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INFLUENCE OF SOME FOLIAR TREATMENT PRODUCTS ON PRODUCTIVITY IN CORIANDER VARIETIES (*Coriandrum sativum* L.)

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Abstract

The field experiment was carried out in 2020 and 2021 crop years on alluvial-meadow soils, on the land of the village of Voivodinovo - central-south Bulgaria. The experiment was set by the method of fraction parcels in four repetitions, with size of the crop parcel - 15 m^2, after a precrop - wheat. Three leaf treatment products were examined in the relevant doses: Grow Plant Gel Energy 20-8-60 + 2% MgO + amino acids and algae extract - 25 l/ha; Fulvin 40-22-80 l/ha; Isabion - 30 l/ha and were compared with an untreated control. The tested products were applied in the stage - budding of five coriander varieties: Jantar, Moroccan, Mesten drebnoploden, Thüringen and Marino. The present research work aims at examining the reaction of coriander varieties with relation to the applied leaf treatment products and their influence on the indicators productivity and seed yield. The obtained results showed that the examined leaf treatment products have a positive effect on seed yield, as well as on productivity elements of the following coriander varieties - Jantar, Moroccan, Mesten drebnoploden, Thüringen and Marino.Compared to the control, all varieties treated with Isabion preparation /30 l/ha/ registered the highest seed yield. Seed yield grew from 8.3 to 13.4 % during the crop years. The increase of seed yields after the application of Isabion - 30 l/ha was due to the higher values of the indicators number of seeds and weight of seeds per plant. The leaf treatment products applied on the coriander varieties increase the values of the indicator number of seeds from 11.3 to 18.6%, and weight of seeds from 5.1 to 21.4%, compared to the control.

Key words*: coriander, variety, foliar fertilizer, productivity, seed yield.*

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is one of the most significant spices and aromatic crops in the world. It is an annual plant, belonging to the Umbelliferae family and mainly cultivated for its seeds.

In order to increase coriander seed yield and the content of etheric oil, as well as to overcome some abiotic stress factors, the incorporation of agro-technical and agro-chemical actions is crucially important, which include the use of leaf treatment products, such as growth regulators, bio-stimulators, retardants, bacterial preparations, vitamins and organic substances.

These products stimulate the biological potential of the coriander and have influence on growth rate with better absorption of nutrients. (Sahu et al., 2014). As a result, it has been registered higher values of the indicators productivity and seed yield compared with the control (Aishwath et al., 2012; Mishra et al., 2017; Haokip et al., 2016; Panda et al., 2007; Singh et al., 2012; Singh et al., 2017; Verma & Sen, 2008). According to Saxena et al. (2014), the efficacy of applying leaf treatment products is determined not only by the variety, but also by the climatic conditions during the vegetation stage. A study has been carried out in Russia and has established the influence of three bio-stimulants (Nagro, Agat - 25 K and Extrasol) on the productivity of two coriander varieties (Jantar and Alekseevski 190). It also has shown that both varieties react strongly toward the used products. The highest seed yield has been obtained with the application of Nagro preparation, which has exceeded the control variants of two varieties averagely with 19% (Vinogradov et al., 2018).

A study conducted in Bulgaria has been related to establishing some biologically active substances. It has been proven that these substances have positive influence on coriander and seed yield with increasing it averagely with 11.6% (Hristova and Nenkova, 2012). Other research studies have reported for the increase of seed yield from 7,4 to 16% (Kolev et al.,

2005; Petrova and Delibaltova, 2018). The study has been carried out in the region of South-eastern Bulgaria and its purpose has been to examine the influence of the biological substance Humustim on coriander. It has showed that the product, enriched in microorganisms, favours plant growth and increases stem height, the number of umbels and the weight of seeds compared to the control. As a result, the increase of seed yield has been established averagely for three years from 5 to 15% (Gramatikov and Koteva, 2006). Results from these studies have registered that coriander reacts positively to the used leaf treatment products. It gives the opportunity for subsequent studies related to that culture. It is necessary to examine the new leaf treatment products launched on the market and to fix these preparations appropriate for coriander cultivation.

The present research work aims at examining the reaction of coriander varieties with relation to the applied leaf treatment products and their influence on the indicators productivity and seed yield.

