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Influence of herbicides and foliar fertilizers on the yield, the structural elements of yield and technological qualities of the maize grain

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Abstract

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The field experiment was conducted in the experimental field of the Institute of Maize – Knezha in the period 2016 – 2018. After sowing of maize hybrid Kneja-613 before weed emergence Stomp New 330 EC (330 g/l pendimethalin) was used in a dose of 400 ml/da. In phase 5th leaf of the culture it was treated with Chemnico 24 SC (240 g/l nicosulfuron) at a dose of 21 ml/da. Simultaneously with Chemnico 24 SC were used: Amalgerol – growth stimulator; Microelements for Maize; Vertex H-34 and Foliar Extra – foliar fertilizers. Highest positive effect on grain yield has the system of pendimethalin and nicosulforone, Microelements for Maize and Amalgerol. The average grain yield for the period is 731.73 kg/da and its increase by 14.16% is statistically proven. The system of pendimethalin and nicosulforone at combination with Amalgerol, with Microelements for Maize, with Vertex H-34 or with Foliar Extra increases the protein content to 9.29%, the fat content to 5.61%, and the starch content to 76, 68% of the grain of the Knezha-613 hybrid.

Keywords: maize; herbicides; foliar fertilizers; technological qualities of the grain

Introduction

Maize is of great importance as a forage crop, because regular, sufficient and good quality forage is the basic need of livestock production. In Bulgaria, maize for grain is grown on 560 911 ha with a total yield of 3 990 190 t, and maize for silage and green fodder is grown on 27 500 ha with a total yield of 588 034 t in 2019 (MZH, 2020).

Of the biotic and a-biotic factors causing yield reduction of maize, the weeds and the water and nutrient deficiencies are essential. Weeds are a serious competitor of agricultural crops in terms of certain vegetation factors (Tonev, 2000; Tonev et al., 2019). Weeds losses are higher than other factors including animal pest, fungal and bacterial pathogens and viruses which caused 16%, 18% and 20% yield loss, respectively (Oerke, 2006). Studies by a number of authors show that depending on the type and degree of weeding, corn yield can be reduced from 24% to 96.7%. (Zhalnov & Raikov, 1996; Khan et al., 2003; Oerke & Dehne, 2004; Mukherjee & Puspajit, 2013; Ehsas et al., 2016; Imoloame & Omolaiye, 2016; Jagadish & Prashant, 2016; Dimitrova et al., 2018).

Weed losses in maize can be minimized by applying mechanical, cultural, chemical, biological and integrated weed control methods (Tonev et al., 2010; Bates et al., 2012; Dimitrova et al., 2013; Goranovska & Kalinova, 2014; Hossein et al., 2014; Mehmeti et al., 2014; Isk et al., 2015; Tonev et al., 2016; Imoloame, 2017; Santos et al., 2018; Sarabi et al., 2018; Swetha et al., 2018; Gehring et al., 2018; Mitkov et al., 2018; Bilal et al., 2019; Mitkov et al., 2019; Langdon et al., 2020).

One of the most important measures to increase yields and reduce fluctuations in growth and crop development is a harmonious fertilization with NPK. By increasing the nutrient reserves, the photosynthetically active area of the leaves increas-

es, which leads to an increase in the yield of the crops (Futó, 2003).

Maize is a crop that reacts strongly positively to nitrogen fertilization. Nitrogen, absorbed before flowering stimulates the development of the cob, affecting the number and size of grains. Nitrogen can affect the development and maintenance of leaf area, as well as photosynthetic efficiency (Arduini et al., 2006) and the distribution of dry matter to the reproductive organs (Vouillot & Devienne-Barret, 1999; Prystupa et al., 2004). The grain is the most active acceptor of assimilates of carbon and nitrogen after their synthesis. Detailed studies in recent years have shown that the nitrogen required for grain enlargement comes both from remobilized nitrogen from leaves and stems and from the continuous uptake of nitrogen from the soil (Burzaco et al., 2013; DeBruin et al., 2013; Haegele et al., 2013). Most researchers have found that the importance of nitrogen fertilization lies in optimizing the efficiency of nitrogen use and reducing the negative impact of the weeds (Hellwig et al., 2002; Evans et al., 2003*).*

