Scientific Papers. Series A. Agronomy, Vol. LXII, No. 1, 2019
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ASSESS OF THE IMPACT OF FERTILIZATION ON WHEAT PROTEIN AND ENERGY NUTRITION

Antoniya STOYANOVA[1], Gancho GANCHEV[1], Velika KUNEVA[2]

[1]Trakia University, Faculty of Agriculture, Student Town, 6015, Stara Zagora, Bulgaria
[2]Agricultural University of Plovdiv, 12 Mendeleev Blvd, Thrace, 4000, Plovdiv, Bulgaria

Corresponding author email: toni_1219@abv.bg

Abstract

The purpose of this study is based of assessing the influence of leaf fertilizers on the two common wheat varieties. The fertilization was started with the liquid fertilizers Lactifrost, Lactofol base and Wuxal Grano. These are leafy liquid fertilizers that are used to nourish crops. A basic fertilization with ammonium nitrate was also carried out. The study options are as follows: 1. Without fertilization; 2. Ammonium nitrate (N14); 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 results of 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. 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, energy nutrition, fertilization, protein feed.*

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 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 & 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 (N_{12} and N_{18}) has been found in post-flowering feeding (Montemurro et al., 2007). Results of experiments with different fertilizer norms to assess the impact of different levels on 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 that under the influence of leaf fertilizers, imported through vegetation.

MATERIALS AND METHODS

For the purpose of the study, 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. The fertilization was started with the liquid fertilizers Lactifrost, Lactofol base and Wuxal Grano.

These are leafy liquid fertilizers that are used to nourish crops. A 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

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

Foliar fertilizers	gL^{-1}					mgL^{-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 experiment included two varieties of common wheat - *Enola* and the introduced *Illico* variety. The experience was brought out during the period 2015-2016. After grain harvesting, the grain chemistry of the common wheat varieties was analyzed. The chemical analysis of the grain was carried out by the Weende method. The levels of crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen free extract (NFE), and mineral substances in the grain of the two studied varieties were determined.

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

By the formulas of 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 - Deg)
FP = 250 – 0,5 DM
BPR = CP(Deg – 0,1) – 0145 FOM

where: GE - gross energy, CP - crude protein, EE - ether extract, CF - crude fibre, NFE - nitrogen free extract, ME - metabolizable energy, DP - digestible protein, DEE - digestible ether extract, DF - digestible fibre, 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, Deg - degradability of dietary protein in the rumen.

Digestible energy (DE) and metabolizable energy (ME) values for pigs and poultry were calculated using the 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

Experimental data were processed by a correlation analysis, which established and evaluated the relationship between the studied indicators. The same is expressed by the correlation coefficient r, determined through the statistical program SPSS 13.

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

RESULTS AND DISCUSSIONS

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

The content of crude protein in the grain of common wheat is a key quality indicator. For Enola variety, the content ranges from 128.50 to 143.94 g/kg DM, and 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. The variation in the range of 109 to 130 g/kg DM was also found by Zilic et al. (2010). For bigger variation in the content of the CP reports Kim et al. (2003) in Australian wheat varieties - 9.7 to 19.1% CP and Dapoza (2006) in Spanish wheat varieties - 7.6 to 15.1% CP.

In Enola, crude protein levels are higher than the fertilizer control with 4.6-12.0%, while in Illico the increase is up to 9.1% relative to the control. From the studied factors, the fertilization with Wuxal Grano has a more significant impact on the crude protein yield (5.3-12.0 %).

The crude fat contents – 16.83-24.32 g/kg DM of the evaluated wheat varieties were similar to reported by Sauvant et al. (2004) and Lasek et al. (2011).

Crude fibre reduce the digestibility of the feed and thus reduce its nutritional value. The value of the CF was established in the range of 15.45 to 19.86 g/kg DM and they are consistent with the established values of Alijosius et al. (2016) and ~~are~~ lower than those established by Zijlstra et al. (1999) and Anjum et al. (2014).

The concentrations of NFE – 798.05-831.32 g/kg DM were in general agreement with the data of Anjum et al. (2014), who was reported, that for 19 different varieties of wheat the NFE in grain ranged from 78.78% to 82.92% DM.

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

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

Var.	Rep.	CP	EE	CF	NFE
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

The FUM content in 1 kg DM ranges from 1.62 to 1.64 for Enola and 1.65 to 1.67 for Illico. 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.

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

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

The data on the PDI content (Table 3) show that the liquid leaf fertilizers studied did not affect the content. In the Enola variety it ranges from 101.50-103.99 g/kg DM, and in Illico the variation is in the range of 100.20-101.91 g/kg DM on average during the field experience. 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 ranging from 15.77 to 15.94 MJ/kg, and in the pigs range from 16.35 to 16.56 MJ/kg DM. Mollah et al. (1983), Wiseman (2000), McCracken et al. (2002) establish similar values for DEp - 8.49 to 15.9 MJ/kg DM.

