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Evaluation of the influence of leaf fertilization the productivity and nutritive value wheat on the basis of mathematical-statistical analysis

Gancho Ganchev[1*], Antoniya Stoyanova[1*], Velika Kuneva[2]

[1]*Trakia University, Faculty of Agriculture, 6000 Stara Zagora, Bulgaria*
[2]*Agricultural University, Department of Mathematics and Informatics, 4000 Plovdiv, Bulgaria*
[*]*Corresponding author:* glen62@abv.bg

Abstract

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Object of the present study are varieties of wheat Enola and Illico, their productivity under the influence of the applied fertilization during the growing season as well as nutritional and energy value of the grain. For fertilization with macro and micro elements are used foliar fertilizers Laktofol major and Wuxal Grano. The aim of the study is by two-way analysis of variance to analyze the impact of the factors variety and variations of the treatment on the nutritional value of two wheat varieties, establishing the power of influence on them independently action, and their interaction. According to the two-factor analysis of variance, both the influence of the two factors (variety and treatment options) separately and their interaction, statistically proven at a very high degree of certainty ($p \leq 0.001$), is the influence on the grain yield indicator. The variety factor (88%) in 2015, followed by fertilization (88%) in 2016, had the strongest influence on the variation of the attribute. The greatest effect on the CP content of both varieties for both years was reported by Wuxal Grano treatment. For Enola, the increase was 15.5% in the first year and 3.9% in the second year. In Illico, the increase was higher in the second year – 9.1%, compared to the first year – 4.9%. Lactofol treatment resulted in an increase in CP content by 5.6% in the first year and by 1.8% in the second year at Enola and by 7.5% in the second and 1.9% in the first year at Illico. Fertilizer application does not affect FUM, FUG and PDI content in ruminants and DE and ME in 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

Wheat provides excellent flexibility and opportunity for growing under different conditions. Globally, there is the question of improving the quality of the grain. All this is the basis of improving the technological level of production in agriculture. These trends are observed in the European Union and particularly in Bulgaria. The analysis of the state of agriculture define strengths and weaknesses and warrants clarification of the main objectives of sustainable development, modernization, reduction of production costs and not the least care for the preservation of the environment (Ivanova 2009; Kanchev, 2009).

For the protein content in addition to the genotype and the supply of nitrogen importance are the influence of the weather conditions, the level of agricultural machines, feeding with other food ingredients entering in protein synthesis (Mangova et al., 2007).

Fertilizer rates can not be determined and fixed. They depend on the potential of the variety of soil fertility and structure of the precursor and thus by mineralization and mobilization of nitrogen. Zelenin et al. (2011) found in their study that administration of siderates increased the crude protein content from 13.6% to 15.8%.

A number of authors have found a positive correlation between nitrogen fertilization and protein content in the grain (Kelley et al. 2007; Mungova et al., 2007; Guang-cail et al., 2009). Vasileva et al. (2012) found that the yield of protein increased with increasing fertilizer rates by ertilization with nitrogen.

Getting more and better quality grain from different varieties of winter wheat depends mainly on agro-meteorological conditions and applied agro-techniques for growing (Dimitrova, 2005; Penchev et al., 2008). To be used at full productive potential of the variety as a factor in obtaining high yield important is choosing the right varieties for each agro-ecological area considered Tzenov et al. (2009).

The aim of the study is by two-way analysis of variance to analyze the impact of the factors variety and variations of the treatment on the nutritional value of two wheat varieties, establishing the power of influence on them independently action, and their interaction.

Materials and Methods

The experiment was conducted in the experimental field of the Department of Crop Production, Faculty of Agriculture, at Trakia University, Stara Zagora. The field experiment is displayed during the years 2014-2016 and two common wheat were used: Enola and Illico with normal sowing rate of 550 seeds/m^2.

The expiremental area on which the test is located in the southeastern part of the Stara Zagora city on typical meadow cinnamon soils. They are deep, developed on deposits under the joint influence of meadow and forest vegetation. Power profile is 103-105 cm, with well-formed horizons. The humus horizon is pronounced with the range 0-45 (50) cm. The B horizon has less power. The horizon C reaches a depth of 103-105 cm. Mechanical composition of the soil is medium sandy-clay. The field moisture limit in the 0-40 cm layer is 31.6%. The soil is on average stored with humus – 3.42% – 4.04%.