MATERIALS AND METHODS

The field experiment was carried out in 2020 and 2021 crop years on alluvial-meadow soils, on the land of the village of Voivodinovo - central-south Bulgaria. The experiment was set by the method of fraction parcels in four repetitions, with size of the crop parcel - 15 m^2, after a precrop - wheat. Three leaf treatment products were examined in the relevant doses: Grow Plant Gel Energy 20-8-60 + 2% MgO + amino acids and algae extract - 25 l/ha; Fulvin 40-22 - 80 l/ha; Isabion - 30 l/ha and were compared with an untreated control. The tested products were applied in the stage - budding of five coriander varieties: Jantar, Moroccan, Mesten drebnoploden, Thüringen and Marino.

The experiment was performed by an adopted technology of cultivation. Soil treatment included ploughing-in of the stubble in June and tilling in depth 20-22 cm in September, two-time pre-planting cultivation with harrowing in depth 5-6 cm (Dallev and Ivanov, 2015). The phosphoric fertilizer was applied before tilling -80 kg/ha, and the nitrogen fertilizer - with the last pre-planting treatment - 10 kg/ha.

Sowing was performed annually in the period 10-20 February at a distance between rows - 12-15 cm and planting norm - 250 seeds per m^2 on depth of 3-4 cm.

The following indicators were reported: seed yield, plant height, number of umbels per plant, number of seeds per plant and seed weight per plant.

In order to establish the quantitative dependences between the examined indicators, the experimental data were processed mathematically by the method of the dispersion analysis/Anova/. The differences between variants were established by means of Dunkan`s multiple range test.

The meteorological factors during the vegetation period of coriander have influence on plant`s growth and productivity (Dyulgerov and Dyulgerova, 2016). Figure 1 and 2 show data for the amount of precipitations, as well as the monthly average air temperatures in the period February 2020 - July 2021. According to the results, the average daily air temperature in both crop years had slightly higher values than those for the multi-year period. It completely met the requirements of coriander with regard to heat from germination stage to ripening stage. Significant deviances from the crop requirements were not observed. Differences between both experimental years were related to the precipitation supply during the vegetation period. During the crop years 2020 and 2021 the precipitation amount was 347,7 and 351,0 mm, correspondingly, which exceeded with 55,7 and 59,0 mm the registered results for the period 1961-1990.

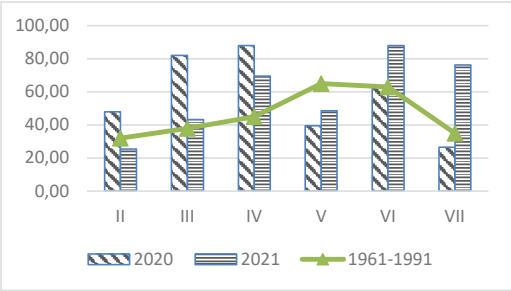

Figure1. Rainfall, mm

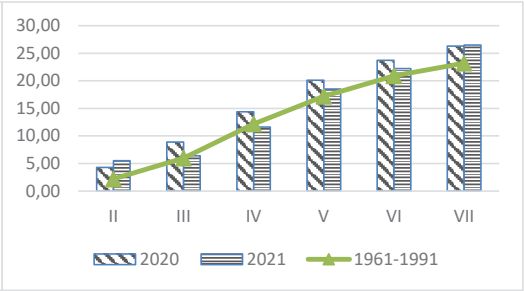

Figure 2. Average monthly air temperature, ^{0}C

In budding and flowering stages the precipitation sum was 39.5 mm in 2020, and 48.5 in 2021. It was about 25.5 and 16.5 mm less than the sum for a multi-year period, which accelerates the stages` course and influences the productivity. During the fruit-formation and ripening stages (June-July) there were fewer precipitations in 2020, while in 2021 they were about 52 mm more than the registered precipitation for the period 1961-1990. In this period plants are very sensitive toward moisture. Insufficient moisture leads to the formation of small seeds with low mass and lower yields (Dyulgerov and Dyulgerova, 2016). Taking into account both experimental years, 2021 was more favorable for the coriander because of more even distribution of precipitations and sufficient moisture supply in plants during the critical stages.

RESULTS AND DISCUSSIONS

More favourable climatic factors and particularly equable distribution of precipitations during coriander vegetation were observed in the crop year 2021 compared to 2020. It was a prerequisite for the obtainment of higher seed yields from the examined varieties.

The applied leaf treatment products influenced positively the values of this indicator for all tested varieties. Compared to the control, the highest yield was reported with the variant treated with Isabion - 30 l/ha (Table 1).

