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Research on the effect of different types of fertilization on the maize (*Zea mays* L.)

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Abstract. Maize is the cereal crop with the greatest productive potential and production in the world. A field research experiment was conducted in the field settings of the Department of "Plant Production" at the Technical University of Varna, to evaluate the effect of foliar fertilizers on the productivity and quality of Dekalb maize hybrids. Four fertilizer variants were examined and the following biometric parameters were assessed: grain yield, weight per 1000 grains, length of cob, number of rows in cob, number of grains in cob, number of grains per row, weight of grain in cob and weight of the cob. A biochemical analysis of the maize grain was performed and the content of protein, starch and fat was determined. It was established that the combined pairing of soil and foliar fertilization leads to increased productivity and enhanced biometric parameters under study, with the highest values being obtained in the variant ammonium nitrate (rate of 12 kg/da) + 250 ml/da NPK 2.5 SO_3 with composition 3.0 N: 1.5 P: 10 K: 2.5 SO_3 + 250 ml/da SO_3 10% Zn, 3% N (sulfides with zinc and nitrogen). It was also ascertained, through the use of the same combination, that the maize hybrids under examination contain the highest amount of protein. Provided, from the findings of the experiment, is a conclusive evidence, that the combination of sowing soil fertilization with ammonium nitrate (rate of 12 kg/da) and two foliar fertilizers (rate of 250 ml/da) – NPK 2.5 SO_3 + SO_3, 10% Zn, 3% N improved the productivity and quality of the investigated Dekalb maize hybrids.

Keywords: maize, foliar fertilization, yield, biometric parameters, protein

1 Introduction

The application of mineral fertilizers in agriculture is a significant financial investment. It is, therefore, essential to use these resources correctly and appropriately in order to keep production costs low. Mineral fertilization is a major agrotechnical factor for increasing yield and its stability, improving the quality of agricultural crops and for sustainable economic growth of agricultural holdings (Todorova et al., 2012; Koteva and Bazitov, 2013; Nikolova, 2018).

In recent years, with the mass introduction of organic production, the attitude towards mineral fertilizers has changed significantly. Currently there has been continuing and intense debate about the negative effects of chemicalization of agriculture and replacing it with ecological and alternative practices, but on the other hand, humanity needs the production of a greater amount of food. The long-term and large-scale application of mineral fertilization leads to a number of adverse consequences that require a major review of the concepts and systems of fertilization, as well as the conditions conducive to the contamination of soils, crop production, air, surface and groundwater with harmful substances human health and animal substances (Karov et al., 2004; Todorova et al., 2013; Mitova and Dinev, 2017).

The production of maize for grain has been very high in recent years. The USA ranks first among the countries where it is grown, followed by China and Brazil, which together account for 50% of the area with this crop (Gerasimova, 2013). Maize is a crop with high genetically determined productivity. For its realization, it is necessary to optimize the main agrotechnical factors, among which are the regime of mineral nutrition, the density of sowing, and the system of irrigation. In non-irrigated conditions, fertilization adds up to about 30-35% of the production costs. Its share is approximately the same as that for yield formation (Mikova et al., 2013; Koteva et al., 2014; Kuneva et al., 2015; Toncheva, 2016; Ivanov and Dimitrov, 2018).

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Foliar fertilization is used as a practice to correct the nutritional regime of agricultural crops, to adjust the quantity and quality of agricultural production. Foliar nutrition can lead to the overcoming of functional diseases in plants caused by the absence or deficiency of a given nutrient element. Foliar fertilization can also be applied in the presence of stressful conditions during the growing season of crops, such as extremely high or low temperatures, drought, pollution, etc. The effect occurs much faster than with soil fertilization (Petkova et al., 2014; Amanullah et al., 2016; Toungos et al., 2016).

The topic of the influence of foliar fertilization on the quantity and quality of agricultural crops is an issue of current interest and lively controversy. In depth scientific research has been carried out, over the past few years, clarifying the numerous possibilities for using foliar fertilizers in various areas of agriculture. Accurate, replicated small-plot trials are needed to clarify the factors influencing the effectiveness of foliar fertilizers (Jakab et al., 2017; Brankov et al., 2020; Al-Dulaimi1 et al., 2021; Nyagorme et al., 2021).

The aim of the present research is to investigate the impact of foliar fertilizers on the productivity and grain quality of new maize hybrids under field conditions, to evaluate their responsiveness to fertilization.

