Trakia Journal of Sciences, No 3, pp 215-221, 2021

Available online at:
http://www.uni-sz.bg

ISSN 1313-3551 (online) doi:10.15547/tjs.2021.03.002

Original Contribution

EFFECT OF LEBOSOL® FOLIAR FERTILIZERS ON ENERGY AND PROTEIN TRANSFORMATION ALONG THE ECO-TECHNICAL CHAIN 'SEED MATERIAL – GRAIN YIELD OF MAIZE'

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ABSTRACT

The aim of the study was to calculate the "multiplication effect" between the included gross energy (crude protein) with the seeds and the same, obtained with the grain yields in the eco-technical system "seed material – soil – grain yield", so as the influence of some foliar fertilizers Lebozol® on it.

For variants were investigated – control without foliar fertilizers and three experimental – trated with Aminosol + Lebosol Zin, Nutriplant 36 and Mix for maize respectively. The multiplication effects were:

- For the Gross energy: Control – 1048.7 times (with variations from 833.36 to 1287.73); First experimental – 1099 times (with variations from 876.49 to 1343.75) – 4.55% exceeding the control; Second experimental – 1093.3 times (with variations from 863.57 to 1341.62) – 4.08% exceeding the control; Third experimental – 1078.8 times (with variations from 862.5 to 1322.54) – 2.80% exceeding the control.
- For the crude protein: - Control – 997.2 times (with variations from 803.28 to 1224.43); First experimental - 1050 times (with variations from 837.58 to 1284.1) – 11.86% exceeding the control; Second experimental – 1131.3 times (with variations from 893.7 to 1338.42) - 11.86% exceeding the control; Third experimental - 1047.7 times (with variations from 837.71 to 1284.57) – 4.83% exceeding the control.

Keywords: crude protein, gross energy, maize-grain, foliar fertilizers, multiplication effect

INTRODUCTION

The energy and protein supply of people and animals is a matter of primary importance (1). The concept of 'yields per unit of area' is a key characteristic in crop breeding. However, when crop production is intended for direct human or animal consumption, the term acquires a different meaning, i.e. 'nutrient supply'. That is necessary because humans and animals receive energy from food for supporting their life processes, as well as proteins, which are the major building blocks of life (2-6). Studies of maize cultivars with high protein content in the grain show the complex nature of research for obtaining high-yielding hybrids with high levels of protein in the grain (7). That can be compensated by the use of foliar fertilizers, which exert an effect on the protein content of grain.

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When an extra energy is supplied to an ecosystem by man, no matter in what way, with the aim of increasing the yields obtained from it, then the system turns from 'ecological' to 'eco-technical' (8-10).

Foliar fertilizers are an up-to-date practice for supplying plants with the necessary elements for their proper growth (11) and at the same time those fertilizers have little effect on soil, as they are applied directly to plant leaves (12-18).

The aim of the present study was to determine the effect of the foliar fertilizers Lebosol (Aminosol + Lebosol Zn), Nutriplant 36 and Mix for maize on the gross energy (GE) and crude protein (CP) yields from maize grain.

MATERIAL AND METHODS

The study was carried out in the experimental field of the Institute of Agriculture and Seed Science 'Obraztsov Chiflik' in Ruse in three consecutive years (2014-2016). The maize hybrid Ruse 464 was used in the experiment, grown under non-irrigated conditions. A non-

standard scheme with a sequential arrangement of the variants was applied and each variant was in 3 replications. The experimental design included 4 variants with a size of the experimental plot of 42 m^2, the seed rate being 8.52 kg/ha and the harvested plot – 30 m^2. During the study period, basic fertilization was applied in all the variants with triple superphosphate at a rate of 150 kg/ha and potassium sulfate at a rate of 150 kg/ha. Pre-sowing fertilization with ammonium nitrate at a rate of 250 kg/ha was carried out. A variant untreated with Lebosol products was used for control. Treatment in all the other variants was performed with foliar fertilizers of Lebosol during the vegetation period, at the growth stage of the crop 4-5 leaf.