The agrochemical characteristic of the soil was made by determining the nutrient reserve. The soil is poorly stocked with available phosphorus. In the 0-30 cm layer, its content is 3.9 mg/100 g of soil. The content of available potassium in the plow layer is 44 mg/100 g of soil, which characterizes the soil as very well stocked with potassium. In the arable layer (0-30 cm), the mineral nitrogen is 33.2 mg/1000 g of soil, which corresponds to a low soil nitrogen supply. According to its mechanical composition, the soil type is sandy-clay.

The area of the experimental field is located at 42.10 north latitude, an altitude of 169 m. The climate is moderate-continental, with average annual rainfall 550 mm and daily average temperature over a period of 89 years.

Object of the present study are varieties of wheat Enola and Illico, their productivity under the influence of the applied fertilization during the growing season as well as nutritional and energy value of the grain.

For fertilization with macro and micro elements are used foliar fertilizers Laktofol major and Wuxal Grano (Table 1). Variants of the study are: 1. Control – Fertilizing with N 140 kg.ha^{-1} 2. Fertilizing with N 140 kg.ha^{-1} + Laktofol major. 3. Fertilizing with N 140 kg.ha^{-1} + Wuxal Grano.

The experimental data obtained were statistically processed by MS Excel computer software. The estimation of the influence of factors is calculated by the method of Plohinski (Lakin, 1990). It is defined as part of the intergroup variation in the total variation. Work with the sum of squares and calculate by the formula:

$$h_x^2 = \frac{D_x}{D_y},$$

where D_x – sum of squares of factor x, D_y – total sum of squares (SS). The influence of both the treatment variant factor and the indicator and their interaction in the two wheat varieties has been established.

The chemical composition of wheat grains was established using the classic Weende method. To calculate the

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
Wuxal Grano	219	–	–	365	29	–	0.0043	0.0043	–	0.0146

digestible nutrient content of wheat, we used data on digestibility coefficients for ruminants and pigs and poultry respectively (Todorov et al., 2007).

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

$$GE = 0.0242\ CP + 0.0366\ EE + 0.0209\ CF + 0.017\ NFE$$
$$ME = 0.0152\ DP + 0.0342\ DEE + 0.0128\ DCF + 0.0159\ DNFE$$
$$q = ME/GE$$
$$FUM = ME\ (0.075 + 0{,}039q)$$
$$FUG = ME\ (0.04 + 0.1q)$$
$$PDI = 1.11CP\ (1 - Deg)\ Dsi + 0.093\ FOM$$
$$FOM = DOM - DEE - FP - CP\ (1 - Deg)$$
$$FP = 250 - 0.5\ DM$$

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

Meteorological characteristics of the experimental years

Yield of wheat and grain quality depend not only on studies factor leaf fertilization with liquid fertilizers. Yields largely are determined by the natural fertility of the soil and weather conditions during the growing period of the culture.

The agro-meteorological conditions in the survey years are very different, with the greatest importance for crops being the amount and distribution of rainfall (Zarkov, 2010) (Figure 1 and 2). For the 2014/2015 business year, they are 707.7 mm. Rainfall is 62.2% higher than the climate norm. At the beginning of the growing season, precipitation amounts to 109.2 mm. The largest deviation was in October, before sowing (exceeded by 63.3 mm) and June (exceeded by 57.0 mm). The emergence of the crops is protected by the moisture provided by the fallen rainfall.

In April, 31.8 mm of rainfall fell, which is 30.6% less than the multi-year rainfall. As a result of the increased amount of rainfall, a high percentage of lying and breaking of the cervix was observed in June. The measured average monthly temperatures at the beginning of the growing season (October-November) are close to the temperature norm. In terms of temperature, this year is characterized by a warm winter, with daily average temperatures higher from 0.8 (January) to 1.6 degrees (December). Conditions are conducive to better wheat breeding. In March-April, when the crops enter a durable spring growing season, the reported temperatures are close to the temperature norm.

