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EFFECT OF GROWTH REGULATORS ON THE STRUCTURAL ELEMENTS AND YIELD OF COMMON VETCH (*VICIA SATIVA* L.).

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Abstract

The aim of the present study was to determine the effect of some exogenously applied growth regulators on the grain yield and its structural elements in common vetch (*Vicia sativa* L.). For achieving it, a three-year field trial was carried out in the period 2008-2010 in the Training-and-Experimental Fields of the Agricultural University – Plovdiv. The experiment was conducted with two Bulgarian common vetch cultivars – Dobrudzha and Obrazets 666, in four replications, the size of the experimental plot being 10 m^2. Foliar treatment with the growth regulators RENI and RENI D and the three commercial products – Bormax, Manganese chelate and Molybdenite, was performed in the stage of budding. The results of the three-year experiment clearly show the effect of RENI, RENI D and Bormax on the structural elements of the yield and on the amount of grain harvested from the two common vetch cultivars.

Keywords: common vetch, growth regulators, grain and legume crops.

INTRODUCTION

Common vetch was the major grass forage crop in our country until 1960, after which the planted areas started to decrease. The reduction of the areas was due to a certain extent of replacing the crop with some higher yielding leguminous forage crops, such as forage peas, alfalfa, etc., but also to its underestimation by the specialists and producers.

The renewed interest in the forage crop in the recent years is based on the need for annual highly plastic forage crops and on the current economic and market conditions.

Extensive studies have been carried out on the effect of different synthetic substances and combinations between them, applied as growth regulators, on the productivity and quality in different peas and vetch cultivars. The following characteristics were studied: stimulating seed germination (Ivanova et al., 2001); root-formation and stem elongation (Sekerka and Sutoris, 1985; Kaur-Sawhney et al., 1986; Wasilewska et al., 1987; Yaxley et al., 2001; Elkoca and Kantar, 2006; Bora and Sarma, 2006); increasing the grain yield (Sanghavi et al., 1980; Triaphathi and Mmithlesh Kumar, 2006; Elkoca and Kantar, 2006; Yadav et al., 2008); increasing the resistance to unfavourable environmental factors (Jia Wen Sua et al.,1996; Upreti et al., 2000; Zdunek and Lips, 2001).

The many-year research showed that RENI products increased the yields of a number of crops, especially in adverse weather conditions (Popov et al., 2011). Directly influencing the activity of various enzyme systems related to nitrogen metabolism (Popov and Georgieva, 2009), RENI preparations affect nitrate reduction and nitrogen fixation and indirectly they have a positive effect on a number of physiological processes, such as photosynthesis, water exchange, etc. (Popov, 1999; Popov et al., 2010; Popov et al., 2010).

When applied at the phenological stage of vetch budding, RENI affects the growth rate and leads to an increase in yield by 17%, in crude protein by 8-9%, reduction of anti-nutrients by 40-50% and of tannins by 14,5-18,6% (Kertikov, 2005).

According to Massoud et al. (2004), the application of Zn and Mo during pea vegetation increased the values of the yield elements – the number of pods per plant, seeds per pod and weight of 1000 seeds, while in other experiments treatment with Mo, B and Zn did not show a significant change in the grain yield (Nasreen and Farid, 2003).

In their study, Rabbani et al. (2005) reported that adding molybdenum to nitrogen and phosphorus significantly increased the number of nodules per plant, the total dry weight, the number of pods per plant, the number of seeds per pod, the weight of 1000 seeds, the green biomass yield and green and mature grain yield in peas. Similar results of the yield elements were reported in the experiment with pea seeds after their preliminary inoculation with Mo, with the difference that in the

latter case the use of Mo did not significantly affect the number of nodules per plant (Brkič et al., 2004).

A number of authors announced for the positive effect of the growth regulators on the processes of flower fertilization, prevention of flower abortion, pod retention and increased grain yield in spring legumes (Nam and Zayakin, 2001; Garcia Martinez and Varbonell, 1980; Nickel, 1982; Ozga et al., 2003; Prusinski and Borowska, 2001).

The cited literature shows that there are data reflecting the effect of some synthetic regulators on the yield and quality of grain in legumes, without studying the mechanism of their stimulating action. More detailed and comprehensive data can be found about the exogenous application of synthetic regulators with hormonal action on growth, development, yield and quality in peas and vetch. However, there is a lack of information related to the use of various trace elements, which are additionally and purposefully combined with agents having some biochemical and physiological effect, such as synthetic regulators of various types, cofactors and activators of a number of biological nitrogen fixation enzymes, major metabolites, etc.

MATERIAL AND METHODS

A field trial was carried out to establish the effect of RENI, applied separately and in a combination with boron, as well as the commercial products Bormax, Manganese Chelate and Molybdenite, on the productivity of two common vetch cultivars. The experiment was based on the split-plot method in four replications, the size of the experimental plot being 10 m^2.

The cultivars were treated at the budding stage with the following preparations: RENI – 0,5%; RENI D – 0,5%; Manganese chelate – 0,4%; Molybdenite – 0,2%; Bormax – 0,4%.

