first business year total temperature does not exceed the temperature norm. In the second year, an increase of 13.6% compared to the temperature norm. Strikes in high security 78.6% in relation to the short period from April to May. The second year is characterized by average daily temperatures close to normal for the period.

The agro-climatic conditions during the first year are characterized by a large amount of rainfall, but unevenly distributed during the vegetation of the crop. The relatively lower rainfall (36.8%) in the spring months and higher temperatures create unfavorable conditions for wheat development. In the second marketing year, the agro-climatic characteristic shows a better supply of rainfall and temperatures close to the norm. Wheat is developing normally this year thanks to a sufficient amount of easily accessible soil moisture. Rainfall during the first ten days of June is sufficient to ensure that the grain is poured. 121.4 mm were registered for the first year in June, but in the second and third ten days. Precipitation in the first ten days of the first business year, measured in the first ten days, is more effective.

Climate change and its impact on agroclimatic resources is an aspect that is still under study. The meteorological situation is characterized by the sum of precipitation, average daytime air temperatures and the hydrothermal coefficient. During the critical months of the development of culture, the hydrothermal coefficients (HTC) were determined by Selyaninov. The Selyaninov coefficient is calculated for a vegetative period of crops with a biological minimum of 10 ° C, i.e. for the period April – September. The interpretation of the coefficient is made according to the classification of Sapozhnikova (1963), according to which at HTC: <0.40 – the conditions are dry; 0.41-0.70 – too dry; 0.71-1.00 – arid; 1.01-1.30 – slightly drowsy; 1.31-1.60 – moist; > 1.60 – moisturized. The analysis of the results shows prevailing conditions in the first ten days of April (HTC = 2.75) and in the last two days in June (HTC = 3.08 and 2.31). The period from the beginning of the second ten-day in April to the second ten-day in May is characterized by dry to very dry (HTC = 0.21-0.83). For the second business year, conditions of humidity were registered during the first ten days of May (HTC = 3.47) and June (HTC = 2.58).

***Productivity of common wheat***

Experimental data were estimated by means of averages, error of averages, root mean square deviation and coefficient of variation (ANOVA: Single Factor). The Duncan test for multivariate comparison grouped variants (Duncan, 1995) at a significance level of 0.05 through the SPSS statistical program. The mathematical processing of the data was done with the Excel and SPSS computer programs.

Tables 2 and 3 show the results of the variational analysis of the data as well as the grouping of the averages according to the Duncan test for the two varieties. The coefficient of variation (CV %) in terms of yield was highest when treated with N 140 kg.ha$^{-1}$ and lowest at var.4 for the Diamond variety.

**Table 2. Characteristics after treatment with liquid fertilizers of the Diamond variety**

| № | Fertilizers | Yield | | | |
|---|---|---|---|---|---|
| | | $\bar{x}$ | $S\bar{x}$ | s | CV, % |
| 1 | Fertilizing with $N_{140\ kg.ha^{-1}}$ | 3342.42 a | 46.69 | 23.35 | 1.4 |
| 2 | Lactofol base | 4043.79 b | 46.03 | 23.01 | 1.14 |
| 3 | Wuxal Grano (400) | 4068.92 b | 29.72 | 14.86 | 0.73 |
| 4 | Wuxal Grano (400+200) | 4836.73 c | 28.83 | 14.42 | 0.6 |

**Table 3. Analysis of variance of the effect of liquid fertilizers on yield in the Diamond variety**

| Source of variation | SQ | df | $S^2$ | F | F crit./α 5% |
|---|---|---|---|---|---|
| Fertilizers*** | 4471602 | 3 | 1490534 | 991.45 | 3.77 |
| Errors | 18040.74 | 12 | 1503.395 | | |
| Total | 4489643 | 15 | | | |

And for the Ingenio variety, the highest is at Wuxal Grano, followed by Lo. In the tables 4 and 5 present the results of the ANOVA single factor for the evaluation of fertilizer in yield. Both varieties are statistically very well proven (F > F crit. At level a significance α = 0.001).

**Table 4. Characteristics after treatment with liquid fertilizers in the Ingenio variety**

| № | Fertilizers | Yield | | | |
|---|---|---|---|---|---|
| | | $\bar{x}$ | $S\bar{x}$ | s | CV, % |
| 1 | Fertilizing with $N_{140\ kg.ha^{-1}}$ | 4626.87a | 4.83 | 2.41 | 0.1 |
| 2 | Lactofol base | 5835.47 b | 39.42 | 19.71 | 0.67 |
| 3 | Wuxal Grano (400 ) | 6007.87c | 7.07 | 3.54 | 0.12 |
| 4 | Wuxal Grano (400+200) | 6272.30 d | 14.64 | 7.32 | 2.35 |

**Table 5. Analysis of the variance of the effect of liquid fertilizers on the yield of the Ingenio variety**

| Source of variation | SQ | df | $S^2$ | F | F crit./α 5% |
|---|---|---|---|---|---|
| Fertilizers*** | 6365792 | 3 | 2121931 | 4607.63 | 0 |
| Errors | 5526,3 | 12 | 460.525 | | |
| Total | 6371318 | 15 | | | |

Duncan's additional test made it possible to group options. In the Diamond variety, we have three groups, with Laktofol base and Wuxal Grano falling into one group. For the Ingenio variety, each variant falls into a separate group. Statistically, at a very high level of significance, the influence of the investigated fertilizers N140 kg.ha$^{-1}$ and Laktofol base on the yield of the Diamond variety was demonstrated, at Ingenio are Wuxal Grano and Laktofol base.