2 Material and methods

The experiment was carried out at the educational and experimental field of the "Plant Production" department at the Technical University of Varna. The experiment was conducted in two replications with a plot size of 12 m^2. Cultivating maize hybrids DKC 4670 (medium early, FAO 380) and DKC 5068 HD (medium late, FAO 440), selection of Dekalb (registered trademark of Monsanto Technology LLC, part of the Bayer Group). Sowing was done manually at a depth of 6-8 cm, standard inter-row distance 0.70 m and intra-row distance 21 cm (6800 plants/da). The treatment of the area intended for the experiment involves double milling. Before sowing, the area was leveled and the plots and paths were subsequently shaped. About a month after the sowing, the crop was hoed in order to combat the sprouted weeds and loosen the soil surface. Sowing feeding with ammonium nitrate was undertaken with a fertilizer rate of 12 kg/da. During the maize growing season, foliar fertilization was implemented twice - 4-8 leaves and the beginning of tassel emergence with a fertilizer rate of 250 ml/da.

The following fertilizer options are available:

- Fert 1 - Ammonium nitrate (34% nitrogen)
- Fert 2 - Ammonium nitrate (34% nitrogen) + 250 ml/da NPK 2.5 SO_3 (with composition 3.0 N: 1.5 P: 10 K: 2.5 SO_3)
- Fert 3 - Ammonium nitrate (34% nitrogen) + 250 ml/da NPK 2.5 SO_3 + 250 ml/da SO_3 with 10% Zn and 3% N (with zinc and nitrogen sulphide composition)
- Fert 4 - Ammonium nitrate (34% nitrogen) + 250 ml/da NPK 2,5 SO_3 + 250 ml/da SO_3 with 20% amino acids and 10% Zn and 3% N (with a composition of sulfides with zinc and nitrogen and 20% amino acids)

The maize production was harvested by hand, on the cob at a standard moisture of 14%. The following biometric parameters were determined on 20 representative cobs from each replication of the specific variant.

- grain yield (kg/da) - Yield
- mass of 1000 grains (g) – M1000
- length of one cob (cm) – LMC
- number of rows in a cob (number) – NRC
- number of grains in a cob (number) – NGS
- number of grains in a row (number) – NGR
- kernel weight in cob (g) – WGC
- cob weight (g) – CW

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The biochemical analysis of the maize grain was accomplished in the Agroecological Laboratory of the Technical University of Varna according to the variants and replications. Applied, to that effect, was, a NIR-analyzer (Model: DA7200 NIR, Producer: Perten Instruments AB, Sweden) was used, and three grain samples from each replication of the specific fertilizer variant were analyzed for protein, starch and fat content.

The statistical processing of the data was carried out using the SPSS 19 software product.

3 Results and discussion

Productivity and grain quality of maize depend on the environmental conditions, the genetic predisposition of the hybrids and the applied agricultural techniques. Precipitation, its distribution and combination with temperature conditions during the growing season are a decisive meteorological factor for their growth and development (Figure 1). According to long-term studies, the average rainfall in the region of Varna is one of the lowest in the country. Their maximum is in June and November, and minimum - in August - September. The total amount of precipitation for the entire growing season is 225.2 l/m². In addition to the total amount of precipitation during the maize growing season, its distribution during the different phenophases of plant development is important for the amount of yield. The year in which the research was conducted was characterized by a good autumn-winter supply of moisture (442.50 l/m²), with the highest amount of precipitation falling in January (188.8 l/m²). In March and April, before sowing the maize, the reported amount was 110.6 l/m², and in June – 154.8 l/m². Moreover, their distribution in June was even, with the majority falling in the second half of the month and thus, contributing to the easy sprouting and better rooting of the plants. During the emergence-sweeping phenophase, the leaf mass grows rapidly and the reproductive organs of the plants are formed. The critical periods in terms of moisture are the phases sweeping and flowering, associated with very low amounts of precipitation 17 l/m² for July and 8.3 l/m² for August. With regard to the temperature regime, the recorded average day and night air temperatures are of normal values. The highest temperature was measured in July (27.2^{0}C). A limiting factor to the crop yield is the low amount of precipitation.

