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# Assessing the Impact of Fertilization on Wheat Protein and Energy Nutrition

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## Abstract

The present research aims at assessing the influence of leaf fertilizers on the two common wheat varieties. Study results show that the crude protein content ranges from 128.50-143.94 g/kg DM in the Enola variety and from 115.93 to 127.34 g/kg DM in the Illico variety. The introduction of Wuxal Grano slurry increased the crude protein content by 9.1 and 12.0 % relative to the control. The applied leaf fertilizers do not affect the contents of FUM, FUG and PDI. As a result of the correlation analysis, a very high correlation (r = 0.947-0.993) was found between CP and PDI for both common wheat varieties.

*Key words:* common wheat, fertilization, protein feed, energy nutrition

## Introduction

Wheat is one of the traditional and economically important crops for many regions around the world. Protein is the main quantitative factor determining the quality of wheat grains. In this connection, factors that affect protein levels are of particular importance.

Increasing grain protein content is a topical issue in the world of nutrition (Uauy et al., 2006; Mangova et al., 2007).

Main criteria for the selection of varieties are resistance to abiotic and biotic stress combined with high productive potential and grain quality (Panayotov et al., 2004; Yanchev et al., 2012).

A number of studies have found a positive correlation between nitrogen fertilization levels and protein content in the grain (Kelley and Sweeney, 2007; Guangkail et al., 2009). According to Kelley and Sweeney (2007), total nitrogen in the grain is strongly influenced by nitrogen fertilization levels and by the type of prior culture.

A positive correlation between productivity, grain protein content and fertilizer levels (N12 and N18) has been found in post-flowering feeding (Montemurro et al., 2007). The results of experiments with different fertilizer norms applied to assess the impact of different levels of inorganic (0, 80, 160 and 240 kg nitrogen $ha^{-1}$) and organic (0, 30 and 60 mg municipal waste compost ha-1) fertilizers on the yield of wheat and protein content have shown that high yields and levels of protein and gluten in the grain (Tayebeh et al., 2010) have been achieved with fertilization with 160 kg $ha^{-1}$ nitrogen.

The current study has a purpose to assess the correlation between the chemical composition of wheat grain and the energy and protein feed of ruminant and non-ruminant wheat typical of the two common wheat varieties imported through vegetation under the influence of leaf fertilizers.

## Materials and Methods

For the purpose of this study, the authors used two-year data from field experiments, conducted in the experimental field of the Faculty of Agriculture, Trakia University of Stara Zagora, Bulgaria. The experiments were carried out on a meadow cinnamon soil.

The trials were based on tripartite plotting, with three replicates of fertilization and liquid fertilizer feed. Fertilization started with the liquid fertilizers Lactifrost, Lactofol base and Wuxal Grano.

These are leafy liquid fertilizers that are used to nourish crops. Basic fertilization with ammonium nitrate was also carried out. The study options are as follows: 1. Without fertilization, 2. Ammonium nitrate ($N_{14}$); 3. Lactifrost - l l/da; 4. Lactifrost + Lactofol base - 1.0 l/da + 0.5 l/da; 5. Lactofol base - 0.5 l/da; 6. Wuxal Grano - 0,400 l/da; 7. Wuxal Grano - 0.400 l/da + 0.200 l/da.

The experiment included two common wheat varieties - *Enola* and the introduced *Illico* variety. The data were collected during the 2015-2016 period. After grain harvesting, grain chemistry of the common wheat varieties was analyzed. The chemical analysis of the grain was carried out by using the Weende method.

The levels of crude protein (CP), crude fibre (CF), crude fats (CFAT), digestible ether extract (DEE) and mineral substances in the grain of the two studied varieties were determined.

Table 1. Content of macro and micro elements in leaf fertilizers

| Foliar fertilizers | gram liter$^{-1}$ | | | | | mg liter$^{-1}$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N* | $P_2O_5$ | $K_2O$ | $SO_3$ | MgO | B | Cu | Mn | Mo | Zn |
| Lactofol base | 101 | 29.4 | 50.9 | 1.36 | - | 305 | 203 | 226 | 23 | 452 |
| Lactifrost | 13.8 | 42.4 | 37.9 | 2.12 | - | 477 | 106 | 106 | 2120 | 64 |
| Wuxal Grano | 219 | - | - | 365 | 29 | - | 0.0043 | 0.0043 | - | 0.0146 |
| * $NO_3$-N + $NH_4$-N + $NH_2$-N (g $l^{-1}$): 22.6 and 13.8 + 11.3 and 6.4 + 67.8 + 0.3 | | | | | | | | | | |

The technology aiming to extract the field survey is standard for the area, except for the fertilization and feeding of common wheat.