The moment of nitrogen application and the fertilization scheme are an important factor for the nitrogen nutrition of maize. It was found that fertilization with nitrogen (240 kg N/ha) in the form of NH_4NO_3 according to the scheme 1/3 before sowing, 1/3 in the 5th leaf phase and 1/3 in the early stage of piling significantly increases the weight of the cob, the mass of the grains and the number of grains in a cob. The total yield of maize hybrid P0216 increases from 4 to 8 t/ha (Minev et al., 2017; Minev et al., 2019).

According to Hajebrahimi et al. (2014) increasing nitrogen levels increases maize tolerance to weeds. Furthermore, reducing the nitrogen level before sowing of maize may lead to the need for immediate and long-term weed control.

Gillani et al. (2014) reported that two foliar sprays with micronutrients 15 days after sowing and 30 days after sowing, together with N and P applied to the soil led to an increase of the yield of green fodder to 58.63 t/ha and the amount of crude protein to 9.55% of the studied hybrid maize.

Bencze and Futó (2017) conduct an experiment with 64 nutrient combinations, 4 nitrogen portions (0 kg ha^{-1}, 70 kg ha^{-1}, 140 kg ha^{-1} and 210 kg ha^{-1}), 4 phosphorus portions (0 kg ha^{-1}, 40 $kgha^{-1}$, 80 $kgha^{-1}$ and 120 $kgha^{-1}$) and 4 potassium portions (0 kg ha^{-1}, 60 kg ha^{-1}, 120 kg ha^{-1} and 180 $kgha^{-1}$) in different combinations. It has been found that phosphorus and potassium have effect mainly to the physiological processes of maize. Their effect on the average yield is smaller, as it is based on the interaction of different nutrients. Nitrogen has the greatest effect on yield.

Kalinova et al. (2014) found that the foliar fertilizer Microelements for Maize (ME for maize) applied together with the growth stimulator Amalgerol in doses of 3 l/ha, 4 l/ha and 5 l/ha has highly effective characteristics especially in unfavorable weather conditions during the vegetation period of maize. The combination of soil fertilization in norm of 200 kg N.ha-1 and foliar feeding with the products ME for Maize + Amalgerol increases the grain yield average of 31%, compared to the unfertilized plants from the control variant. The balanced fertilization of maize in norm $N_{200}P_{150}K_{150}$, combined with the foliar product ME for Maize and growth stimulator Amalgerol significantly improves the agronomic efficiency of nitrogen, compared to the variants only with soil fertilization in norms $N_{200}P_{150}K_{150}$ and $N_{300}P_{150}K$. The partial productivity of nitrogen decreases with increasing nitrogen input and its values do not depend on foliar fertilization.

Fertilizers have a different effect on the composition of weed associations. Cheimona et al. (2017) report that there are significant differences between fertilizers in terms of their effect on weed density and species composition. The variety of weeds is highest in the control without fertilizers and is lower in the plots fertilized with N and P. The total dry mass of weeds is lower in plots that are not fertilized and those with phosphorus fertilization, and highest in plots that are fertilized with nitrogen.

Tahir et al. (2012) experimented with foliar application of boron 20 days after the emergence of the maize at 0.0, 0.15, 0.30 and 0.45 kg B/ha. The authors found that the application of B by 0.30 kg/ha increases the height of the plant, leaf area, stem diameter, cob weight, number of cob grains, protein and oil content. The maximum grain yield (7.14 t/ha) and the biological yield (527.4 t /ha) were registered in the variant with application of 0.30 kg/ha of boron, but the further increase of the boron dose reduced the yield.

The purpose of the present study is to trace the influence of herbicides and foliar fertilizers on yield, the structural elements of yield and technological qualities of the grain in maize.