Soil Analysis

Mineral nitrogen (ammonium and nitrate) by extraction with 1% KCl was applied. The amount of mobile phosphates was determined by the Egner-Reim method. Absorbable potassium was determined after extraction with 2N HCl acid. Soil reaction (pH) was measured potentiometrically in aqueous extract.

Plant Analysis

Biometric measurements of 20 randomly selected plants from each variant and a replication in the stage of 70% fruit ripening were performed every year for studying the morphological characteristics.

The following indicators were reported:

- Plant height/Stem length (cm) – by measuring the plants from the soil surface to the top.
- Number of productive nodes – the number of nodes bearing pods was reported.
- Number of pods per plant – all the pods formed by a plant.
- Number of seeds per plant – the total number of seeds from the whole plant was reported.
- Weight of the seeds per plant (g) – the sum of the weight of seeds from all the pods in a plant.

Grain yield (kg/ha) – reported in full maturity stage of vetch, after mowing each plot for drying and subsequent threshing with Wintersteiger plot combine harvester for experimental purposes, then weighing the amount of grain for each variant separately.

Common vetch cultivars used

Common vetch of cultivar Obrazets 666. The cultivar was developed by Prof. M. Pehlivanov and tested by the State Varietal Testing system for biological and economic qualities in 1970-1973 and for distinctness, uniformity and stability – in 2001-2002. The cultivar has a rapid development rate, early flowering and matures before summer droughts. The absolute seed weight is 80-100 g and the hectolitre weight – 80-85 kg. The average yield is 2326 kg/ha.

Common vetch, cultivar Dobrudzha. Established at Dobrudzha Agricultural Institute in General Toshevo. Tested by the State Varietal Testing system for biological and economic qualities in 2001-2002 and for distinctness, uniformity and stability – in 2002-2003. The vegetation period is 81 days on average. The height of the first pod is 33 cm. The cultivar is susceptible to lodging, as is the standard cultivar. The weight of 1000 seeds is 62,99 g. The hectoliter weight varies from 76,9 to 85 kg. The protein content is 31,37% of the absolute dry matter on average. It is moderately resistant to ascochitosis and resistant to powdery mildew and rust.

Growth regulators used

RENI – RENI products are combinations of molybdenum, manganese and magnesium ions in different concentrations and ratios, which are additionally and purposefully combined with agents with a biochemical and physiological action, such as trace elements, synthetic regulators of cytokinin type, basic metabolites, etc. **RENI-D** contains the

main elements of RENI products with B (boron) added.

Manganese chelate is a foliar fertilizer for fertigation, hydroponics and foliar application in manganese deficiency. It is applied at a concentration of 0,2 – 0,4% solution. Its application can be combined with foliar nutrition with an aqueous solution of urea. In the present study Mn was in a chelated form (EDTA), which is easily absorbed by plants.

Molybdenite is a foliar fertilizer for fertigation, hydroponics and foliar application in crops with high molybdenum requirements: potatoes, cabbage, broccoli, beans, peas, tomatoes. Leaf application is at a concentration of 0,1 – 0,2%.

Bormax is a foliar fertilizer for all the crops with high requirements for boron – maize, beets, fruit, potatoes, legumes, vegetables and flowers. Foliar application is at a concentration 0,3 – 0,4% and the application rate is 1 l/ha.

Soil and Climatic Characteristics

The soil in the experimental fields of the Agricultural University – Plovdiv is alluvial-meadow. In terms of geographical location, the area belongs to the Thracian-Strandzha region, the first sub-region. Alluvial-meadow soils are developed on sandy-clayey and sandy-gravel Quaternary sediments. According to FAO international classification, they refer to Mollic Fluvisols. They are formed on alluvial deposits and have a well-formed humus-accumulative horizon, which gradually passes into the C horizon. Deep in the soil-forming materials (below 100 cm), a charred layer is found – profile A-C-G. The humus content is usually not high – no more than 1-2%.

- NH_4^+ – 14,00, mg/1000g
- NO_3^- - 16,80, mg/1000g
- Total nitrogen – 30,80 mg/1000g
- P_2O_5 – 22,0, mg/100g
- K_2O – 36,0, mg/100g
- CaO – 20,63 mgeq/100g
- MgO – 5,18 mgeq/100g
- MnO4 – 210,0 mg/1000g
- pH (H_2O) – 7,83.

Those data show that the soil has a weak alkaline reaction, poorly stocked with N and well-stocked with P_2O_5 and K_2O. Exchangeable calcium (CaO) and magnesium (MgO) are in amounts, typical of the soil type. The total amount of MnO_4 was also determined, defining the soil as well-stocked with that element. However, due to the alkaline soil type, its mobility and accessibility to plants is poor.