In the second year of the survey, rainfall is close to the climate norm. Drying periods are observed. The dynamics of average daily temperatures are close to the norm for the multiyear period for the first months of the growing season of wheat (October-December). Negative temperatures

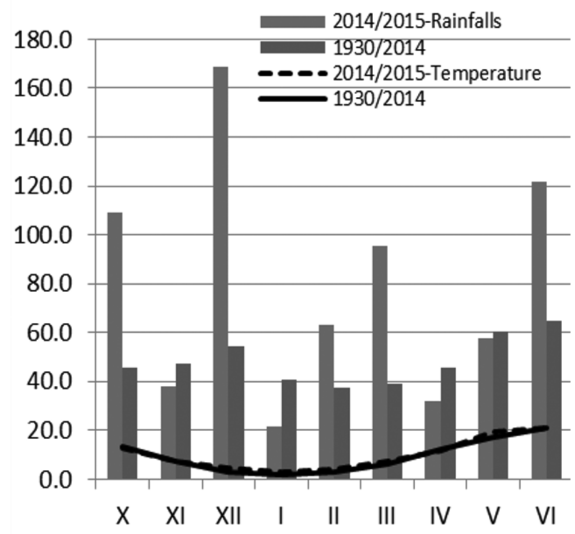

Fig. 1. Temperature and precipitation conditions in the Stara Zagora region during 2014-2015 and the period 1930-2014

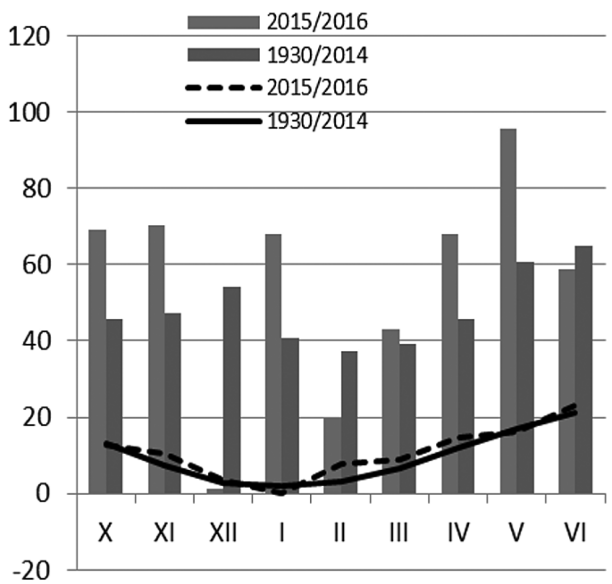

Fig. 2. Temperature and precipitation conditions in the Stara Zagora region during 2015-2016 and the period 1930-2014

Table 2. Hydrothermal coefficient values during the study period

Months/Ten-day period	April			May			June		
	1	2	3	1	2	3	1	2	3
2015	2.75	0.47	0.21	0.57	0.83	1.59	0.31	3.08	2.31
2016	0.08	0.7	1.98	3.47	0.72	1.95	2.58	0.05	0.18

(-13.4°C) were reported in January. 4.7°C were higher in February, when the crops began to develop. Temperatures in March and April are above normal, which favours the spring vegetation of wheat.

On the basis of the reported meteorological indicators average daily air temperature (°C), temperature sum (°C), and sum of precipitation for a period with average daytime temperatures > 10°C, the hydrothermal coefficient (HTC) according to Selyaninov was calculated. The observation period shall cover the months of April-June (Table 2). The hydrothermal coefficient is calculated in ten days. The period during the first ten days of April (HTC = 2.75) and the second and third ten days of June (HTC = 3.08 and 2.31) is strongly overpowered. Conditions have been dry over the last ten days of April and June (HTC = 0.21 and 0.31).

Analysis of variance

The variance analyses made for the influence of the variety factors, fertilizers options and their interaction on the yield of wheat of the Enola and Illico varieties are presented in Table 3. Table 3 shows the results of the analysis of the wheat yield data for the varieties. For the yield indicator over the years considered (table 3) the strongest influenza of the variety factor was observed with a dominant influenza of 64% and with a clear confidence of $p \leq 0.001$ on the change in the indicator. The second is the fertilization factor with an impact of 3%, and with 2% respectively the interaction of the two factors.

From the results obtained, in the considered indicator "yield" reliable variants for the variety factor, but the fertilization factor and the interaction of the two factors is statistically less pronounced.