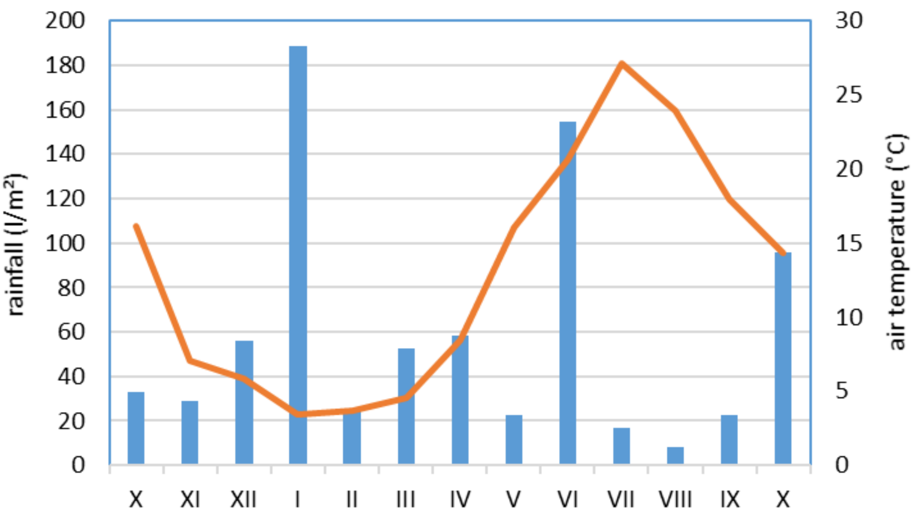

Fig. 1. Weather conditions during the study period.

One of the most important agrotechnical factors influencing the growth and development of maize is mineral nutrition, and as a crop with a relatively long growing season, it absorbs nutrients throughout its life cycle. Maize refers to crops that respond positively to the application of fertilizers, which in turn, promotes sustainable high grain yields. An additional agrotechnical practice to the maize fertilization system is the application of foliar fertilization with complex fertilizers containing trace elements in chelated form.

Productivity is a total indicator, which is determined by the genetic potential of the hybrid and the applied agricultural techniques in combination with the weather conditions during the growing season. The analysis of variances shows the independent influence of the studied factors, as well as the interaction between them (Table 1). The independent effect of the researched factors is more pronounced and proven in the formation of productivity and most biometric parameters, while the combined effect being weak and statistically unreliable. Application of mineral and foliar fertilization has the strongest effect on yield. Fertilization (expressed by the sum of the squared deviations relative to the total variation) has the most significant influence on the yields - 96.83% of the total variation in the data results from this factor (Koteva et al., 2014; Kuneva and Bazitov, 2014; Kuneva et al., 2015; Toncheva, 2016; Traykov et al., 2017; Ivanov and Dimitrov, 2018). The absolute mass of the grain, the weight of the grain in one cob are signs that are directly related to productivity. The mass of 1000 grains is one of the most important indirect indicators that characterizes the technological value of the grain and its quality as seed material and gives an idea of its size and protection. The type of hybrid is the factor that affects these indicators more strongly.

Table 1. Anova of investigated factors.

Source of variation Biometric parameters		Fertilization A	Hybrid B	Fert * Hybr A*B
Yield	F	106,122	23,639	0,686
	Sig.	0.000	0.001	0.585
LMC	F	4,91	2,52	1,11
	Sig.	0.032	0.151	0.402
NRC	F	0,733	1.80	0,20
	Sig.	0,561	0.217	0,894
NGC	F	10,299	3,214	0,387
	Sig.	0.004	0.111	0.766
NGR	F	75.00	72.00	1.00
	Sig.	0.000	0.000	0.441
WGC	F	24,106	39,623	2,229
	Sig.	0.000	0.000	0.162
CW	F	36,099	785,638	8,266
	Sig.	0.000	0.000	0.008
M1000	F	35,847	63,104	2,568
	Sig.	0.000	0.000	0.127

Depending on the type and rates of applied fertilization, maize hybrids react differently, resulting in different grain yields and related biometric parameters (Table 2). The combined pairing of soil fertilization with ammonium nitrate and foliar fertilization leads to an increase in productivity (Fert 2, Fert 3 and Fert 4) compared to the variant in which mineral fertilizer was applied alone (Fert 1), and then arranging them into separate, statistically proven groups. The highest grain yield was obtained in Fert 3, with an increase of 21% over Fert 1. A marked improvement was also observed in Fert 2 (by 12.4%) and the smallest one in Fert 4 (by 6.7%). Foliar fertilization increased the number of kernels in a row, the number of kernels per cob and hence the kernel weight per cob and the mass of 1000 kernels. Fertilization had a weaker effect on the biometric parameters length and the number of rows in one cob. Distinguished under the conditions of the experiment, are Fert 3 and Fert 2 variants, with the highest values for all the surveyed indicators being Fert 3, followed by Fert 2, divided into separate, statistically reliable groups. The results obtained from the Fert 1 and Fert 4 variants are found to be similar and fall into one statistical group according to some of the studied biometric indicators.