Materials and Methods

The field experiment was conducted in the experimental field of the Institute of Maize – Knezha in the period 2016 – 2018. The experiment is based on the block method, with 9 variants in 4 repetitions per variant. Knezha-613 maize hybrid with a sowing density of 4500 plants/da, grown under non-irrigated conditions, was used. The size of the experimental plot is 50 m^2, and the harvest one – 39.2 m^2. Maize in all experimental variants and economic control was grown in the background – basic fertilization with 20 kg/da NPK. The sowing in all three years of the experiment was carried out in the third ten days of April. The experimental area is kept free of weeds, as in the autumn of the previous year deep plowing

was carried out, and before sowing of maize – two pre-sowing cultivations. After sowing of maize before weed emergence, Stomp New 330 EC (active ingredient 330 g/l pendimethalin) was imported in a dose of 400 ml/da, and in phase 5th leaf of the maize the crop was treated with Chemnico 24 SC (active ingredient 240 g/l nicosulfuron) at a dose of 21 ml/da. The herbicide preparations were applied with a back sprayer at a working solution consumption of 30 l/da. Simultaneously with Chemnico 24 SC were imported: bio-stimulator – Amalgerol; foliar fertilizers – Microelements for Maize (ME for Maize), Vertex H-34 and Foliar Extra.

Three weeks after the vegetation treatment, one inter-row and one intra-row hoeing was performed.

The economic control is maintained free of weeds by hoeing, without use of herbicides. The zero control is without tillage and without use of herbicides.

The grain yield from maize was determined from the harvest plots in 4 repetitions for each variant and was equated to the standard moisture for maize – 14%.

The structural elements of the yield, which determine it as the length of cob, the number of rows in cob, the number of grains in a row, the mass of one cob, the mass of grains in one cob and the mass of 1000 grains were studied.

To determine the structural elements of the yield, ten standard cob from every repeat were used.

To determine the technological qualities of the grain of the hybrid Knezha – 613, average samples were taken from each variant during plowing. The percentage of protein, fat and starch per unit dry matter in the grain is determined on the device "Infralizer 400".

Mathematical data processing was performed by a single-factor dispersion analysis ANOVA, using specialized statistical software Statgraphics Plus package for Windows, Version 2.1.

Results and Discussion

The Microelements for Maize at a dose of 100 ml/da, co-administered with Amalgerol in doses of 300 ml/da, 400 ml/da and 500 ml/da increased grain yields respectively by 10.26%, 12.35% and 14.16%. Data are statistically proven at $GDP_{5\%}$ and $GDP_{1\%}$ (Table 1).

Table 1. Yield of maize after treatment with herbicides and foliar fertilizers, 2016-2018

Variants	Yield of Grain, kg/da 2016	Yield of Grain, kg/da 2017	Yield of Grain, kg/da 2018	Average yield for the period		
				Average yield, kg/da	% compared to the economic control	Proof of the difference
1. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da	568.100	597.284	778.088	668.824	3.62	+
2. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml / da + ME-100 ml / da	590.500	634.828	811.348	678.892	8.58	+
3. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-300 ml/da	585.200	659.100	823.817	689.372	10.26	+
4. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-400 ml/da	598.312	668.016	841.052	702.460	12.35	+
5. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-500 ml/da	602.250	685.672	853.280	713.734	14.16	+ +
6. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da +Vertex H-34 – 300 ml/da	579.300	646.052	794.032	673.128	7.66	+
7. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + Foliar extra-250 ml/da	585.400	674.752	783.742	681.298	8.97	+
8. Control – untreated	111.500	119.752	125.312	118.855	0.19	–
9. Economic control – with hoeing	555.280	585.344	735.042	625.222	–	–
Proof of the differences to economic control	$gDp_{5\%}$ = 33.2 $gDp_{1\%}$ = 48.3 $gDp_{0,1\%}$ = 72.2	$gDp_{5\%}$ = 35.5 $gDp_{1\%}$ = 62.3 $gDp_{0,1\%}$ = 78.4	$gDp_{5\%}$ = 41.1 $gDp_{1\%}$ = 62.2 $gDp_{0,1\%}$ = 82.5	$gDp_{5\%}$ = 42.821 $gDp_{1\%}$ = 75.961 $gDp_{0,1\%}$ = 104.821		

The microelements for Maize at a dose of 100 ml/da increased the grain yield for the study period on average by 8.58% compared to the economic control. Data are statistically proven.