Variants:
1. Control – untreated with foliar fertilizers
2. First experimental – treatment with a combination of Aminosol + Lebosol Zin 700 SC at rates of 1000 ml/ha + 1000 ml/ha.
Aminosol foliar fertilizer is an organic NK-fertilizer, liquid, with the following nutrients: 9.4% total nitrogen (N) 115 g/l and 1.1% total potassium oxide (K2O) 15 g/l and pH: 5.0 – 7.0. Foliar fertilizer Lebosol Zinc 700 SC is a suspension of zinc fertilizer containing the nutrient: 40% total zinc (Zn) and zinc oxide 700 g/l and pH: 8.0 – 9.0.
3. Second experimental – Nutriplant 36 at a rate of 5000 ml/ha.
Nutriplant 36 is a solution containing the nutrients: 27% total nitrogen (N) 350 g/l, 4% ammonium nitrogen (N), 5% nitrate nitrogen (N), 18% amide nitrogen (N), 3% water-soluble magnesium (MgO) 40 g/l and pH: 6.0 – 8.0.
4. Third experimental – Mix for maize at a rate of 1000 ml/ha.

That fertilizer is a liquid mixture of trace elements with boron (B), manganese (Mn) and zinc (Zn), respectively. Nutrients: 4.3% total boron (B) as calcium borate 70 g/l, 9.2% total manganese (Mn) as manganese carbonate 155 g/l, 4.8% total zinc (Zn) as zinc oxide 80 g/l and pH: 8.0.

In all the variants, the grain moisture at harvest was measured in % with an electronic hygrometer, the 1000 grain weight was determined in grams and the yield in $kg.ha^{-1}$ was reported.
The chemical analysis of the seed material and of the average sample from the three years by variants was determined by Weende method (19).
The gross energy values of the seed material and of the yields were calculated according to the formula of (20):
GE (MJ) =
0.0242*CProtein+0.0366*CFats+0.0177*CFiber+0.0170*NPExtract

The multiplication coefficients were calculated by the formula:
[Gross energy (crude protein) in the yield] * [gross energy (crude protein) in the seed $material^{-1}$]
The results were statistical processed method by "Excel – Descriptive Statistics".

RESULTS AND DISCUSSION

Table 1 shows the chemical composition and energy value of the seed material and the averaged three-year samples from the control and the experimental variants. The table shows that foliar fertilizers did not have a significant effect either on the crude protein content (variations in the different variants were between 8.19 (control) and 8.94% in the dry matter (second experimental variant), or on the other organic ingredients.

On that basis, the gross energy (GE) contents were also insignificant and they ranged from 18,470 (control) to 18,647 MJ/kg dry matter (DM), (first experimental variant). Their values, as well as the crude protein and gross energy contents in the seed material – 8.52% and 18.284 MJ/kg DM, respectively, were very close to the cited averaged data for maize grain in Bulgaria (21-23).

Yields by years and in average for the 3 experimental years are presented in **Table 2.**

The lowest yield on average for the whole experimental period was obtained from the control – 7609.6 kg/ha and the highest yield – from the variant treated with Nutriplant – 7909.1 kg/ha. Despite the large differences in the average yields, no statistical significance was established between them ($P \geq 0.05$), mainly due to the very low yields from all the four variants in the second year and the high variation between the different experimental years. Considered for each year separately, the differences between the control and the three experimental variants were statistically significant ($P \leq 0.05$). Significance between the differences ($P \leq 0.05$) was observed in all the three experimental variants within the same year, but they were quite controversial.

Table 1. *Chemical composition and Gross energy values of sown grain and grain obtained from control and experimental varants (averaged samples)*

Indexes	Dry matter-%	Crude protein –g		Crude fats –g		Crude fiber –g		Crude NPE -g		Gross energy – MJ	
		In DM	In native	In DM	In native	In DM	In native	In DM	In native	In DM	In native
CONTROL											
Mean from 3 years	86.50	**81.9**	**70.8**	44	38.06	25	21.63	834.1	721.49	**18.470**	**15.976**
I-st experimental											
Mean from 3 years	86.63	**83.1**	**71.99**	43	37.25	24	20.79	845.01	732.03	**18.647**	**16.154**
II-nd experimental											
Mean from 3 years	86.50	**89.4**	**77.33**	44	38,06	25	21.63	825.6	714.14	**18.524**	**16.023**
III-rd experimental											
Mean from 3 years	86.38	**83.8**	**72.39**	45	38.87	23	19.87	833.2	719.72	**18.501**	**15.982**
Chemical composition and gross energy of the grain used as sowing material (sowing rate 8.52 native kg / ha // 7.33 kg dry matter / ha)											
Mean from 3 years	**86.00**	**85.2**	**73.27**	44	37.84	24	20.64	834.5	717.67	**18.284**	**15.72**