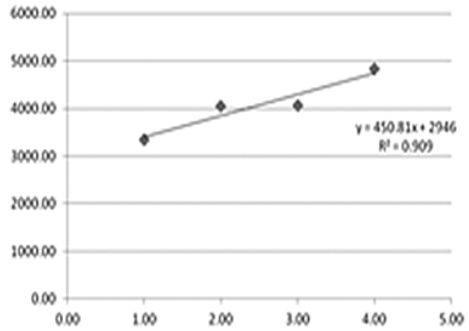


**Fig. 1. Linear regression model between treatment options and yield in Diamond**

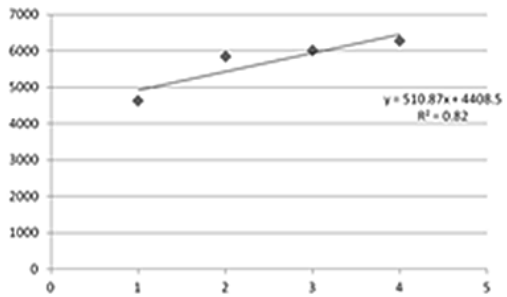


**Fig. 2. Linear regression model between treatment options and yield in Ingenio**

Assessment of the degree of influence of the treatment with fertilizers on the productivity of wheat is presented in Figure 1 and 2. By means of applications regression analysis established the nature of the relationship between the tested components – production and variations of treatment. The calculated correlation coefficient in two varieties, which measures the strength of the relationship is r = 0.909 at Diamond and r = 0.82 i.e. there are a strong correlation.

***Nutritional value of the grain***

The crude protein content data are presented in Figure 3 and 4. The analysis showed a higher content of crude protein in the grain in the second year of the experiment. Values ranged from 118.13 to 127.96 g/kg DM in the first year and from 132.23 to 143.217 g/kg DM in the second year in Diamond.

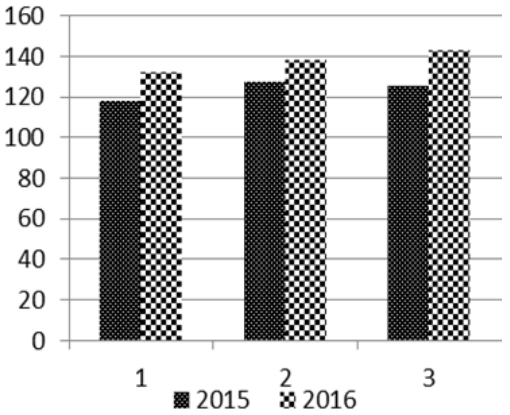


**Fig. 3. Crude protein content in the grain of common wheat variety Diamond in 2015 and 2016**

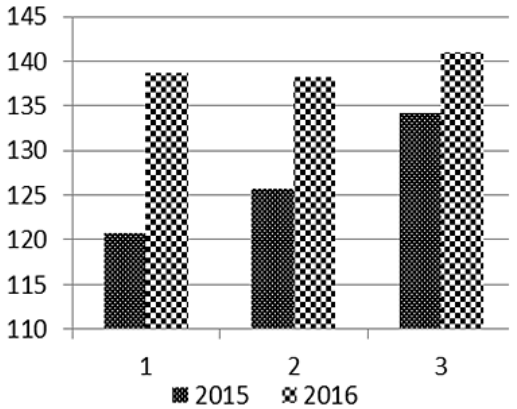


**Fig. 4. Crude protein content in the grain of common wheat variety Ingenio in 2015 and 2016**

An increase in the crude protein content of variants treated with liquid fertilizers has been reported. The same trend was observed by Pavlova and Bachvarov (1991) in the study of the complex leaf fertilizers Lactofol base (N, P, K + trace elements) and Hezal 1 (N, P, Mg + trace elements). In their study, they found an increase in yield (up to 10% after application of the complex leaf fertilizer Lactofol Basic), as well as an increase in protein and gluten content in the grain. The quality of the grain and the amount of protein increase with the increase of fertilizer norms have been established by Vasilev et al. (2012). The increase is on average 6.5% and 7.4% respectively in the second and third options in Diamond. Storage of crude protein in Ingenio increased on aver-

age for a period 1.7% and 6.1% respectively in the second and third variants.