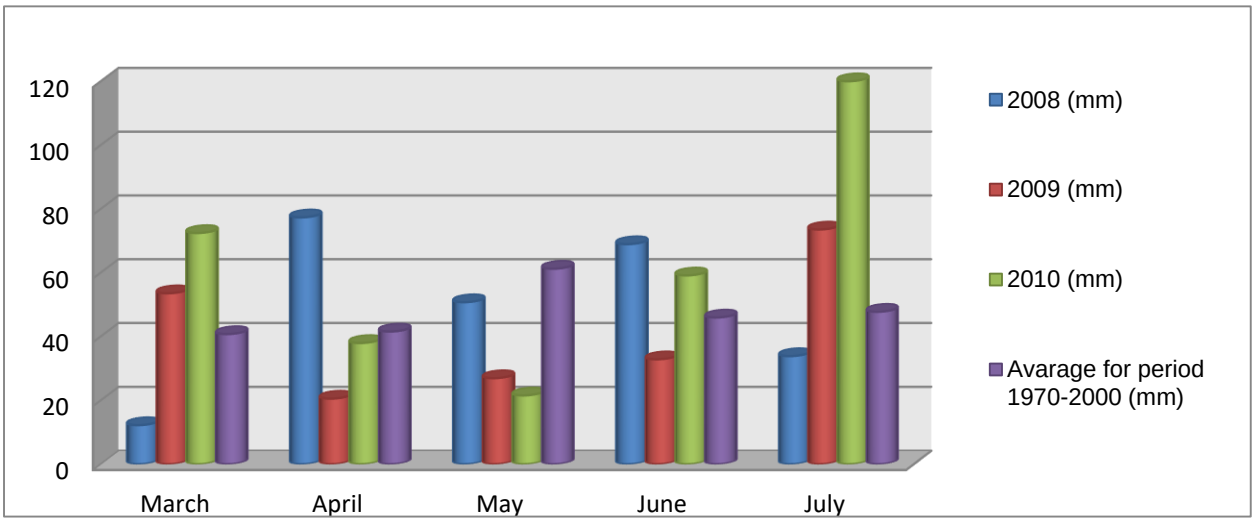

Fig. 1. Amount of monthly precipitation (mm) during vetch vegetation

In the first year of the field trial with common vetch (2008), thanks to the moisture accumulated in the soil during the rainy year 2007, there were favourable conditions for the normal germination and timely emergence of the vetch plants of both studied cultivars(Fig. 1).

The favourable combination of the climatic factors – abundant initial moisture, enough rainfall in the critical stages of vetch development and optimal conditions for ripening and harvesting of the grain, contributed to obtaining almost record grain yields in the first experimental year 2008, approaching the productive potential of the crop.

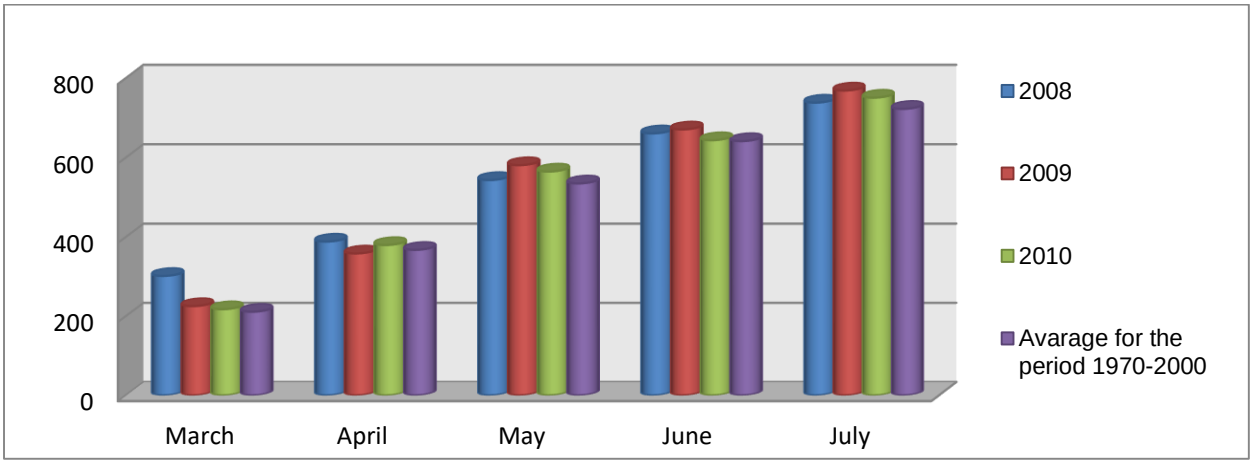

Fig. 2. Average monthly air temperatures (°C) during the vegetation period of vetch

The second vegetation season of common vetch (2009) was characterized by precipitation below the climatic norm with a moisture deficit of almost 30 mm (Fig. 1). The drought spell during the key months of common vetch vegetation led to a significant reduction in grain yields in that experimental year. The temperature sum for the season was 2604.4 ° C, which was 5,1% higher than the long-term average (2477.7 ° C). The highest average temperatures were reported in May, which had a significant adverse effect on pod formation and grain filling in both vetch cultivars (Fig. 2).