Grain protein content by years and varieties

In addition to the productivity of varieties of decisive nutrition, the nutritional value of wheat used in animal rations is also important. It is determined by the chemical composition and digestibility of the individual nutrients. The content of crude protein (Figure 3 and 4) in the grain for Enola varied ranges from 127.92 to 147.78 g/kg DM for the first year and from 135.76 to 141.04 g/kg DM for the second year. For Illico variety ranges from 114.32 to 119.97 g/kg DM for the first year and from 115.36 to 125.91 g/kg DM for the second year. Variations from 9.7 to 19.1% of CP were found by Kim et al. (2003) in Australian wheat cultivars and from 7.6 to 15.1% CP by Dapoza (2006) in Spanish wheat cultivars.

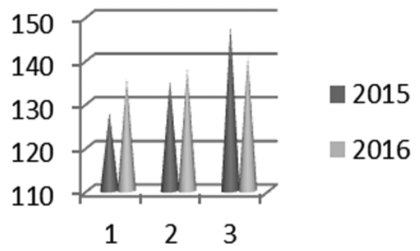

Fig. 3. Crude protein content in the grain of common wheat variety Enola in 2015 and 2016

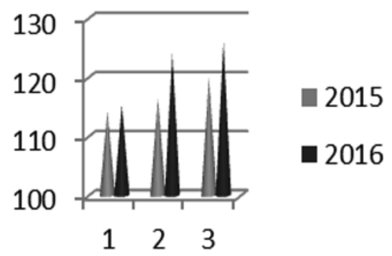

Fig. 4. Crude protein content in the grain of common wheat variety Illico in 2015 and 2016

Table 3. Two-factor ANOVA: A – variety and B – treatment options for wheat production in 2015-2016.

Source of variation	Power of influence	SS	df	MS	F	P-value	F crit
Variety (A)**	64%	4212543	1	4212543	21.02	0.00	4.75
Fertilizers (B)	3%	4.87	2	2.43	0.00121	0.99	3.89
Interaction (AxB)	2%	1255.6	2	627.81	0.003	0.99	3.89
Errors		2404603	12	200383.60			

***, **, * – proved respectively at $p \leq 0.001$, $p \leq 0.01$ and $p \leq 0.05$; n.s. – unproven

The lowest is the content of the CP for variants that are only fertilized with N 140 kg.ha^{-1} An increase in the content of CP is observed in the treatment with leaf fertilizers. At Enola treatment Wuxal Grano adds to the content of the CP with 15.5% in the first and 3.9% in the second panel year while treatment Laktofol to increase only by 5.6% in the first and 1.8% in the second year. Illico has the same dependency, with the largest increase in the content of CP when treated with Wuxal Grano 1 – 9.1% in the second and 4.9% in the first year, respectively. Lactofol treatment increased the content of the CP by 7.5% in the second and 1.9% in the first year, respectively.

Treatment during the formation of the flags sheet with this liquid formulation, enriched with copper, contributes to increasing the levels of protein. According to some authors, there is a negative correlation between yield and protein content (Yanchev et al., 2004). The increase in yield of grains in the var. 2 was 7.3% compared to the first year control. In the second year the increase was 24.3%. When feeding with Wuxal Grano in the first year productivity has increased by 4.8%, while in the latter, characterized by a high air temperature and a uniform distribution of rainfall, the increase in yield is by 23.7%.

Correlation analysis establishes a positive correlation of grain yield and total above ground biomass in spindling, flowering and full maturity, the number and weight of the grain in the class, the mass of grain by direct assimilation, total nitrogen in the biomass at full maturity and the content of protein by vegetation phase (Vasileva et al., 2012). According to Cheleeva et al. (2000) between the magnitude of the yield and quality of the protein and wet gluten grain exists slightly negative to very high positive correlation in some varieties and lines. They found that the percentage of positive proven relation between yield and protein in the grain was 42.8%, while the percentage of the negative is higher – 57.2%.

Illico has the same trend. When feeding with liquid fertilizer were measured higher values of crude protein. Impact on the absorption of imported food items has weather elements. In the first year yields increased 15.1% and 16.6% compared to the control variant after treatment. In the second year the daily average temperature during growth of the stem and the formation of grain were measured higher. An increase of 18.3% and 21.0% was registered in the yields, respectively in the 2 and 3 feed options. Lactofol basic treatment contributes to an increase in crude protein by 1.9% to 7.5%. The analysis found an increase after the administration of Wuxal Grano by 4.9% to 9.1%. Wheat Illico is found to be a better absorbed nutrient in intensive sunbathing.