Table 1. Yield seeds kg/ha

Years of study	Treatment products	Cultivars				
		Jantar	Moroccan	Mesten drebnoploden	Thüringen	Marino
2020	Control	1446 [a]	2119 [a]	2034 [a]	1680 [a]	1623 [a]
	Grow Energy 20-8-60	1488 [b]	2235 [b]	2172 [b]	1779 [b]	1728 [b]
	Fulvin 40-22	1500 [b]	2240 [b]	2194 [c]	1770 [b]	1700 [b]
	Isabion	1578 [c]	2380 [c]	2251 [d]	1820 [c]	1782 [c]
2021	Control	1525 [a]	2209 [a]	2141 [a]	1768 [a]	1712 [a]
	Grow Energy 20-8-60	1589 [b]	2346 [b]	2268 [b]	1825 [b]	1810 [b]
	Fulvin 40-22	1617 [c]	2355 [b]	2286 [c]	1839 [c]	1835 [c]
	Isabion	1658 [d]	2505 [c]	2390 [d]	1951 [d]	1876 [d]

With relation to the untreated variants, yield rise was from 8.3 to 12.3% and from 8.7 to 13.4% for the examined varieties in 2020 and 2021, correspondingly. The received results were statistically proven. Moroccan variety reacted to most extent to the applied product Isabion - 30 l/ha. Yield grew from 261 kg/ha in the crop year 2020 to 296 kg/ha in 2021.

It was followed by Mesten drebnoploden variety, which grew from 217 and 249 kg/ha, and Thüringen variety with a yield 140-180 kg/ha higher than the control. Jantar variety reacted most weakly to the applied product Isabion.

Compared to the control, its yield increased during both years within the bounds from 8,7 to

9.1%. The applied preparations Grow Plant Gel Energy 20-8-60 + 2% MgO + amino acids and algae extract – 25 l/ha and Fulvin 40-22 - 80 l/ha contributed for the increase of seed yield from 3,0 to 7,0% in comparison with the control variants. The two-factor dispersion analysis statistically proved the strong influence of the varieties and the leaf treatment products on seed yield. Furthermore, the correlation between both factors was mathematically proven (Table 2).

Table 2. Two-way ANOVA analysis of the yield of seeds

Years of study	Source of Variation	Sum of Square (SS)	df	Mean Square (MS)	F	P-value	F crit
2020	Treatment products	315627.6	3	105209.2	145.8429	0.00*	2.758078
	Cultivars	6464557	4	1616139	2240.321	0.00*	2.525215
	Interactions	42920.67	12	3576.723	4,958116	0.00*	1.917396
2021	Treatment products	404204.1	3	134734.7	583.3093	0.00*	2.758078
	Cultivars	6663563	4	1665891	7212.169	0.00*	2.525215
	Interactions	42011.85	12	3500.988	15.15688	0.00*	1.917396

*F-test significant at P<0.05; ns non-significan

The received results related to the height of the examined varieties and the applied leaf treatment products showed that this indicator varied from 53,7 to 94,0 cm in the crop year 2020 and from 57,7 to 95,1 cm in 2021 (Table 3).

Table 3. Height of plants

Years of study	Treatment products	Cultivars				
		Jantar	Moroccan	Mesten drebnoploden	Thüringen	Marino
2020	Control	55.9 [a]	66.0 [a]	82.0 [a]	73.6 [b]	65,4 [a]
	Grow Energy 20-8-60	63.1 [b]	78.2 [b]	88.8 [b]	76.2 [c]	71.7 [c]
	Fulvin 40-22	53.7 [a]	76.2 [b]	94.0 [c]	62.7 [a]	75.6 [d]
	Isabion	63.3 [b]	81.8 [c]	90.6 [b]	64.5 [a]	69.6 [b]
2021	Control	60.1 [a]	70.4 [a]	84.1 [a]	74.2 [b]	70.3 [a]
	Grow Energy 20-8-60	64.8 [b]	80.8 [b]	89.6 [b]	77.2 [c]	79.8 [c]
	Fulvin 40-22	57.7 [a]	81.5 [b]	95.1 [c]	70.6 [a]	78.4 [c]
	Isabion	65.0 [b]	84.4 [b]	91.9 [b]	71.2 [a]	74.2 [b]

With relation to Moroccan, Mesten drebnoploden, and Marino varieties, all treated variants had higher values than the untreated ones. The use of Fulvin 40-22 - 80 l/ha and Isabion - 30 l/ha with Thüringen variety led to the decrease of plant height compared to the control. Using Fulvin 40-22 - 80 l/ha with Mesten drebnoploden and Marino varieties plant height in the end of vegetation stage was bigger with 13% - 15%, and with 19.8% - 23,9% for Moroccan variety treated with Isabion - 30 l/ha compared to the control.