The amount of precipitation in the last year of the experiment (2010) was 310,9 mm, which was 31,2% (73,9 mm) above the values of the climatic norm (Fig. 1), defining the year as wet. The amount of precipitation during that vegetation season exceeded the average for the 30-year period by 31,2% (73,9 mm). However, the rainfall distribution by months was relatively unfavourable. The last vegetation was characterized by humid March, June and July and in the last month the amount of precipitation was 151,6% (72,3 mm) above the climatic norm. That hindered seed ripening and harvesting. The months of April and May, when the most active vegetation processes take place, were relatively dry – with a moisture deficit of 8,7% and 64,9% below the average values for the 30-year period (1971-2000). The temperature sum in 2010 was close to the climatic norm, slightly exceeding it by 3,2% (Fig. 2). A more significant increase compared to the average temperatures was observed only in April, when they were 30 ° C above the long-term average.

Statistical analysis

To compare the difference between the variables, ANOVA test has been made. The LSD (Least Significant Difference) calculates the smallest significant between two variables.

RESULTS AND DISCUSSION

Stem Length

During the wet spring of 2008, in the period of vetch growth and development, the monthly amount of precipitation was close to and above the normal. The average stem length in Dobrudzha cultivar reached from 110,4 cm in the variant treated with RENI D to 126,3 cm in the variant with RENI, the differences being statistically significant. In the second and third experimental years, the longest stems were formed after treatment with Bormax and RENI D, the effect of Bormax being statistically significant (Tabl. 1).

The favourable climatic conditions (humidity and warm weather) in the experimental year 2008 led to the formation of longer stems in Obrazets 666 in all the studied variants. In 2009 the months of April and May were characterized by precipitation below the climatic norm, which explains the shorter stem length during that experimental season. The wet spring of 2010 also facilitated the formation of plants of a higher habitus compared to the previous season, but the dry April slowed down their further intensive growth and the values were lower compared to the first year of the experiment (2008).

Treatment of the cultivar with growth regulators had a positive effect on the stem length in all the studied variants. Bormax had the most pronounced and statistically significant effect on the values of that characteristic during the three years of the study. Although insignificant, RENI D and RENI also had a positive effect on stem length.

Dobrudzha cultivar responded with an increased stem length in all the variants of the experiment. In that cultivar, the longest stems were

formed after treatment with Bormax – 87,2 cm, RENI – 85,8 cm and RENI D – 83,4 cm, exceeding the value of the untreated plants by 9,3%; 7,5% and 4,5%, respectively.

Table 1. Stem length of vetch cultivars Dobrudzha and Obrazets 666, cm for the period 2008-2010

Variants	Stem length – cm		
	2008	2009	2010
Dobrudzha			
Control	119,0^{bc}	48,9^{b}	70,7^{d}
RENI	126,3^{a}	52,2^{ab}	79,0^{bc}
RENI D	110,4^{c}	53,4^{ab}	86,3^{ab}
Bormax	117,0^{abc}	55,1^{a}	89,4^{a}
Mn chelate	122,8^{ab}	49,5^{ab}	74,8^{cd}
Molybdenite	115,4^{bc}	50,4^{ab}	78,9^{bc}
LSD 5%	*11,870*	*6,453*	*8,847*
Obrazets 666			
Control	111,0^{bc}	49,5^{a}	60,9^{d}
RENI	104,5^{c}	54,1^{a}	71,5^{a}
RENI D	118,8^{a}	53,9^{a}	66,7^{c}
Bormax	114,5^{ab}	53,9^{a}	67,4^{bc}
Mn chelate	97,5^{d}	52,3^{a}	70,4^{ab}
Molybdenite	105,0^{c}	51,1^{a}	69,9^{abc}
LSD 5%	*7,638*	*7,721*	*3,844*

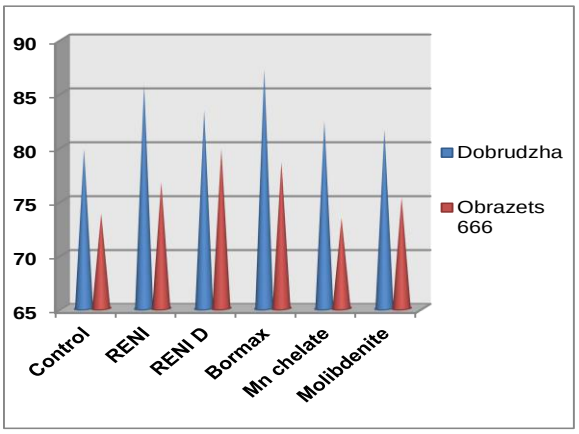

Fig. 3. Stem length on average for the three-year period 2008-2010 (cm)

The average three-year data of the stem length in Obrazets 666 cv. show that the growth regulators RENI D and Bormax had the highest stimulating effect. In the variants with their application the stem length of the vetch plants was 79,8 cm and 78,6 cm, exceeding the control values by 8,1% and 6,5%, respectively.

Number of productive nodes

The analysis of the results shows that no varietal difference was observed in terms of the values of that characteristic.

In 2008 the number of the productive nodes in Dobrudzha cv.varied from 3,4 for the plants from the control variant to 4,8 in the plants treated with RENI, while in Obrazets 666 cv., the largest number of productive nodes was formed after treatment with RENI D. Due to the more unfavourable climatic conditions (high temperatures and lower air humidity) in the experimental 2009, the number of the productive nodes was twice less than in the other two years.