Nutritional value

Data base for the nutritional value for both year for ruminants are given in Tables 4 and 5. The FUM content in 1 kg of DM is 1.47 for Enola for both years, regardless of the treatment applied. For the Illico variety in the first year the content of FUM 1.49 in the third treatments is slightly higher than the values for the second year 1.47-1.48. FUG is also unaffected by the fertilization applied.

Table 4. Energy and protein value of common wheat for ruminants in 1 kg DM, 2015

Common wheat	Variant	FUM	FUG	PDI
Enola	1	1.47	1.64	101.49
	2	1.47	1.64	102.88
	3	1.47	1.64	104.83
Illico	1	1.49	1.67	99.73
	2	1.49	1.67	100.33
	3	1.49	1.66	100.76

Table 5. Energy and protein value of common wheat for ruminants in 1 kg DM, 2016

Common wheat	Variant	FUM	FUG	PDI
Enola	1	1.47	1.64	102.75
	2	1.47	1.64	102.46
	3	1.47	1.63	103.81
Illico	1	1.47	1.65	100.16
	2	1.48	1.65	101.34
	3	1.47	1.65	101.63

In spite of the high content of CP in the variants treated with Wuxal Grano and Laktofol, the content of protein digestible in the intestine (PDI) differs insignificantly as in two varieties and for two years – 101.49-104.83 g/kg DM 2015 and 102.75- 103.81 g/kg DM 2016 for Enola and accordingly 99.73-100.76 g/kg DM 2015 and 100.16-101.63 g/kg DM 2016 for Illico.

There were also no significant differences in the energy value of the two wheat varieties in birds and pigs over the two years (Tables 6 and 7). The higher energy nutrition of both pig wheat varieties is a result of the higher digestibility

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

Common wheat	Variant	DEp	MEp	DEpg	MEpg
Enola	1	15.82	15.2	16.43	16.13
	2	15.85	15.19	16.46	16.14
	3	15.92	15.2	16.54	16.19
Illico	1	15.82	15.26	16.41	16.15
	2	15.84	15.27	16.43	16.17
	3	15.87	15.28	16.47	16.19

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

Common wheat	Variant	DEp	MEp	DEpg	MEpg
Enola	1	15.89	15.22	16.49	16.17
	2	15.94	15.26	16.57	16.23
	3	15.9	15.21	16.5	16.16
Illico	1	15.69	15.13	16.26	16.01
	2	15.81	15.21	16.4	16.12
	3	15.81	15.19	16.39	16.1

of the nutrients. The content of DE in birds for the two wheat varieties ranges from 15.82 to 15.92 MJ/kg in 2015 and from 15.69 to 15.94 MJ/kg DM in 2016. Varying in DEp content in the range of 8.49 to 15.9 MJ/kg DM establish Mollah et al. (1983), Wiseman (2000) and McCracken et al. (2002). The content of DE in pigs for both wheat varieties also varies within a narrow range and is not affected by the treatment applied – 16.41 to 16.54 MJ g for 2015 and from 16.26 to 16.57 MJ/kg DM for 2016.

Conclusions

1) According to the two-factor analysis of variance, both the influence of the two factors (variety and treatment options) separately and their interaction, statistically proven at a very high degree of certainty ($p \leq 0.001$), is the influence on the grain yield indicator. The variety factor (64%), followed by fertilization, had the strongest influence on the variation of the attribute.

2) The greatest effect on the CP content of both varieties for both years was reported by Wuxal Grano treatment. For Enola, the increase was 15.5% in the first year and 3.9% in the second year. In Illico, the increase was higher in the second year – 9.1%, compared to the first year – 4.9%.

3) Lactofol treatment resulted in an increase in CP content by 5.6% in the first year and by 1.8% in the second year at Enola and by 7.5% in the second and 1.9% in the first year at Illico.

4) Fertilizer application does not affect FUM, FUG and PDI content in ruminants and DE and ME in non-ruminants.

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