The 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.

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 and Illico variety (r = 0.993). High positive values of r (r = 0.809) are reported between NFE and FUG. We have found also a high correlation (r = 0.99, $P<0.01$) between CP and PDI and between NFE and FUG (r = 0.99, $P<0.01$) in our other research.

We have a negative correlation between the CP and FUG (r = -0.790). Negative correlation is established between CF and FUM/FUG (r = -0.420, and r = -0.4670) (Table 4). Stoyanova et al. (2016) also establish negative correlation between CF and FUG (r = -0.20, $P<0.05$). Mathematically unproven are the correlation relationships between EE and the other indicators considered.

In Illico variety high positive values of r (r = 0.794, r = 0.821) was obtained between EE and FUM/FUG (Table 5). A negative correlation between NFE and PDI (r = -0.964) was also obtained.

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

	CP	EE	CF	NFE	FUM	FUG	PDI
CP	1	0.288	0.242	-0.835*	-0.433	-0.790*	0.947**
EE		1	-0.072	-0.654	-0.294	-0.138	0.016
CF			1	-0.291	-0.420	-0.467	0.271
NFE				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

Table 5. Correlation coefficients between wheat grain chemistry, energy and protein feed of wheat for ruminants in Illico variety 2015-2016

	CP	EE	CF	NFE	FUM	FUG	PDI
CP	1	-0.386	-0.322	-0.986**	-0.322	-0.634	0.993**
EE		1	0.076	0.251	0.794*	0.821*	-0.449
CF			1	0.345	0.208	0.362	-0.229
NFE				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

A high positive correlation is recorded between the CP and DEpg (r = 0.767). The correlation between CP and MEpg (r = 0.662) is also very positive (Table 6).
The correlation between the content of CF and DEp/MEp negative as logical. The content of CF in the feed affect digestibility and energy nutrition.
We have also found negative correlation between CF and DEpg and MEpg (r = - 0.600 ÷ 0.741) and positive correlation dependence (r = 0.660) between CP and DEpg (r = 0.619) was found (Stoyanova et al. 2018) in our previous studies. Positive correlation between the contents of the CP and DE and a negative correlation between the content of CF and DE tempting 15 samples of wheat in experiments with pigs establish and Zijlstra et al. (1999).
The negative correlation between the CP and NFE found in both wheat varieties (r = -0.835, and r = -0.986). Analogous results between the crude protein and NFE (r = -0.83) and establish Alijosius et al. (2016).
High positive correlation relationships are reported between EE and DEp (r = 0.970) and EE and DEpg/MEpg (r = 0.775, r = 0.899) (Table 7).

Table 6. Correlation coefficients between wheat grain chemistry, energy and protein nutrition of non-ruminant wheat for Enola variety 2015-2016

	CP	EE	CF	NFE	DEp	MEp	DEpg	MEpg
CP	1	0.288	0.242	-0.835*	0.731	0.212	0.767*	0.662
EE		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
NFE				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

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

	CP	EE	CF	NFE	DEp	MEp	DEpg	MEpg
CP	1	-0.386	-0.322	-0.986**	0.366	-0.332	0.244	-0.032
EE		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
NFE				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

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, a very high correlation correlation (r = 0.947-0.993) was found between CP and PDI for both common wheat varieties.

REFERENCES

Alijosius, S., Svirmickas, G.J., S. Bliznikas, Gruzauskas, R., Sasyte, V., Raceviciute-Stupeliene, A., Kliseviciute, V., Dauksiene, A. (2016). Grain chemical composition of different varieties of winter cereals. *Zemdirbyste-Agriculture*, *103*(3), 273–280.

Anjum M.I., Ghazanfar S., Begum I. (2014). Nutritional composition of wheat grains and straw influenced by differences in varieties grown under uniform agronomic practices. *International Journal of Veterinary Science*, *3*(3), 100–104.

Dapoza, C., 2006. How to manage the variability of protein and amino acid contents in raw materials. *Amino NewsTM, Degussa 7*(1), 1–12.

Genchev, G., Marinkov, E., Yovcheva, V., Ognqnova, A. (1975). Biometric methods in plant growing, genetics and selection. Zemizdat, Sofia, Bg.

Guang-cail Z., Xu-hong, C., Yu-shuang, Y., Shan-shan, L., Ming, F., Yu-ping, D., Xiu-hong, W., Tie-heng, Z. (2009). Grain yield and protein components responding to the amount and rate of nitrogen application in winter wheat. *Journal of Triticeae Crops*, 09–02.