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Table 2. Means of the indexes according to fertilization.

Ferti-liza-tion	In-dex	Mean	Sign	Index	Mean	Sign	Index	Mean	Sign	Index	Mean	Sign
Fert 1	Yield	644,69	a	LMC	18,25	a	NRC	17,25	a	NGC	555,75	a
Fert 2		724,88	c		20,18	b		17,75	a		641,00	b
Fert 3		780,68	d		20,18	b		17,50	a		651,25	b
Fert 4		687,84	b		19,50	ab		17,25	a		587,00	a
Fert 1	NGR	30,50	a	WGC	175,64	a	CW	241,13	a	M1000	312,88	a
Fert 2		35,75	c		197,86	b		267,56	b		331,36	b
Fert 3		37,25	d		213,18	c		297,98	c		342,75	c
Fert 4		32,50	b		190,72	b		254,40	b		327,99	b

* Values with the same letter do not differ significantly

The performed correlation analysis shows the relationship between the yield produced and the biometric parameters (Table 3). The relationship between the yield and the number of grains (0.795*) and their weight (0.800*) in one cob, as well as the weight of the cob (0.908**) is statistically proven and significant. The absolute mass has a well-expressed positive correlation with the length of the cob (0.767*), the number of grains in the cob (0.871**) and in the row (0.755*). Among biometrics, there was a strong positive statistically proven correlation between the cob length and the number of kernels per cob (0.777*) and in row (0.732*) and between the number of kernels per cob and cob weight (0.765*).

Table 3. Correlations.

Parameters	Yield	LMC	NRC	NGC	NGR	WGC	CW
LMC	0,479						
NRC	-0,175	0,061					
NGC	**0,795***	**0,777***	-0,244				
NGR	-0,014	**0,732***	0,163				
WGC	**0,800***	0,693	-0,127	**0,765***	0,302		
CW	**0,908****	0,228	-0,233	0,629	-0,092	0,692	
M1000	0,594	**0,767***	-0,106	**0,871****	**0,755***	0,624	0,534

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

The indicators that directly testify to the quality of the maize grain and are subjected to express analyzes are moisture, protein, fat and starch (Table 4). The applied foliar fertilization has an effect on the content of protein, starch and fat in the maize grain of the studied hybrids, but it is less pronounced. A probable reason for this is the prolonged drought that occurred in July and August, when the recorded amount of precipitation was minimal - 25.3 l/m². Consequently, the positive effect of the applied foliar fertilizers was not reached to the maximum extent. Nutrient availability, transport and absorption are hindered in the absence of sufficient moisture (Aslam et al., 2013). There is no clear trend for the effect of added foliar fertilizer. Longer studies in this direction are needed (Traykov et al., 2017). The influence of fertilization is more pronounced in the content of protein and starch. According to the amount of protein, the fertilizer variants fall into separate statistical groups. The most protein is contained in the maize grain in the variant Fert 3 (8.443%), followed by Fert 2 (8.137%). The amount of starch was lower in Fert 3 (60.423%) and Fert 2 (60.335%) when compared with the other two fertilizer options. Regarding the fat content, there were no proven differences between the individual variants of the experiment. Similar results were obtained by Koteva and Marcheva (2016), analyzing obtained data on grain yield and its quality characteristics from different maize hybrids grown in a long-term stationary experiment (1986-2011), brought out in the experimental field of the Institute of Agriculture, Carnobat.

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Table 4. Mean values of quality indexes according to fertilization.

Fertilization	Parameter	Mean	Sign	Parameter	Mean	Sign	Parameter	Mean	Sign
Fert 1	Protein	7,973	a	Starch	61,453	b	Fat	3,741	a
Fert 2		8,137	b		60,335	a		3,856	a
Fert 3		8,443	c		60,423	a		3,837	a
Fert 4		7,828	a		61,779	b		3,714	a

* Values with the same letter do not differ significantly

4 Conclusions

The independent act of fertilization has the strongest influence on the yield formation of the DKC 4670 and DKC 5068 HD maize hybrids. The type of hybrid is the factor that more strongly affects the mass of 1000 grains and the weight of the grain in one cob.

The combined pairing of soil and foliar fertilization leads to an increase in productivity and the biometric parameters under study, with the highest values obtained in the variant ammonium nitrate + 250 ml/da NPK 2.5 SO3 + 250 ml/da SO3 with 10% Zn and 3% N (sulfides with zinc and nitrogen).