Results from the dispersion analysis showed significant influence of the examined factors on plant height. The correlation between the leaf treatment products and the variety was also proven (Table 4).

Table 4. Two-way ANOVA analysis of the height of plants

Years of study	Source of Variation	Sum of Square (SS)	Df	Mean Square (MS)	F	P-value	F crit
2020	Treatment products	1145.034	3	381.6781	29.81967	0.00*	2.758078
	Cultivars	8875.974	4	2218.993	173.3651	0.00*	2.525215
	Interactions	2580.521	12	215.0434	16.80087	0.00*	1.917396
2021	Treatment products	1238.715	3	412.905	176.6753	0.00*	2.758078
	Cultivars	7832.884	4	1958.221	837.891	0.00*	2.525215
	Interactions	1238.524	12	103.2103	44.16202	0.00*	1.917396

*F-test significant at P<0.05; ns non-significan

The more favorable climatic factors in 2021 were a prerequisite for the formation of more umbels per plant with comparison to 2020 (Figures 3 and 4).

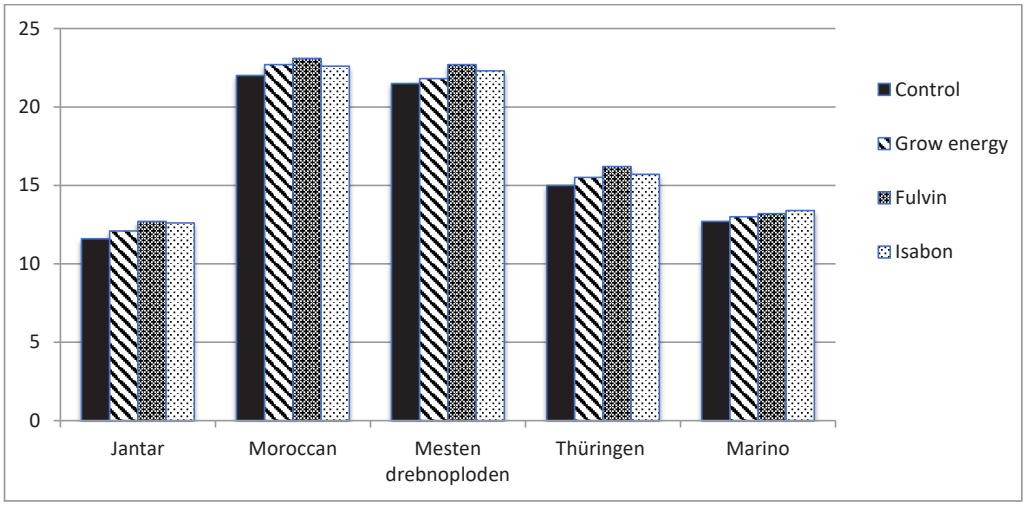

Figure 3. Number umbels per plant in 2020

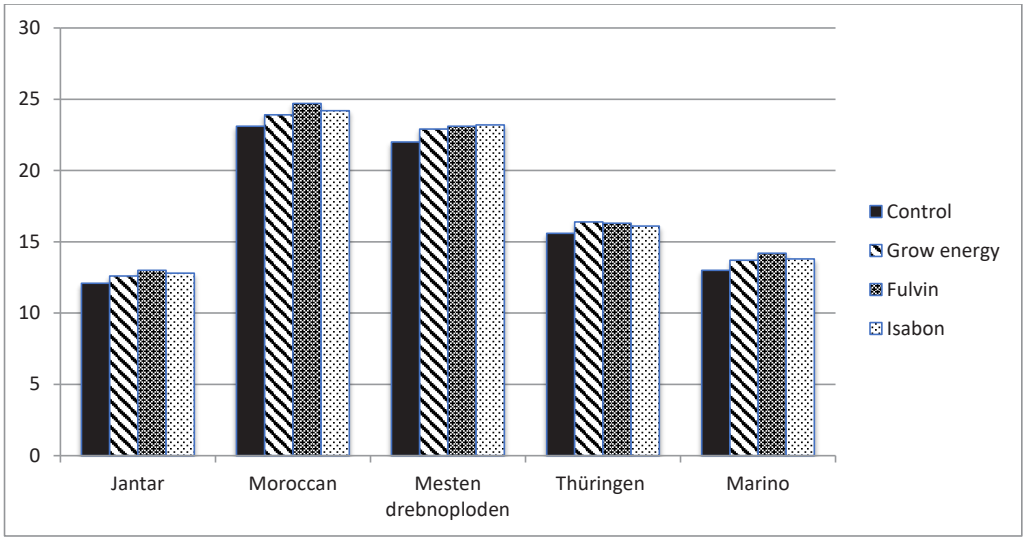

Figure 4. Number umbels per plant in 2021

The highest values of this indicator were registered for Moroccan variety treated with Fulvin 40-22 - 80 l/ha - 23.1 and 24.2 numbers. It exceeded the control with 5.0% and 6.9% for 2020 and 2021, correspondingly. Jantar variety had the fewest number of umbels - 11.6 and 12.1 numbers for the control to 12.7 and 13.0 numbers after the application of Fulvin 40-22 - 80 l/ha.

The use of this leaf product facilitated the increase of the number of umbels per plant for Mesten drebnoploden variety - to 5.6%, for Thüringen - to 8.0%, and for Marino - to 9.2%. The dispersion analysis registered statistically proven influence of the factors, and not proven influence of their interaction (Table 5).

Table 5. Two-way ANOVA analysis of the number of umbels per plant

Years of study	Source of Variation	Sum of Square (SS)	df	Mean Square (MS)	F	P-value	F crit
2020	Treatment products	9.965375	3	3.321792	10.00163	0.00*	2.758078
	Cultivars	1539.113	4	384.7783	1158.535	0.00*	2.525215
	Interactions	2.96275	12	0.246896	0.743382	0.70 ns	1.917396
2021	Treatment products	16.25937	3	5.419792	3.423837	0.02*	2.758078
	Cultivars	1852.974	4	463.2436	292.6442	0.00*	2.525215
	Interactions	16.67375	12	1.389479	0.877774	0.57 ns	1.917396