Kelley, K. & Sweeney, D. (2007). Placement of preplant liquid nitrogen and phosphorus fertilizer rate affects no-till wheat following different summer crops. *Agronomy Journal*, *99*, 1009–1017.

Kim, J.C., Mullan, B.P., Simmins, P.H. and Pluske, J.R. (2003). Variation in the chemical composition of wheats grown in Western Australia as influenced by variety, growing region, season and post-harvest storage. *Australian Journal of Agricultural Research*, *54*, 541–550.

Lasek, O., Barteczko, J., Augustyn, R., Smulikowska, S., Borowiec, F. (2011). Nutritional and energy value of wheat cultivars for broiler chickens. *Journal of Animal and Feed Sciences*, *20*, 246–258.

McCracken, K.J., Preston, C.M., Butler, C. (2002). Effects of wheat variety and specific weight on dietary apparent metabolizable energy concentration and performance of broiler chicks. *Br. Poult. Sci*., *43*, 253–260.

Mollah, Y., Bryden, W.L., Wallis, I.R., Balnave, D., Annison, E.F. (1983). Studies on low metabolizable energy wheats for poultry using conventional and rapid assay procedures and the effects of processing. *Br. Poult. Sci*., *24*, 81–89.

Mungova, M., & Vasileva, E. (2007). Amendment of cereal grain quality depending on nitrogen fertilization. *International Scientific Conference "The Plant Gene Fund - The Base of Modern Agriculture*", 13-14.06.2007, Bg.

Montemurro, F., Convertini, G., Ferri, D. (2007). Nitrogen application in winter wheat grown in Mediterranean conditions: effects on nitrogen uptake, utilization efficiency and soil nitrogen deficit. *Journal of Plant Nutrition, 30*(10), 1681–1703.

Panayotov, I., & Atanasova, D. (2004). New results in wheat breeding and their use in a global scale. Proceedings of the 17th EUCARPIA General Congress *"Genetic variation for plant breeding", 8-11 Sept., Tulln, Austria*, 181–184.

Sauvant, D., Perez, J.M., Tran, G. (2004). Tables of Composition and Nutritional Value of Feed Materials. Pigs, Poultry, Cattle, Sheep, Goats, Rabbits, *Horses and Fish.* 2nd revised Edition. INRA, Wageningen Academic Publishers.

Stoyanova, A., Ganchev, G., Kuneva, V. (2016). Nutrition value of two grain common wheat. *Scientific Papers. Series A. Agronomy*, *LIX*. 421–425. ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785.

Stoyanova, A., Kuneva, V., Ganchev, G., Georgiev, M. (2018). Evaluation of energy and protein nutrition of common valuation wheat varieties treated whit leaf fertilizers valuation. *2nd International Conference on Food and Agricultural Economics 27-28th April, Alanya, Turkey*, 298–304.

Tayebeh A., Alemzadeh, S., Kazemeini, A., Abdolreza, S. (2010). Effect of Organic and Inorganic Fertilizers on Grain Yield and Protein Banding Pattern of Wheat. *Australian Journal of Crop Science., 4*(6), 384–389.

Todorov, N., Ilchev, A., Georgieva, V., Girginov, D., Djouvinov, D., Penkov, D., Shindarska, Z. (2004). Animal nutrition. Textbook, UNISCORP, Sofia, 312 p.

Todorov, N., Krachunov, I., Djouvinov, D., Alexandrov, A. (2007). Handbook of Animal Feeding. Matkom Sofia, 400, Bg.

Uauy, C., Distelfeld, A., Fahima, T., Blechl, A., Dubcovsky, J. (2006). A NAC Gene Regulating Senescence Improves Grain Protein, Zinc, and Iron Content in Wheat. *Science, 314*(5803), 1298–1301, DOI: 10.1126/science.1133649.

Wiseman, J. (2000). Correlation between physical measurements and dietary energy values of wheat for poultry and pigs. *Animal Feed Science and Technology*, *84*, 1–11.

Yanchev, I. & Ivanov, U. (2012). Comparative study of physical, chemical and technological properties of the Greek and Bulgarian common wheat varieties. *FCS*, *8*(2), 219–226, Bg.

Zijlstra, R.T., , De Lange C.F.M., Patience, J.F. (1999). Nutritional value of wheat for growing pigs: chemical composition and digestible energy content. *Canadian Journal of Animal Science, 79*(2), 187–194.

Zilic, S., Dodig, D., Hadzi-Taskovic S., V., Maksimovic, M., Saratlic, G., Skrbic, B. (2010). Bread and durum wheat compared for antioxidants contents, and lipoxygenase and peroxidase activities. *International Journal of Food Science and Technology, 45*, 1360–1366.