Using the formulas by Todorov et al. (2004, 2007), the FUM, FUG and PDI content of ruminants were calculated.

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. q = ME / GE
FUM = ME (0.075 + 0.039q)
FUG = ME (0.04 + 0.1q)
PDI = 1.11CP (1 - Deg) Dsi + 0.093 FOM
FOM = DOM - DEE - FP - CP (1 - PП)
FP = 250 – 0.5 DM
BPR = CP (Deg – 0.1) – 0145 FOM

where: GE – gross energy, EE – ether extract, ME – metabolizable energy, NFE – nitrogen free extract, DP – digestible protein, E – digestible ether extract, DNFE – digestible nitrogen free extract, Deg – degradability of dietary protein in the rumen, FOM – fermentable organic matter, DOM – digestible organic matter, PDI – protein digestible in (small) intestine, Dsi– digestibility in small intestine.

Digestible energy (DE) and metabolizable energy (ME) values for pigs and poultry were calculated using the following equations (Todorov et al., 2004):

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

The experimental data were processed by a correlation analysis, which served to establish and evaluate the relationship between the indicators under study. The same is expressed by the correlation coefficient r, determined by means of the SPSS 13 statistical program.

The correlation dependencies are the product of mathematical and statistical processing of Genchev's output data and others (1975).

## Results and Discusison

The material under study presents the data on the organic matter contents in the grain of two common wheat varieties obtained by the Weende analysis. The analysis of the levels of qualitative indicators in different feeds of common wheat shows that the variance under the influence of liquid fertilizers is poor for both varieties.

The content of crude protein in the grain of common wheat is a key quality indicator. For the Enola variety, the content ranges from 128.50 to 143.94 g/kg DM, and for the Illico variety from 115.93 to 127.34 g/kg DM. The increase due to fertilizer use during crop vegetation is in a narrow range.

In Enola, crude protein levels are higher than in the fertilizer control by 4.6 - 12.0 %, while in Illico the increase is up to 9.1 % relative to the control. Based on the factors under study, fertilization with Wuxal Grano has more significant impact on the crude protein yield (5.3 - 12.0 %). Crude fibre reduces the digestibility of the feed and thus reduces its nutritional value.

A major indicator of the nutritional value of feed is its energy and protein nutrition. In ruminants, two units of energy nutrition assessment are used: feed unit for growth (FUG) and feed unit for milk (FUM).

Protein nutrition is determined by the amount of protein, truly digestible in the intestine - protein digestible in (small) intestine (PDI). This indicator takes into account the contribution of feed to meet the animal's protein needs.

The FUM content in 1 kg DM ranges from 1.62 to 1.64 for Enola and 1.65 to 1.67 for Illico. The FUG analysis for Enola shows slight variation at 1.46-1.47, and 1.41-1.49 at Illico.

The data show the weak influence of the liquid fertilizers studied on FUM and FUG.

In fact, the content of raw nutrients in the grain of common wheat under the influence of feeding with various liquid fertilizers during vegetation changes in narrow limits.

Table 2. Chemical composition of common wheat grain, g/kg DM

| Var. | Rep. | CP | CFAT | CF | DEE |
|---|---|---|---|---|---|
| Enola | 1 | 128.50 | 20.75 | 17.59 | 813.52 |
| | 2 | 134.46 | 20.57 | 18.73 | 809.77 |
| | 3 | 135.80 | 21.10 | 15.45 | 809.68 |
| | 4 | 137.53 | 24.32 | 17.37 | 798.05 |
| | 5 | 136.60 | 23.93 | 18.52 | 804.43 |
| | 6 | 143.76 | 21.16 | 20.07 | 799.23 |
| | 7 | 143.94 | 22.65 | 17.00 | 800.70 |
| Illico | 1 | 116.72 | 21.04 | 19.86 | 828.89 |
| | 2 | 115.93 | 17.25 | 20.36 | 831.32 |
| | 3 | 119.90 | 17.74 | 18.85 | 826.64 |
| | 4 | 117.10 | 18.66 | 17.38 | 829.49 |
| | 5 | 119.21 | 19.83 | 18.55 | 826.93 |
| | 6 | 122.94 | 19.38 | 18.90 | 824.18 |
| | 7 | 127.34 | 16.83 | 18.46 | 820.75 |

For pigs and poultry, the feed content of digestible and exchangeable energy is used as an indicator of the feed energy feed.