Table 2. *Yield of grain/ha (in DM) for each year and mean from 3 years (kg)*

Variants / Years	Control	I experimental	II experimental	III experimental
I	9343.9±30.1	9657.8±51.6*a	9706.53±15.2*ab	9580.4±17.2*ab
II	6041.5±47.3	6299.5±54.3*a	6247.9±12.90*a	6247.9±30.1*a
III	7477.7±8.60	7763.7±23.7*a	7763.7±6.50*b	7699.2±6.50*ab
Mean from 3 years	7609.6±468.8	7899.1±481.8	7909.1±499.4	7814.5±483.1

Significance by P≤0.05: *-* between control and the experimental variants; a-a between I-st experimental and 2-nd and 3-rt experimental variant; b-b between II-nd and III-rd experimental variant

Table 3 shows the gross energy and crude protein values at the input and output of the different eco-technical systems that were the subject of the present experiment.

The average gross energy yield from the control variant was the lowest – 140549.31 MJ/ha and the foliar fertilizers had a positive effect in all three experimental variants. The highest yield was reported in the first experimental variant –

147294.52, followed by the second – 146519.28 and the third – 144576.06 MJ/ha. The differences were statistically insignificant (P≥0.05) but that was primarily due to the low average yield in the second experimental year, which presupposed the high overall variation of yields.

Table 3. *Yield of gross energy (GE) – MJ) and crude protein (CP) – kg) from ha for each of the variants (exit of the system) and invested GE and CP through sown seeds (entrance of the system)*

Variants / Years	Control	I experimental	II experimental	III experimental
		Yield of Gross energy (GE) – MJ/ha		
I	172581.83±555.95	180089.00±962.19*a	179803.76±281.56*b	177246.98±318.22*ab
II	111686.31±873.63	117466.78±1012.53*a	115736,10±238.96*a	115592.40±556.88*a
III	138113.12±158.84	144769.71±441.93*ab	141962.38±120.41*a	142442.90±120.26*ab
Mean from 3 years	140549.31±8658.7	147294.52±8984.12	146519.28±9250.89	144576.06±8937.83
		Yield of crude protein (CP) – kg/ha		
I	765.27±2,47	802.56±4.29*a	867.76±1.36*ab	802.84±1.44*b
II	502.05±3.87	523.49±4.51*a	558.56±1.15*ab	523.57±2.52*b
III	612.42±0.704	645.16±1.97*a	694.01±0.58*ab	645.19±0.54*b
Mean from 3 years	623.23±38.39	656.42±40.04	707.07±44.64	654.81±40.48
		Gross energy and crude protein input through the sown seeds		
Gross energy input in the system – 134.02 MJ/ha				
Crude protein input in the system – 0.625 kg/ha				

Significance by P≤0.05: *-* between control and the experimental variants; a-a between I-st experimental and 2-nd and 3-rt experimental variant; b-b between II-nd and III-rd experimental variant

Observed by years, the differences between the experimental variants and the control followed the general tendency of the average yields, but for each year the differences by variants were significant (P≤0.05), especially between the control and each of the experimental variants. That is the reason to conclude that the application of the foliar fertilizers Aminosol + Lebosol Zn, Nutriplant 36 and Mix for maize SC had a significant positive impact on gross energy yields. Similar effect with increased yields and efficiency as a result the application of the foliar fertilizer LEBOSOL NUTRIPLANT 36 in winter wheat were reported by (24).

Exactly the same tendency was observed in the crude protein yield per hectare. The average

yield per hectare for the three years was 623.23 kg in the control. The highest yield was reported in the second experimental variant – 707.07 kg, followed by the first – 656.42 kg and the third – 654.81 kg.