The analysis of the average three-year data for that characteristic shows the positive impact of the applied products.

Dobrudzha cultivar shows the best results after treatment with RENI D, RENI and Bormax. The reported number of productive nodes in those variants was 3,7, which is 27,6% above the values in the control (Fig. 4).

The same tendency was observed in Obrazets 666 – the strongest effect was obtained in the variants treated with RENI D and Bormax, in which the number of the production nodes was 4,0 and 3,8 or 29,0% and 22,6% more than in the control variant. The application of Mn chelate and Molybdenite had a slight effect on the number of productive nodes in that cultivar (Fig. 4).

Foliar application of the growth regulators RENI D, RENI and Bormax in the stage of budding to beginning of flowering was an effective measure in terms of the formation and setting of productive nodes on the vetch stem, which had a positive effect on grain yield in both studied cultivars.

Number of pods per plant

Pod formation is a process that directly correlates with the grain yield in cereal and leguminous crops.

The results obtained (Tabl. 2) show the strong effect of the applied growth regulators on the number of pods in both cultivars of common vetch, their impact being more pronounced in Dobrudzha than in Obrazets 666.

During the first vegetation (2008) both cultivars formed the largest number of pods per plant after treatment with Bormax – Dobrudzha cv. formed 14,6 pods and Obrazets 666 –13,8. The results obtained in 2010 experimental year were similar. In 2009 the pods were twice less than in the other two years – from 4,7 (Control) to 6,7 (treatment with RENI D) in Dobrudzha and from 5,3 (treatment with Mn chelate) to 7,1 (treatment with RENI E) in Obrazets 666.

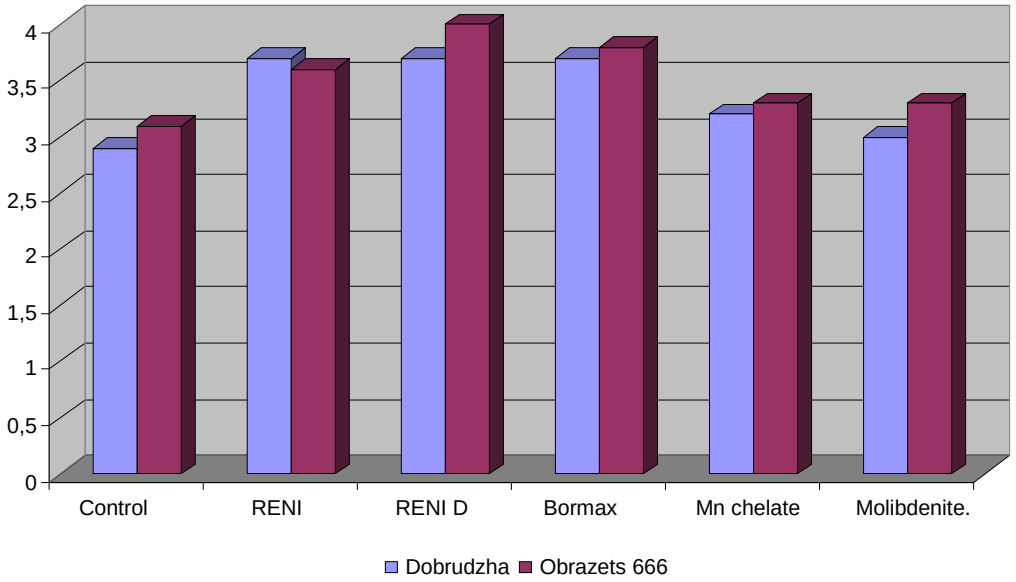

Fig. 4. Number of productive nodes in common vetch, Dobrudzha and Obrazets 666 cultivars, on average for the three years of the study

The results obtained after treatment with Bormax (in the first and third year of the experiment) and RENI D (in the second and third year) show a high degree of statistical significance compared to the untreated variant in Dobrudzha cultivar. The application of RENI growth regulator led to a significant difference with the control only in the first experimental year.

Table 2. Number of pods per plant in vetch of Dobrudzha and Obrazets 666 cvs. by years and on average for the period 2008-2010

Variants	Number of pods per plant		
	2008	2009	2010
Dobrudzha			
Control	9,3^{d}	4,7^{d}	10,0^{c}
RENI	14,3^{a}	6,6^{ab}	13,0^{b}
RENI D	11,5^{b}	6,7^{a}	18,0^{a}
Bormax	14,6^{a}	6,3^{ab}	16,4^{a}
Mn chelate	10,8^{bc}	5,9^{bc}	12,6^{b}
Molybdenite	9,9^{cd}	5,2^{cd}	12,0^{b}
LSD 5%	*1,347*	*1,090*	*2,391*
Obrazets 666			
Control	8,6^{c}	5,6^{c}	11,4^{a}
RENI	12,5^{a}	6,5^{ab}	12,0^{a}
RENI D	13,6^{a}	7,1^{a}	12,5^{a}
Bormax	13,8^{a}	6,4^{b}	13,3^{a}
Mn chelate	9,0^{c}	5,3^{c}	12,5^{a}
Molybdenite	10,3^{b}	5,4^{c}	12,3^{a}
LSD 5%	*1,514*	*0,294*	*2,224*