*F-test significant at P<0.05; ns non-significan

Data related to the number of seeds per plant showed that the applied leaf treatment products increased the values of this indicator during the crop years from 15.5% to 18.6% for Moroccan, and from 13.3% to 15.2% for Mesten drebnoploden compared to the control. Increase up to 14.1%, 12.7% and 11.3% was reported for Marino, Jantar and Thüringen varieties, correspondingly (Table 6).

Table 6. Number of seeds per plant

Years of study	Treatment products	Cultivars				
		Jantar	Moroccan	Mesten drebnoploden	Thüringen	Marino
2020	Control	109 a	273 a	250 a	220 a	156 a
	Grow Energy 20-8-60	118 b	288 b	270 b	232 b	160 b
	Fulvin 40-22	117 b	300 c	265 b	228 b	170 c
	Isabion	121 c	324 d	288 c	248 c	178 d
2021	Control	120 a	289 a	271 a	229 a	162 a
	Grow Energy 20-8-60	126 b	297 b	284 b	232 b	171 b
	Fulvin 40-22	129 b	311 b	294 b	237 b	178 b
	Isabion	135 c	334 c	307 c	256 c	182 c

For all varieties it was statistically proven that the applied leaf treatment products exceeded the control. The number of seeds was reported with highest values with all variants treated with Isabion - 30 l/ha, followed by those treated with Fulvin 40-22 - 80 l/ha and Grow Plant Gel Energy 20-8-60 + 2% MgO + amino acids and algae extract - 25 l/ha. The dispersion analysis showed statistically proven influence on the examined variants, as well as on the varieties along with their specific genetic features. The interaction between Variant and Variety was unproven (Table 7).

Table 7. Two-way ANOVA analysis of number of seeds per plant

Years of study	Source of Variation	Sum of Square (SS)	df	Mean Square (MS)	F	P-value	F crit
2020	Treatment products	9137.85	3	3045.95	12.57964	0.00*	2.758078
	Cultivars	359372.8	4	89843.21	371.0485	0.00*	2.525215
	Interactions	4325.275	12	360.4396	1.4886	0.15^{ns}	1.917396
2021	Treatment products	8518.25	3	2839.417	10.14681	0.00*	2.758078
	Cultivars	363546.8	4	90886.71	324.7887	0.00*	2.525215
	Interactions	3554.875	12	296.2396	1.058629	0.41 ^{ns}	1.917396

*F-test significant at P<0.05; ns non-significan

An important indicator affecting coriander yield is the mass of seeds per plant. The studied varieties treated with leaf products formed seeds with different weight (Table 8).