The data on the PDI content (Table 3) show that the liquid leaf fertilizers studied did not affect the PMS content. In the Enola variety it ranges from 101.50-103.99 MJ/kg, and in Illico the variation is in the range of 100.20-101.91 MJ/kg DM on average during the field experiment. The increase in PDI content for both varieties ranged from 1.7-2.4 %.

Table 3 also provides the calculated digestate and exchange rate data for non-ruminant pigs and poultry in 1 kg DM. The digestible energy content of the birds varies between two wheat varieties by ranging from 15.77 to 15.94 MJ/kg, and in the pigs it ranges from 16.35 to 16.56 MJ/kg DM.

These differences are extremely insignificant. The swine content is higher, but the differences are again negligible. The values of the exchange energy also vary within narrow limits. Again, the trend in digestible energy levels is higher in pigs (16.09-16.22) MJ/kg DM.

Table 3. Energy and protein value of common wheat for ruminants, for pigs and poultry in 1 kg DM

| Var. | Rep. | Ruminant animals | | | Non-ruminant animals | | | |
|---|---|---|---|---|---|---|---|---|
| | | FUM | FUG | PDI | DEp | MEp | DEpg | MEpg |
| Enola | 1 | 1.47 | 1.64 | 101.50 | 15.81 | 15.18 | 16.40 | 16.10 |
| | 2 | 1.47 | 1.64 | 102.65 | 15.86 | 15.21 | 16.47 | 16.15 |
| | 3 | 1.47 | 1.64 | 102.75 | 15.89 | 15.22 | 16.49 | 16.17 |
| | 4 | 1.46 | 1.63 | 102.26 | 15.82 | 15.15 | 16.43 | 16.11 |
| | 5 | 1.47 | 1.64 | 102.67 | 15.90 | 15.23 | 16.52 | 16.19 |
| | 6 | 1.46 | 1.62 | 103.99 | 15.89 | 15.18 | 16.50 | 16.16 |
| | 7 | 1.47 | 1.63 | 103.98 | 15.94 | 15.24 | 16.56 | 16.22 |
| Illico | 1 | 1.49 | 1.67 | 100.20 | 15.83 | 15.26 | 16.43 | 16.16 |
| | 2 | 1.48 | 1.66 | 100.25 | 15.77 | 15.20 | 16.35 | 16.09 |
| | 3 | 1.48 | 1.65 | 100.70 | 15.78 | 15.19 | 16.36 | 16.09 |
| | 4 | 1.48 | 1.66 | 100.20 | 15.79 | 15.22 | 16.37 | 16.10 |
| | 5 | 1.49 | 1.66 | 100.54 | 15.82 | 15.24 | 16.41 | 16.14 |
| | 6 | 1.48 | 1.66 | 101.20 | 15.84 | 15.24 | 16.43 | 16.15 |
| | 7 | 1.48 | 1.65 | 101.91 | 15.81 | 15.19 | 16.39 | 16.10 |

*DEpg – digestible energy for pigs, MEpg – metabolizable energy for pigs, DEp – digestible energy for poultry, MEp – metabolizable energy for poultry

After the correlation analysis of the studied varieties of common wheat, a very high correlation (r = 0.947) was found between the CP and the PDI in the Enola variety. High positive values of r (r = 0.809) were reported between DEE and FUM. We have a negative correlation between the CP and FUM and the CF and FUM (Table 4).

Tab. 4. Correlation coefficients between wheat grain chemistry, energy and protein nutrition of ruminant wheat for Enola variety 2015-2016

| | CP | CFAT | CF | DEE | FUM | FUG | PDI |
|---|---|---|---|---|---|---|---|
| CP | 1 | 0.288 | 0.242 | -0.835* | -0.433 | -0.790* | 0.947** |
| CFAT | | 1 | -0.072 | -0.654 | -0.294 | -0.138 | 0.016 |
| CF | | | 1 | -0.291 | -0.420 | -0.467 | 0.271 |
| DEE | | | | 1 | 0.728 | 0.809* | -0.622 |
| FUM | | | | | 1 | 0.806* | -0.226 |
| FUG | | | | | | 1 | -0.686 |
| PDI | | | | | | | 1 |

*Correlation significant at the 0.05 level, **Correlation significant at the 0.01 level

The correlation relationships between CM, SBI and the other indicators considered were not mathematically proven.

Also, high positive correlation was recorded between the CP and DEpg (r = 0.767).