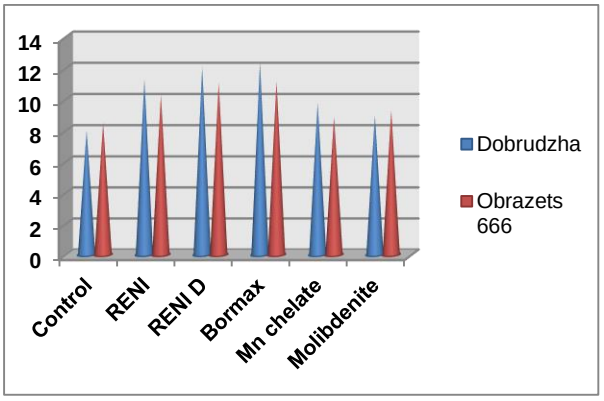

Fig.5. Number of pods per plant on average for the three-year period (2008-2010)

Dobrudzha responded strongly to the products introduced in the stage of budding to beginning of flowering. The average values for the three years of study showed that Bormax-treated plants formed an average of 12,4 pods, exceeding the control by 55,0%. After applying the products RENI D and RENI, an average of 12,1 and 11,3 pods per plant were formed, i.e. 51,3% and 41,3% more than in the untreated variant. Mn chelate and Molybdenite also had a positive effect, although to a lesser degree. In those variants the number of pods per plant was 9,8 and 9,0, which was 22,5% and 12,5% more than in the control.

Obrazets 666 also responded to the application of growth regulators, although to a lesser extent. In that cultivar the strongest effect on that yield element was also reported after the

application of Bormax and RENI D – 11,2 and 11,1 pods per plant, respectively, exceeding the results in the control variant by 31,8% and 30,6%, followed by the variant with treatment with the main composition of RENI (Fig. 5).

Number of seeds per plant

Table 3 presents the values of the two studied cultivars by years. In the experimental year 2010 the plants of the two cultivars had the highest number of seeds after treatment with Bormax – 85,8 in Dobrudzha cultivar and 69,9 in Obrazets 666. The results in the experimental year 2008 were close, while in the dry and warm 2009 the vetch plants formed a significantly smaller number of seeds in all the studied variants – from 21,8 (Control) to 35,7 (RENI D) in Dobrudzha and from 25,1 (Mn chelate) to 33,4 (RENY D) in Obrazets 666.

The statistical analysis of the results for Dobrudzha cultivar shows statistically significant effect of the boron-containing products Bormax (2008 and 2010) and RENI D (2009 and 2010). The results obtained after treatment with those two growth regulators were statistically significant in Obrazets 666 for the three years of the study.

Table 3. Number of seeds per plant in common vetch of Dobrudzha and Obrazets 666 cvs. by years and on average for the period 2008-2010

Variants	Number of seeds per plant		
	2008	**2009**	**2010**
Dobrudzha			
Control	44,6^{d}	21,8^{d}	50,2^{c}
RENI	66,9^{b}	32,0^{b}	63,2^{b}
RENI D	52,5^{c}	35,7^{a}	82,7^{a}
Bormax	76,0^{a}	30,9^{bc}	85,8^{a}
Mn chelate	51,7^{c}	28,1^{c}	62,8^{b}
Molybdenite	45,2^{d}	23,7^{d}	59,7^{b}
LSD 5%	*5,906*	*4,409*	*4,342*
Obrazets 666			
Control	43,7^{c}	27,4^{b}	58,9^{b}
RENI	60,8^{b}	30,6^{a}	63,9^{ab}
RENI D	77,4^{a}	33,4^{a}	65,6^{ab}
Bormax	81,3^{a}	31,9^{a}	69,9^{a}
Mn chelate	44,3^{c}	25,1^{b}	66,2^{ab}
Molybdenite	46,1^{c}	25,3^{b}	65,3^{ab}
LSD 5%	*9,199*	*3,386*	*11,387*

Dobrudzha cultivar showed a relatively stronger response to the effect of the applied products in comparison with the other studied cultivar. The largest number of seeds were formed by the plants of Dobrudzha cv., treated with Bormax and RENI D – 64,2 and 57,0 seeds per plant, exceeding the values in the untreated control by 65,0% and 46,5%. RENI also showed a relatively high effect. The number of seeds also increased with the application of Mn chelate and Molybdenite, although to a lesser extent. Those growth regulators contributed to the formation of 47,5 and 42,9 seeds per plant on average, or 22,1% and 10,3% more than the control.