Under experimental conditions, the treatment during the vegetation period of maize with herbicides and a foliar fertilizer Vertex H-34 at a dose of 300 ml/da increases the grain yield of maize average by 7.66%.

The results of the three-year experiment for the influence of the foliar fertilizer Foliar Extra in a dose of 250 ml/da are one-way and show that the increase of the yield compared to the economic control for the period of study is average 8.97%. These data are also statistically proven.

The lowest increase was obtained after treatment only with Stomp nov 330 EC at a dose of 400 ml/ da and Chemnico 24 SK at a dose of 21 ml/da, without the introduction of biostimulant and foliar fertilizers. The increase of yield on average for the study period was 3.62% compared to the economic control and it was proved mathematically at $GDP_{5\%}$.

The highest yield is obtained with the use of Amalgerol at a dose of 500 ml/da + Microelements for Maize at a dose of 100 ml/da. The increase over the study period compared to economic control is average 14.16%.

In order to explain the changes in grain yield, some of its structural elements that determine it have been studied.

The results of the structural analysis of the yield show that the increase in the grain yield is mostly due to the increase in the weight of the cob and the mass of the grain in the cob.

The analysis of the values of the structural elements of the yield for 2016 shows that the largest increase is in weight of cob, grain weight in one cob and weight of 1000 numbers grains.

The highest values of the indicated indicators are established in combination. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-500 ml/da.

The weight of one cob is 303.6 g – 38.1 g more than the economic control. The weight of the grains in the cob is 33.4 g more and the weight of 1000 grains is 12.2 g more.

Table 2. Structure of maize yield after treatment with herbicides and foliar fertilizers – 2016

Variants	Length of cob, cm	Number of rows in a cob	Mass of one cob,g	Mass of grains in a cob, g	Number of grains in one row	Absolute mass, g
1. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da	21.0	16.0	268.3	192.5	45.0	290.0
2. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml / da + ME-100 ml / da	21.5	17.1	275.2	197.0	46.2	301.0
3. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-300 ml/da	21.7	17.3	291.5	225.2	44.1	303.2
4. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-400 ml/da	22.2	17.5	298.0	238.0	45.5	310.3
5. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-500 ml/da	22.5	17.0	303.6	243.5	46.3	315.2
6. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da +Vertex H-34 – 300 ml/da	23.2	16.4	301.0	242.0	45.4	311.3
7. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + Foliar extra-250 ml/da	24.1	16.2	265.5	210.5	46.2	305.0
8. Control – untreated	17.2	11.2	105.0	80.0	35.5	115.0
9. Economic control – with hoeing	20.8	15.8	265.5	210.1	45.1	303.0
Proof of the differences to economic control	$gDp_{5\%}$ = 4.4 $gDp_{1\%}$ = 22.3 $gDp_{0,1\%}$ = 222.8	$gDp_{5\%}$ = 1.3 $gDp_{1\%}$ = 6.4 $gDp_{0,1\%}$ = 63.4	$gDp_{5\%}$ = 10.5 $gDp_{1\%}$ = 24.3 $gDp_{0,1\%}$ = 77.4	$gDp_{5\%}$ = 9.0 $gDp_{1\%}$ = 20.8 $gDp_{0,1\%}$ = 66.4	$gDp_{5\%}$ = 8.9 $gDp_{1\%}$ = 44.6 $gDp_{0,1\%}$ = 445.6	$gDp_{5\%}$ = 7.9 $gDp_{1\%}$ = 18.2 $gDp_{0,1\%}$ = 57.8

The influence of the tested preparations on the indicators cob length, number of rows in the cob and number of grains in a row is less pronounced (Table 2).

Similar results were obtained in 2017, despite differences in climate conditions. The largest increase in the indicators cob weight, grain weight in one cob and weight per 1000 grains was shown by the combination of herbicides + Microelements for Maize at a dose of 100 ml/da + Amalgerol at a dose of 500 ml/da (Table 3).