Using the same combination, the highest amount of protein was found in the investigated maize hybrids.

As a result of the experiment, a general conclusion can be drawn that the combination of sowing soil fertilization with ammonium nitrate (rate of 12 kg/da) and two foliar fertilizers (rate of 250 ml/da) – NPK 2.5 SO3 + SO3 with 10% Zn and 3% N will boost the productivity and improve the quality of the researched Dekalb maize hybrids.

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References

Al-Dulaimi1, O.I., Al-Ani, M. H., Al-Rawi, O. H., Al-Rawi, A. R. & Seadh, S. E. (2021). Response of Some Maize Hybrids to Foliar Spraying Treatments 2- Yield and Components. *IOP Conf. Series: Earth and Environmental Science*, 761 (1), pp. 012071. https://doi.org/10.1088/1755-1315/761/1/012071

Amanullah, Saleem, A., Iqbal, A. & Fahad, S. (2016). Foliar Phosphorus and Zinc Application Improve Growth and Productivity of Maize (*Zea mays* L.) Under Moisture Stress conditions in Semi-Arid Climates. *Journal of Microbial & Biochemical Technology*, 8 (5), pp. 433-439. https://doi.org/10.4172/1948-5948.1000321

Aslam, M., Zamir, M. S. I., Afzal, I., Yaseen, M., Mubeen, M. & Shoaib, A. (2013). Drought stress, its effect on maize production and development of drought tolerance through potassium application. *Cercetări Agronomice în Moldova*, 46 (2), pp. 99-114. Retrieved from https://www.researchgate.net/publication/305471407

https://doi.org/10.29114/ajtuv.vol7.iss1.282
Vol.7 Issue 1 (2023)
Published: 2023-06-30
ISSN 2603-316X (Online)

Brankov, M., Simic, M., Zeljko, D., Rajkovic, M., Mandic, V., & Dragicevic, V. (2020). The Response of Maize Lines to Foliar Fertilizing. *Agriculture*, 10 (9), pp. 365. https://doi.org/10.3390/agriculture10090365

Gerasimova, N. (2013). Effect of postemergence herbicides on yields in maize (*Zea mays* L.). *Scientific works of the University of Ruse*, Volume 52, Series 1.1, pp. 52-56 (Bg). Retrieved from https://www.researchgate.net/publication/356101791

Ivanov, M. & Dimitrov, I. (2018). Influence of some agro-technical factors on the productivity of triple crop rotation in the agro-ecological conditions of the Upper Thracian lowland. *Bulgarian Journal of Crop Science*, 55 (4), pp. 14-23 (Bg). Retrieved from https://cropscience-bg.org/page/bg-topmenu/about.php

Ivanov, M. & Dimitrov, I. (2018). Influence of some agro-technical factors on the productivity of triple crop rotation in the agro-ecological conditions of the Upper Thracian lowland. *Bulgarian Journal of Crop Science*, 55 (4), pp. 14-23 (Bg). Retrieved from https://cropscience-bg.org/page/bg-topmenu/about.php

Jakab, P., David, Z., & Komarek, F. (2017). Investigation of Foliar Fertilization in Maize Production. *Advanced Research in Life Sciences*, 1 (1), pp. 1-6. https://doi.org/10.1515/arls-2017-0001

Karov, St., (ed.). (2004). Basics of organic farming. *Bioselena Foundation*, pp. 50 (Bg). Retrieved from https://orgprints.org/id/eprint/30831/1/Organic_Farming_Bulgaria.pdf

Koteva, V. & Bazitov, R. (2013). Mineral Fertilization Effect's on Common Wheat, Cultivated in Favorable and Risky Climate Conditions. *Bulgarian Journal of Soil Science, Agrochemistry and Ecology*, Vol. XLVII, № 3, pp. 39-46 (Bg). Retrieved from https://soilscience-bg.org/page/en-topmenu/home.php

Koteva, V. & Marcheva, M. (2016). Productivity and Grain Quality of Maize, Cultivated on Pellic Vertisol without Fertilization in South-East Bulgaria. *New Knowledge Journal of Science, Anniversary International Scientific and Applied Conference – UARD, Bulgaria*, pp. 181-187 (Bg). Retrieved from https://science.uard.bg/index.php/newknowledge/index