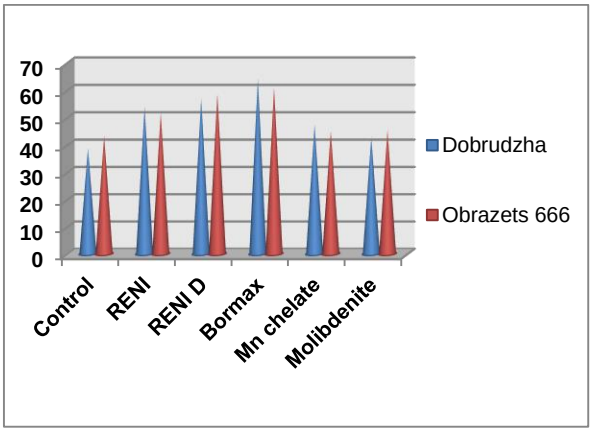

Fig.6. Number of seeds per plant on average for the three-year period (2008-2010)

Similar dependences were found in the other cultivar Obrazets 666. The application of the boron-containing products had a significant effect. After foliar treatment with Bormax and RENI D, an average of 61,0 and 58,8 seeds per plant were formed, which exceeded the control by 40,9% and 35,8%, respectively. The effect of Mn chelate and Molybdenite on the studied structural element of the yield was insignificant (Fig. 6).

Seed weight per plant

The data in Table 4 show that the highest seed weight was obtained in the experimental years 2010 and 2008, which was a result of the favourable climatic factors during the vetch vegetation season.

In Dobrudzha cultivar, the products Bormax and RENI D had the strongest effect on the studied characteristic, the differences to the control being highly significant in all three years of the study.

Table 4. Seed weight the per plant in common vetch of Dobrudzha and Obrazets 666 cvs, by years and on average for the period 2008-2010, g

Variants	Seed weight per plant		
	2008	2009	2010
Dobrudzha			
Control	2,55^{b}	1,16^{c}	2,36^{d}
RENI	3,91^{a}	1,58^{b}	2,71^{c}
RENI D	3,00^{b}	1,81^{a}	4,00^{a}
Bormax	4,07^{a}	1,56^{b}	3,99^{a}
Mn chelate	2,87^{b}	1,40^{b}	3,35^{b}
Molybdenite	2,49^{b}	1,10^{c}	2,69^{c}
LSD 5%	*0.861*	*0.278*	*0.301*
Obrazets 666			
Control	2,41^{c}	1,39^{b}	3,10^{b}
RENI	3,37^{b}	1,56^{a}	3,10^{b}
RENI D	4,23^{a}	1,62^{a}	3,51^{a}
Bormax	4,27^{a}	1,60^{a}	3,65^{a}
Mn chelate	2,54^{c}	1,18^{c}	3,41^{ab}
Molybdenite	2,68^{c}	1,25^{bc}	3,12^{b}
LSD 5%	*0.486*	*0.195*	*0.442*

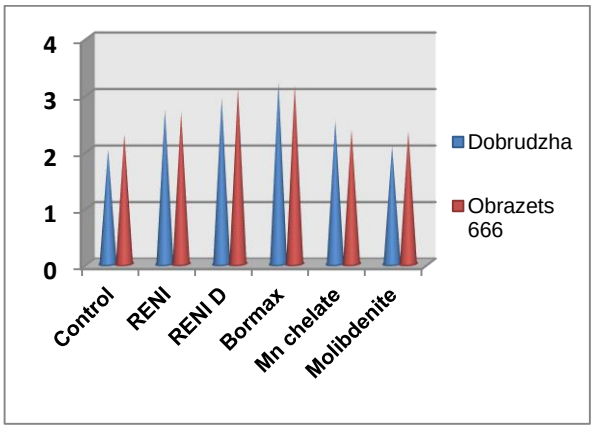

Fig.7. Seed weight per plant on average for the three-year period (2008-2010)

The average three-year data for Dobrudzha cultivar show that after treatment with Bormax, the weight of the seeds per plant was 3,21 g, exceeding the control by 58,9%. The application of RENI D also significantly affected the values of that structural element – the seeds per plant were 45,5% heavier than the seeds in the untreated control. Although lower, but significant differences were reported in the variants treated with RENI and Mn chelate, in which the weight of the seeds was 2,73 g and 2,54 g, respectively.

In Obrazets 666 the application of the growth regulators Bormax and RENI D also led to an increase in seed weight. The seeds of the plants treated with those products were 3,17 g and 3,12 g in weight, exceeding those in the control by 37,8% and 35,7%, respectively. The effect of RENI was significantly lower. The application of Mn chelate and Molybdenite did not result in a change in the seed weight per plant in that cultivar (Fig. 7).

Grain yield

The best results in Dobrudzha cultivar in 2008 were obtained after treatment with Bormax – 2088 kg/ha and RENI – 1938 kg/ha, exceeding the control by 344 kg/ha and 194 kg/ha (Table 5). The differences to the untreated variant were statistically significant.

In Obrazets 666, which appears to be higher yielding than Dobrudzha, similar results for the grain production values were reported.

The highest grain yield (2213 kg/ha) was obtained after treatment with Bormax, the difference to the control variant being significant. Relatively high yields, although statistically insignificant, were reported in the variants treated with RENI – 2083 kg/ha, i.e. 178 kg/ha more than the control (Tabl. 5).