The data on the structural elements of the yield in 2018 show that the largest increase in cob weight, grain weight of 1 cob and weight of 1000 grains was found after using a mixture of herbicides and a leaf fertilizer Foliar Extra in a dose of 250 ml/da (Table 4).

In conclusion, we can say that the treatment with the bio-stimulant Amalgerol, as well as foliar fertilizers Microelements for Maize, Vertex H-34 and Foliar Extra leads to sustainable yields from the maize hybrid Kneja-613. There is a proportional difference between the values of the yield, the mass of the cob, the mass of the grain in 1 cob and the mass of 1000 grains.

Maize is one of the main cereal crops with high potential for productivity and energy value. In modern technologies for growing crops, one of the innovative possibilities is the use of growth regulators and foliar fertilizers in combination with plant protection products. This is one of the prerequisites for the plants to realize to the maximum extent their biological potential for grain yield and quality. In this regard is the study of the influence of the bio-stimulant Amalgerol and foliar fertilizers Vertex H-34, Foliar Extra and Microelements for Maize on the protein, fat and starch contents in the grain of maize hybrid Knezha-613.

Table 3. Structure of maize yield after treatment with herbicides and foliar fertilizers – 2017

Variants	Length of cob, cm	Number of rows in a cob	Mass of one cob,g	Mass of grains in a cob, g	Number of grains in one row	Absolute mass, g
1. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/da	24.2	16.0	275.9	220.0	49.5	328.0
2. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml / da + ME-100 ml / da	24.8	16.2	280.2	225.2	48.3	333.8
3. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/ da + ME-100 ml/da + Amalgerol-300 ml/da	25.0	16.8	291.1	233.4	49.1	342.2
4. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/ da + ME-100 ml/da + Amalgerol-400 ml/da	25.6	16.4	293.4	235.0	47.4	343.0
5. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/ da + ME-100 ml/da + Amalgerol-500 ml/da	25.7	16.9	295.0	236.8	48.5	351.5
6. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/da +Vertex H-34 – 300 ml/da	24.9	16.5	268.3	205.5	49.3	328.3
7. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/da + Foliar extra-250 ml/da	25.1	16.0	279.0	224.8	49.0	331.4
8. Control – untreated	18.3	11.0	125.0	98.2	22.3	188.2
9. Economic control – with hoeing	24.0	16.0	243.3	208.0	48.1	326.1
Proof of the differences to economic control	$gDp_{5\%}$ = 4.3 $gDp_{1\%}$ = 19.1 $gDp_{0,1\%}$ = 191.0	$gDp_{5\%}$ = 5.1 $gDp_{1\%}$ = 25.5 $gDp_{0,1\%}$ = 254.6	$gDp_{5\%}$ = 9.7 $gDp_{1\%}$ = 16.1 $gDp_{0,1\%}$ = 30.1	$gDp_{5\%}$ = 8.0 $gDp_{1\%}$ = 18.4 $gDp_{0,1\%}$ = 58.5	$gDp_{5\%}$ = 5.1 $gDp_{1\%}$ = 25.5 $gDp_{0,1\%}$ = 63.7	$gDp_{5\%}$ = 8.2 $gDp_{1\%}$ = 19.0 $gDp_{0,1\%}$ = 60.4

Table 4. Structure of maize yield after treatment with herbicides and foliar fertilizers – 2018