Tab. 5. Correlation coefficients between wheat grain chemistry, energy and protein nutrition of non-ruminant wheat for Enola variety 2015-2016

| | CP | CFAT | CF | DEE | DEp | MEp | DEpg | MEpg |
|---|---|---|---|---|---|---|---|---|
| CP | 1 | 0.288 | 0.242 | -0.835* | 0.731 | 0.212 | 0.767* | 0.662 |
| CFAT | | 1 | -0.072 | -0.654 | 0.094 | -0.077 | 0.200 | 0.158 |
| CF | | | 1 | -0.291 | -0.029 | -0.239 | 0.033 | -0.066 |
| DEE | | | | 1 | -0.332 | 0.209 | -0.419 | -0.287 |
| DEp | | | | | 1 | 0.812* | 0.990** | 0.988** |
| MEp | | | | | | 1 | 0.781* | 0.867* |
| DEpg | | | | | | | 1 | 0.987** |
| MEpg | | | | | | | | 1 |

*Correlation significant at the 0.05 level, **Correlation significant at the 0.01 level

After the correlation analysis of the studied wheat varieties, a very high correlation (r = 0.993) was found between CP and PDI in the Illico variety.

Tab. 6. Correlation coefficients between wheat grain chemistry, energy and protein feed of wheat for ruminants in the Illico variety 2015-2016

| | CP | CFAT | CF | DEE | FUM | FUG | PDI |
|---|---|---|---|---|---|---|---|
| CP | 1 | -0.386 | -0.322 | -0.986** | -0.322 | -0.634 | 0.993** |
| CFAT | | 1 | 0.076 | 0.251 | 0.794* | 0.821* | -0.449 |
| CF | | | 1 | 0.345 | 0.208 | 0.362 | -0.229 |
| DEE | | | | 1 | 0.197 | 0.571 | -0.964** |
| FUM | | | | | 1 | 0.636 | -0.369 |
| FUG | | | | | | 1 | -0.642 |
| PDI | | | | | | | 1 |

*Correlation significant at the 0.05 level, **Correlation significant at the 0.01 level

High positive values of r (r = 0.794, r = 0.821) were obtained between CFAT and FUM/FUG (Table 6). Negative correlation between DEE and PDI (r = -0.964) was also obtained.

Tab. 7. Correlation coefficients between wheat grain chemistry, energy and protein feed of wheat for non-ruminants in the Illico variety 2015-2016

| | CP | CFAT | CF | DEE | DEp | MEp | DEpg | MEpg |
|---|---|---|---|---|---|---|---|---|
| CP | 1 | -0.386 | -0.322 | -0.986** | 0.366 | -0.332 | 0.244 | -0.032 |
| CFAT | | 1 | 0.076 | 0.251 | 0.691 | 0.970** | 0.775* | 0.899** |
| CF | | | 1 | 0.345 | -0.068 | 0.105 | 0.025 | 0.161 |
| DEE | | | | 1 | -0.468 | 0.220 | -0.356 | -0.086 |
| DEp | | | | | 1 | 0.753 | 0.989** | 0.911** |
| MEp | | | | | | 1 | 0.824* | 0.936** |
| DEpg | | | | | | | 1 | 0.958** |
| MEpg | | | | | | | | 1 |

*Correlation significant at the 0.05 level, **Correlation significant at the 0.01 level

High positive correlation relationships were reported between CFAT and DEpg/MEpg (r = 0.899, r = 0.970).

## Conclusions

The results of the present study show that the crude protein content ranges from 128.50-143.94 g/kg DM in the Enola variety and from 115.93 to 127.34 g/kg DM in the Illico variety. The introduction of Wuxal Grano slurry increased the crude protein content by 9.1 and 12.0 % relative to the control.

The applied leaf fertilizers do not affect the contents of FUM, FUG and PDI. As a result of the correlation analysis, very high correlation (r = 0.947-0.993) was found between CP and PDI for both common wheat varieties.

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# Процјена утицаја ђубрења на садржај протеина и енергетску вриједност зрна пшенице

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## Сажетак

Циљ овог истраживања је процјена утицаја фолијарних ђубрива на карактеристике двије сорте гајене пшенице. Према приказаним резултатима, садржај сирових протеина се кретао у распону од 128,50 до 143,94 g/kg суве масе код сорте Enola и у распону од 115,93 до 127,34 g/kg суве масе код сорте Illico. Употреба Wuxal Grano фолијарног ђубрива повећао је садржај сирових протеина за 9,1 и 12,0 % у односу на контролу. Кориштени облици фолијарних ђубрива нису значајно утицали на параметре FUG, FUM и PDI. Према резултатима корелационе анализе, висок степен повезаности (r = 0,947 до 0,993) имале су CP и PDI код обе сорте пшенице.

*Кључне ријечи:* обична пшеница, ђубрење, протеинска исхрана, енергетска исхрана

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