The second year of the experiment (2009) was characterized by dry April, May and June, when the deficit of precipitation was 49,6% (-21,0 mm), 46,1% (-34,3 mm) and 79,5 % (-79,5 mm). That resulted in a negative effect on the grain yield values in both common vetch cultivars, the yields being twice lower than in the previous year. In Dobrudzha cv. the highest yields in that year were obtained after treatment with RENI D – 990 kg/ha. In the second studied cultivar (Obrazets 666), the results also varied greatly – from 928 kg/ha (treatment with Molybdenite) to 1157 kg/ha (treatment with RENI D), but the differences were statistically insignificant.

The results obtained during the third experimental year occupied an intermediate position compared to the previous two in terms of grain yields. In terms of climatic conditions the year was characterized as wet, but rainfall was unevenly distributed by months. March was extremely humid, April was characterized by normal rainfall, while May and June were dry. The lowest grain yields (945 kg/ha) were obtained from the untreated variant, and the highest (1157 kg/ha) in the variant treated with Bormax, the differences being statistically significant. There was a slight increase in yield after treatment with Mn chelate (Table 5).

In Obrazets 666, the tendency of better performance in terms of productivity was maintained in the third year of the experiment too, but the grain yield was not significantly influenced by the treatment with the studied products.

Table 5. Grain yield by years and on average for the period 2008-2010, kg/ha

Variants	2008		2009		2010		Average	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Dobrudzha								
Control	1744^{b}	100,0	808^{b}	100,0	945^{c}	100,0	1167	100,0
RENI	1938^{a}	111,1	826^{b}	102,2	953^{c}	100,8	1239	106,2
RENI D	1777^{b}	101,9	990^{a}	122,5	1140^{a}	120,6	1302	111,6
Bormax	2088^{a}	119,7	898^{ab}	111,1	1157^{a}	122,4	1381	118,3
Mn chelate	1838^{b}	105,4	913^{ab}	113,0	1109^{ab}	117,4	1287	110,3
Molybdenite	1694^{b}	97,1	685^{c}	84,8	1051^{b}	111,2	1143	97,9
LSD5%	*186,24*		*130,53*		*88,88*			
Obrazets 666								
Control	1905^{bc}	100,0	1045^{abc}	100,0	1271^{a}	100,0	1407	100,0
RENI	2083^{ab}	109,3	1120^{a}	107,2	1307^{a}	102,8	1503	106,8
RENI D	2007^{b}	105,4	1157^{a}	110,7	1301^{a}	102,4	1488	105,8
Bormax	2213^{a}	116,2	1099^{ab}	105,2	1282^{a}	100,9	1531	108,8
Mn chelate	1913^{bc}	100,4	976^{bc}	93,4	1279^{a}	100,6	1389	98,7
Molybdenite	1738^{c}	91,2	928^{c}	88,8	1278^{a}	100,6	1315	93,5
LSD5%	*226,22*		*151,64*		*73,20*			

The introduction of growth regulators in the stage of budding to beginning of flowering had a distinct effect in the two studied cultivars of common vetch, Dobrudzha cultivar responding more strongly to their application compared to the higher-yielding cultivar Obrazets 666.

The analysis of the results of the three-year study shows a clear effect of the boron-containing products Bormax and RENI D on the grain yield in both cultivars, which is due to the higher values of the number of pods, the number of seeds and the seed weight per plant, reported when evaluating the structural elements of the yield in those two variants (Tables 2, 3 and 4).

The highest average values of grain yield from Dobrudzha cv. were obtained after treatment with Bormax (1381 kg/ha) and RENI D (1302 kg/ha), exceeding the control by 214 kg/ha and 135 kg/ha, respectively.

Bormax and RENI had the most pronounced stimulating effect on the grain yield in Obrazets 666 cv. The yields obtained after treatment with those products were 1531 kg/ha and 1503 kg/ha, respectively, exceeding the control by 124 kg/ha and 96 kg/ha. According to the data obtained for that cultivar, it can be assumed that the higher the yield of a cultivar, the weaker the effect of exogenously applied stimulators.

CONCLUSIONS

The growth regulators RENI D and Bormax had the highest stimulating effect on the stem length in common vetch. Stem length of the plants in those variants was 79,8 cm and 78,6 cm, exceeding the control by 8,1% and 6,5%, respectively.

Foliar application of the growth regulators RENI D, RENI and Bormax in the stage of budding to beginning of flowering is an effective measure in terms of the formation and setting of productive nodes in the vetch stem, resulting in a positive effect on grain yield in both studied cultivars.

The largest number of pods per plant in both cultivars was found after treatment with the boron-containing products Bormax and RENI D, due to the positive effect of boron on the processes related to the setting and formation of the reproductive organs.

The application of the boron-containing

growth regulators Bormax and RENI D led to a statistically significant increase in the number of seeds in the two studied cultivars throughout the experimental period, which is associated with the larger number of the developed productive nodes and pods in those variants.

The treatment of the two common vetch cultivars with the products Bormax and RENI D, applied at the stage of budding and beginning of flowering, resulted in a significant increase in the seed weight per plant, which also affected positively the yield obtained.

The application of the boron-containing products Bormax and RENI D had the greatest effect on the grain yield in both common vetch cultivars, which is related to the pronounced increase of the values of the structural elements of the yield in those two variants.

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