Variants	Length of cob, cm	Number of rows in a cob	Mass of one cob,g	Mass of grains in a cob, g	Number of grains in one row	Absolute mass, g
1. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da	24.4	16.0	285.0	228.0	48.1	310.0
2. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml / da + ME-100 ml / da	25.0	16.8	290.0	237.0	48.7	321.0
3. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-300 ml/da	26.4	16.2	296.2	239.3	48.8	325.2
4. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-400 ml/da	26.3	16.6	301.5	241.2	49.3	331.0
5. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-500 ml/da	26.3	17.1	303.1	242.1	49.2	333.1
6. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/da +Vertex H-34 – 300 ml/da	25.6	17.4	345.5	276.4	44.3	368.5
7. Stomp New 330 EC-400 ml/ da + Chemnico 24 SK-21 ml/da + Foliar extra-250 ml/da	25.6	17.2	349.2	280.0	49.2	375.0
8. Control – untreated	18.0	13.4	182.8	146.0	25.7	220.8
9. Economic control – with hoeing	24.0	16.0	283.2	227.0	49.4	320.9
Proof of the differences to economic control	$gDp_{5\%}$ = 5.1 $gDp_{1\%}$ = 25.5 $gDp_{0,1\%}$ = 254.6	$gDp_{5\%}$ = 5.1 $gDp_{1\%}$ = 25.5 $gDp_{0,1\%}$ = 254.6	$gDp_{5\%}$ = 7.0 $gDp_{1\%}$ = 16.1 $gDp_{0,1\%}$ = 51.2	$gDp_{5\%}$ = 18.7 $gDp_{1\%}$ = 93.6 $gDp_{0,1\%}$ = 935.8	$gDp_{5\%}$ = 5.1 $gDp_{1\%}$ = 25.5 $gDp_{0,1\%}$ = 254.7	$gDp_{5\%}$ = 10.0 $gDp_{1\%}$ = 16.7 $gDp_{0,1\%}$ = 31.2

Table. 5. Qualitative characteristics of maize grain after treatment with herbicides and foliar fertilizers (average for 2016-2018)

Variants	Protein	Fat	Starch
	% in unit dry matter	% in unit dry matter	% in unit dry matter
1. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da	9.06	5.38	74.30
2. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml / da + ME-100 ml / da	9.08	5.43	76.64
3. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-300 ml/da	9.09	5.47	76.52
4. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-400 ml/da	9.01	5.45	74.68
5. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + ME-100 ml/da + Amalgerol-500 ml/da	9.29	5.49	74.97
6. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da +Vertex H-34 – 300 ml/da	9.00	5.55	75.30
7. Stomp New 330 EC-400 ml/da + Chemnico 24 SK-21 ml/da + Foliar extra-250 ml/da	9.24	5.61	76.68
8. Control – untreated	8.44	5.18	72.28
9. Economic control – with hoeing	9.02	5.35	74.25

The analysis of the data on the influence of herbicides, growth regulator and foliar fertilizers on the content of protein, fat and starch in the grain of the studied hybrid shows that in all three years of research it is one-way, therefore the results for the chemical composition of the grain are presented on average for the period 2016-2018 (Table 5).

The percentage of protein per unit dry matter in the grain in the untreated control is 8.44%. In the variant of herbicides, Microelements for Maize at a dose of 100 ml/da and Amalgerol at a dose of 500 ml/da it is 9.29%. The protein in the economic control is 9.02%

The percentage of fat per unit dry matter in the combined treatment variants is higher than the economic control.

Starch varies from 62.28% in the untreated control to 76.64% in the combination of herbicides + Microelements for Maize (variant 2). The starch content in the economic control is 74.25%.

In conclusion, the effect of the combined use of plant protection products, growth stimulants and foliar fertilizers on the chemical composition of maize grain is indirect and less pronounced. Despite this fact, the inclusion of new methods and tools in the technological process of growing the maize is a prerequisite for optimizing the conditions for growth, development and productivity of the crop, as well as for improving the nutritional value of the grain.

Conclusions

The system of pendimethalin and nicosulforone, Microelements for Maize and Amalgerol has the highest positive effect on the yield of maize. The average grain yield for the period is 731.73 kg/da and its increase by 14.16% is statistically proven. A directly proportional relationship was found between the yield, the weight of the cob, the mass of the grain in 1 cob and the mass of 1000 grains in all variants with herbicides, growth regulator and foliar fertilizers.

The system of the soil herbicide pendimethalin and the vegetation one nicosulforone, applied in combination with Amalgerol, with Microelements for Maize, with Vertex H-34 or with Foliar Extra increases the protein content to 9.29%, fat to 5.61%, and starch up to 76.68% of the grain of the hybrid Knezha-613. The combined use of herbicides, bio-stimulant and foliar fertilizers has a positive effect on the chemical composition of the grain of the maize hybrid Knezha-613, which determines its higher nutritional value.

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