While the differences in the average three-year yields between the control and the experimental variants were statistically insignificant, the control gave significantly lower yields of crude protein by years, compared to all the experimental variants (P≤0.05). It can be concluded that foliar fertilizers had a positive effect on crude protein yield per hectare.
Since the seeding rate (8.52 native kg/ha / 7.33 kg dry matter/ha) was the same both by years and by variants, the input gross energy (134.02 MJ/ha) and crude protein (0.625 kg/ha) were also the same and when calculating the multiplier effect **(Table 4)**, the same tendencies were observed as in Table 3.

The multiplier effect in gross energy on average for the three years in the control variant was the lowest – 1048.7 times and the highest in the first experimental variant – 1099 times (4.55% exceeding the control), followed by the second experimental variant – 1093.3 times (4.08% exceeding the control) and the third experimental variant – 1078.8 times (2.80% exceeding the control).

The multiplier effect in crude protein was again the lowest in the control variant – 997.2 times; the highest was reported in the second experimental variant – 1131.3 times (11.86% exceeding the control), followed by the first experimental variant – 1050 times (5.13% exceeding the control) and the third experimental variant – 1047.7 times (4.83% exceeding the control).

Table 4. *Multiplication effect (times) of gross energy and crude protein from control and experimental variants (average of three-year experiments)*

Groups Multiplication effect	Control	I experimental	II experimental	III experimental
		For the Gross energy (GE)		
I year	1287.73±0.43	1343.75±0.72*a	1341.62±0.21*ab	1322.54±0.24*ab
II year	833.36±1.05	876.49±1.16*a	863.57±0.28*a	862.50±0.65*a
III year	1030.54±0.15	1080.21±0.41*a	1059.26±0.11*ab	1062.85±0.11*ab
Mean from 3 years	1048.7±64.6	1099.0±67.0	1093.3±69.0	1078.8±66.7
		For the Crude protein (CP)		
I year	1224.43±0.002	1284.10±0.003*a	1388.42±0.001*ab	1284.57±0.001*b
II year	803.28±0.004	837.58±0.005*a	893.70±0.001*ab	837.71±0.003*b
III year	979.87±0.001	1032.26±0.002*a	1110.42±0.001*ab	1032.30±0.001*b
Mean from 3 years	997.2±6.14	1050.0±36.4	1131.3±71.4	1047.7±64.7

Significance by P≤0.05: *-* between control and the experimental variants; a-a between I-st experimental and 2-nd and 3-rt experimental variant; b-b between II-nd and III-rd experimental variant

Although the differences between the control and the experimental variants on average for the three experimental years were statistically insignificant (P≥0.05) for both gross energy and crude protein, the significance of the differences between the variants for each experimental year gave the reason to draw significant conclusions about the positive effect of the foliar fertilizer combinations on gross energy and crude protein yields.

The transformation coefficients obtained were compatible with those reported by (3) for gross energy but higher for crude protein.

CONCLUSIONS

The following multiplier effects were found in the present experiment:

For the gross energy:

- Control – 1048.7 times (with variations from 833.36 to 1287.73);
- First experimental (Aminosol + Lebosol Zin) – 1099 times (with variations from 876.49 to 1343.75) – 4.55% exceeding the control;
- Second experimental (Nutriplant 36) – 1093.3 times (with variations from 863.57 to 1341.62) – 4.08% exceeding the control;
- Third experimental (Mix for maize) – 1078.8 times (with variations from 862.5 to 1322.54) – 2.80% exceeding the control.

For the crude protein:

- Control – 997.2 times (with variations from 803.28 to 1224.43);
- First experimental (Aminosol + Lebosol Zin) - 1050 times (with variations from 837.58 to 1284.1) – 11.86% exceeding the control;
- Second experimental (Nutriplant 36)) – 1131.3 times (with variations from 893.7 to 1338.42) - 11.86% exceeding the control;
- Third experimental (Mix for maize) - 1047.7 times (with variations from 837.71 to 1284.57) – 4.83% exceeding the control.

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