Table 8. Seed weight per plant

Years of study	Treatment products	Cultivars				
		Jantar	Moroccan	Mesten drebnoploden	Thüringen	Marino
2020	Control	0.61 ^{a}	1.18 ^{a}	1.07 ^{a}	0.97 ^{a}	0.70 ^{a}
	Grow Energy 20-8-60	0.66 ^{b}	1.24 ^{b}	1.10 ^{b}	1.11 ^{b}	0.74 ^{b}
	Fulvin 40-22	0.70 ^{b}	1.37 ^{c}	1.27 ^{c}	1.06 ^{b}	0.82 ^{c}
	Isabon	0.68 ^{b}	1.42 ^{c}	1.30 ^{c}	1.13 ^{b}	0.74 ^{b}
2021	Control	0.66 ^{a}	1.24 ^{a}	1.13 ^{a}	1.05 ^{a}	0.74 ^{a}
	Grow Energy 20-8-60	0.71 ^{b}	1.31 ^{b}	1.19 ^{b}	1.13 ^{b}	0.78 ^{b}
	Fulvin 40-22	0.73 ^{b}	1.39 ^{c}	1.29 ^{c}	1.11 ^{b}	0.81 ^{b}
	Isabon	0.79 ^{c}	1.45 ^{d}	1.34 $^{c\,d}$	1.17 ^{c}	0.89 ^{c}

The lowest values of this indicator were registered with the control variants of the studied varieties. In 2020 the increase of seed mass varied from 8.1% to 14.7%; from 5.1% to 20.3%; from 2.8% to 21.4%; from 9.2% to 16.5% and from 5.7% to 17.0%, while in 2021 it was within the bounds of 7.6%-19.6%; 5.6%-16.9%; 5.3%-18.5%; 7.6%-11.4% and 5.4%-20.2% for Jantar, Moroccan, Mesten drebnoploden, Thüringen and Marino, correspondingly.

This indicator had the highest values after the application of Isabion - 30 l/ha, and in the experimental years they were averagely up to 21,7% compared to the control.

Dispersion analysis results related to the influence of factors and their interaction on the indicator weight of seeds per plant showed clear reliability with relation to the alternation of the indicator (Table 9).

Table 9. Two-way ANOVA analysis of the yield of seeds

Years of study	Source of Variation	Sum of Square (SS)	df	Mean Square (MS)	F	P-value	F crit
2020	Treatment products	0.278845	3	0.092948	31.40146	0.00*	2.758078
	Cultivars	4.985013	4	1.246253	421.0315	0.00*	2.525215
	Interactions	0.128618	12	0.010718	3.620988	0.00*	1.917396
2021	Treatment products	0.31813	3	0.106043	22.93242	0.00*	2.758078
2021	Cultivars	5.055608	4	1.263902	273.3253	0.00*	2.525215
	Interactions	0.096733	12	0.008061	1.743242	0.08 ^{ns}	1.917396

*F-test significant at P<0.05; ns non-significan

The interaction between both factors was statistically proven for 2020, and it was not proven for 2021.

CONCLUSIONS

The examined leaf treatment products have a positive effect on seed yield, as well as on productivity elements of the following coriander varieties - Jantar, Moroccan, Mesten drebnoploden, Thüringen and Marino.

Compared to the control, all varieties treated with Isabion preparation /30 l/ha/ registered the highest seed yield. Seed yield grew from 8.3% to 13.4% during the crop years. The increase of seed yields after the application of Isabion - 30 l/ha was due to the higher values of the indicators number of seeds and weight of seeds per plant. The leaf treatment products applied on the coriander varieties increase the values of the indicator number of seeds from 11.3% to 18.6%, and weight of seeds from 5.1% to 21,4%, compared to the control. All treated variants of Moroccan, Mesten drebnoploden, and Marino varieties formed higher plants than the untreated variants. Taking into account Thüringen variety, the use of the products Fulvin 40-22 - 80 l/ha and Isabion - 30 l/ha led to decrease in the values of this indicator compared to the control.

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