For Ingenio, crude protein values for the first year range from 120.75 DM to 134.17 DM. In the second year of the Polish experience, values from 138.70 to 141.04 DM were registered. The increase in crude protein content in the second year is significantly higher than the first. Lower average daily temperatures reduce the growth rate of the stem and less crude protein accumulates in the formation of the grain. Another limiting factor is insufficient moisture. When dried, a grain with lower protein content is formed.

**Table 6. Energy and protein value of common wheat for ruminants in 1 kg DM, 2015**

| Common wheat | Variant | FUM | FUG | PDI |
|---|---|---|---|---|
| Diamond | 1 | 1.49 | 1.67 | 100.47 |
| | 2 | 1.48 | 1.65 | 101.97 |
| | 3 | 1.48 | 1.66 | 101.48 |
| Ingenio | 1 | 1.48 | 1.66 | 100.52 |
| | 2 | 1.48 | 1.66 | 101.33 |
| | 3 | 1.47 | 1.64 | 102.79 |

**Table 7. Energy and protein value of common wheat for ruminants in 1 kg DM, 2016**

| Common wheat | Variant | FUM | FUG | PDI |
|---|---|---|---|---|
| Diamond | 1 | 1.47 | 1.64 | 102.81 |
| | 2 | 1.46 | 1.63 | 103.34 |
| | 3 | 1.47 | 1.63 | 104.14 |
| Ingenio | 1 | 1.47 | 1.63 | 103.23 |
| | 2 | 1.47 | 1.64 | 102.46 |
| | 3 | 1.47 | 1.63 | 103.81 |

The results presented in Table. 6 and 7 show variation within narrow limits of FUM and FUG values for both varieties for both years. For Diamond, the content of FUM is in the range of 1.46-1.49 FUM/kg DM, and for Ingenio from 1.47 to 1.48 FUM/kg DM. The FUG values for Diamond are from 1.63 to 1.67 FUG/kg of DM, and for Ingenio from 1.63 to 1.66 FUG/kg DM. No significant differences in energy value were found despite the higher CP content as a result of the fertilizers applied.

There was little effect on the treatment of wheat with liquid fertilizers and on the content of PDI in both common wheat varieties.

In Tables 8 and 9 are presented the results of the energy value results of both pig and poultry varieties. Here, as with ruminants, variations in energy value are within a very narrow range, with no clear impact on the applied leaf fertilizers. For Diamond, the content of DEp and MEp for the two years is in the range of 15.85-15.95 MJ DEp/kg DM and 15.17-15.30 MJ MEp/kg DM respectively. For Ingenio these values are 15.84-15.99 MJ DEp/kg DM and 15.18-15.27 MJ MEp/kg DM respectively.

**Table 8. Energy and protein value of common wheat for poultry and pigs in 1 kg DM, 2015**

| Common wheat | Variant | DEp | MEp | DEpg | MEpg |
|---|---|---|---|---|---|
| Diamond | 1 | 15.88 | 15.3 | 16.47 | 16.2 |
| | 2 | 15.88 | 15.25 | 16.48 | 16.18 |
| | 3 | 15.91 | 15.29 | 16.51 | 16.22 |
| Ingenio | 1 | 15.84 | 15.25 | 16.43 | 16.15 |
| | 2 | 15.88 | 15.27 | 16.48 | 16.19 |
| | 3 | 15.91 | 15.26 | 16.51 | 16.2 |

**Table 9. Energy and protein value of common wheat for poultry and pigs in 1 kg DM, 2016**

| Common wheat | Variant | DEp | MEp | DEpg | MEpg |
|---|---|---|---|---|---|
| Diamond | 1 | 15.87 | 15.22 | 16.45 | 16.15 |
| | 2 | 15.95 | 15.25 | 16.55 | 16.21 |
| | 3 | 15.85 | 15.17 | 16.45 | 16.12 |
| Ingenio | 1 | 15.9 | 15.22 | 16.5 | 16.18 |
| | 2 | 15.87 | 15.18 | 16.5 | 16.16 |
| | 3 | 15.99 | 15.27 | 16.51 | 16.2 |

Minor are differences in the energy value of the two varieties in pigs. In Diamond range from 16.45 to 16.55 MJ DEpg/kg DM, and at Ingenio from 16.43 to 16.51 MJ DEpg/kg DM for both years. Values for MEpg in Diamond in the range of 16.15 to 16.22 MJ MEpg/kg DM, and at Ingenio from 16.15 to 16.20 MJ MEpg/kg DM.

## Conclusions

The leaf fertilizers used increase the CP content on average 6.5% and 7.4% in the second and third treatment at Diamond, and 1.7% and 6.1% respectively at Ingenio, but have no effect on the PDI content of both varieties.

The applied products for fertilization the crops and the variety do not effect of the energy nutrition of wheat in ruminants and non-ruminants.

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