Koteva, V., Kostadinova, S. & Popova, Yo. (2014). Effectiveness of Mineral Fertilization on Maize for Grain, Cultivated in Pellic Vertisol, FAO in Southeastern Bulgaria in Favorable and Risky Meteorological Conditions. *Bulgarian Journal of Soil Science, Agrochemistry and Ecology*, Vol. XLVIII, № 2, pp. 34-42 (Bg). Retrieved from https://soilscience-bg.org/page/en-topmenu/home.php

Kuneva V. & Bazitov, R. (2014). Influence of fertilization on the level on the structural indexes of maize hybrid LG 35.62. *Scientific works of the University of Ruse*, Volume 53, Series 1.1, pp. 44-47 (Bg). Retrieved from https://conf.uni-ruse.bg/bg/docs/cp14/1.1/1.1-8.pdf

Kuneva V., Kalaidzieva, R., Matev, A., & Kirchev, H. (2015). Evaluation of the Factors Fertilization and Irrigation Regimes on the Yield of Maize Based of Mathematical-Statistical Analysis. *Bulgarian Journal of Crop Science*, 5, pp. 79-83 (Bg). Retrieved from https://www.researchgate.net/publication/286924867

Mikova, A., Alexandrova, P., & Dimitrov, I. (2013). Maize grain yield response to N fertilization, climate and hybrids. *Bulgarian Journal of Agricultural science*, 19 (3), pp. 454-460. Retrieved from https://www.agrojournal.org/19/03-10.pdf

Mitova, I. & Dinev, N. (2017). Agricultural development - Conventional and/or organic? Sustainable. *East-West Publishing House - Sofia*, pp.167 (Bg). Retrieved from https://www.researchgate.net/publication/370389070

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Annual Journal
https://doi.org/10.29114/ajtuv.vol7.iss1.282
Vol.7 Issue 1 (2023)
Published: 2023-06-30
ISSN 2603-316X (Online)

Nikolova, M. (2018). Plant nutrition management - modern approaches. *Plant protection* (Bg), Retrieved from https://www.plant-protection.com/article/902

Nyagorme, D., Amoah A. & Gyapong, T. (2021). Response of maize (*Zea mays* L.) to foliar and soil applied fertilizers in the Semi-deciduous forest zone of Ghana. *African Journal of Agricultural Research*, 17 (8), pp. 1114-1122. https://doi.org/10.5897/ajar2021.15561

Petkova, V., Yusmen, M. & Koleva-Valkova, L. (2014). Effect of Foliar Fertilizers on Young Sunflower and Maize Plants under Nitrogen Deficiency. *Agricultural University – Plovdiv, Scientific Works*, vol. LVIII, pp. 241-248 (Bg). Retrieved from http://nauchnitrudove.au-plovdiv.bg/28

Todorova, S., Trendafilov, K. & Valcheva, V. (2013). Differentiation of fertilization rates with phosphorus and potassium based on geospatial data for their reserves in soil. *Scientific papers series a. agronomy*, vol. LVI, pp. 126-132. Retrieved from https://www.yumpu.com/en/document/view/28043732/scientific-papers-series-a-agronomy

Todorova, S., Simeonova, N., Trendafilov, K. & Valcheva, V. (2012). Change of available forms of nitrogen and phosphorus in alluvial-meadow soil, after long-term fertilization. *Agricultural Science and Technology*, vol. 4, pp. 388-391. Retrieved from https://agriscitech.eu/

Toncheva, R. (2016). Investigation the Productivity of Maize in Different Agroecological Conditions, Fertilization and Plant Density I. Non-Irrigated Conditions. *Bulgarian Journal of Soil Science, Agrochemistry and Ecology*, 50, 2, pp. 50-59 (Bg). Retrieved from https://soilscience-bg.org/page/en-topmenu/home.php

Toungos, M.D., Bamai, N. & Yamma, K.M. (2016). Effects of Combined Application of NPK and Foliar Fertilizer (Boost-Extra) On Yield and Yield Components of Maize (Zea mays L.) In Mubi, Northern Guinea Savannah Zone of Nigeria. *International Journal of Innovative Agriculture & Biology Research*, 4 (3), pp. 17-25. Retrieved from http://www.seahipaj.org/

Traykov, N., Toncheva, R. & Dimitrov, I. (2017). Investigation of the productivity of maize depending on agro-ecological conditions and applied agrotechnics. *Bulgarian Journal of Soil Science, Agrochemistry and Ecology*, 51, 1, pp. 12-24 (Bg). Retrieved from https://soilscience-bg.org/page/en-topmenu/home.php