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PRODUCTIVITY AND QUALITY PARAMETERS ON PERSPECTIVE ALFALFA VARIETIES IN SANDY SOIL CONDITIONS

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Abstract

The investigation was performed in the 2016-2018 period, near Plovdiv, Bulgaria by the block method in 4 replications in 10 m^2 lots in a sandy soil conditions. The aim of the research is to study productivity and quality parameters of native (Prista 3) and Dorine -yellow Jacket Rhizobium coated alfalfa varieties (new technology of adding high levels of effective Rhizobia, embedded in a protective polymer matrix, together with a nutrient booster containing all essential minerals and trace elements). The two varieties were treated with growth regulators (Tekamin Max, Fertigrain Foliar and Tekamin Brix) to help plant development under the sandy soil conditions. The results show better protein value, higher carbohydrate and cellulose content and higher green mass yield in all treated variants. Dorine significantly exceeds the values obtained at Prista 3.

Key words*: alfalfa, growth regulators, quality, yield.*

INTRODUCTION

Alfalfa yield formation is complicated process due to the interaction of plants with agro-climatic and soil conditions. For different alfalfa varieties it also depends to a large extent on the values of the productive components - plant height, number of stems per m^2, stem weight, leaf weight, stalk/leaf ratio, etc. which is found in a number of studies (Kertikova & Yancheva, 2000; Yancheva et al., 2001; Johnson et al., 2007; Petkova et al., 2007; Popovic et al., 2007)

The green mass and hay yield also depends on the yield components as plant height, stem thickness, number of shoots per unit area, weight of shoots from one plant, etc., which also change their values under the influence of various factors (Ventorini et al., 2010).

Alfalfa green mass yield is in positive correlation with the leaf surface of a plant. This is because the leaves represent 30-60% of the total fodder yield (Foutz et al., 1976; Hart et al., 1978; Sheaffer et al., 1980; Volonec et al., 1987). Different types of fertilization also have a serious influence on crop yield. The timely application and the appropriate combinations of elements can significantly enhance yield and also the quality of the production (Aguilar et al., 2012; Al-Juhaimi et al., 2014). A positive influence on crop yield can be also influenced by using various organic fertilizers and manure (Aguilar et al., 2012; Al-Juhaimi et al., 2014).

With great importance for symbiotic nitrogen fixation are Rhizobium tuberculous bacteria living in symbiosis with bean plants. On average, these bacteria fix from 0 to 50 kg N/da for a year (Kimmenov, 1994; Russelle et al., 2008). In poor (sandy) soils, nitrogen fixation is poor, and the aplication of these bacteria into the seeds is of particular importance for the regular development of the plants, allowing to achieve results tipical of rich soils.

Using coated seeds, together with the seeds in the soil can be applied variety of elements as pine, molybdenum and cobalt, which have a significant influence on the nutrition of plants (Zehirov & Georgiev, 2001; Zehirov & Georgiev, 2002). Molybdenum positively affects the synthesis of protein substances. (Kaiser et al., 2005).

Application of growth regulators in leguminous crops or leaf fertilizers (Osman et al., 2010) leads to positive changes in productivity, chemical composition, leaf area and pure productiveness of photosynthesis, increasing the symbiotic activity of tuberous bacteria, which directly affects the quality and yield of the crop.

Some authors (Hall et al., 2002) found that the application of certain leaf fertilizers and growth regulators to stimulate branching and increase

yield and quality in lucerne did not increase in same way in specific soil and climatic conditions.

Sammaura and Yaday (2008) studies show a positive effect of foliar fertilizers and regulators on the alfalfa growth, development and yield.

In recent years, many preparations with different physiological effects, connected to the efficiency of the biological nitrogen fixation, have been tested, aiming to regulate productive capacities and the growth of alfalfa in order to increase the yield and quality of the plant production.

Our studies are targeted also to a group products with a regulatory effects on productivity and confirm the above results.

MATERIALS AND METHODS

Scientific research was carried out during the 2016-2018 period at the experimental field of the Crop science Department at the Agricultural University of Plovdiv. To achieve the stated goals, a field experience has been set for establishing the influence of some leaf preparations with a regulatory effect on the productivity and quality of alfalfa. Experience is based on the fractional plot method, in 4 replicates and plot size of 10 m^2. Four preparations and their combinations (Tekamin Max, Fertigrain Foliar, Tekamin Max + Fertigrain foliar and Tekamin Brix) over two alfalfa varieties (Prista 3 and Dorine) have been tested.

The seeding was created and grown by the conventional technology for growing alfalfa for fodder (Yankov et al., 1994).

The obtained data are mathematically processed by the dispersion analysis method through the SPSS program.

The soil on which the experience was condacted is slightly salted, sandy, poorly stocked with nitrogen, moderately loaded with phosphorus, well-stocked with potassium and well-stocked with calcium and magnesium. The content of essential nutrients, combined with neutral pH creates favorable conditions for the development of alfalfa and the nitrogen fixation.

Years of the experience have been characterized as appropriate to the crop development. The lack of drastic cold in winter is a prerequisite for good wintering and garnishing of the crop. All three years are characterized as warm and reasonably well-moistened. These conditions, reveal the potential for high yields at the researched alfalfa varieties.

RESULTS AND DISCUSSIONS

A number of authors point that the height of plants is a varietiy attribute but changes under the influence of various factors (Berg et al., 2007; Wang et al., 2010; Wang et al., 2010; Ventroni et al., 2010).

The analysis of the obtained results shows, that the plants are highest in the first swath, which is typical for the crop. The exception is the first year, when the spring sowing makes highest the second swath. However, average for the researched period is the first, followed by the second and third. In the second year of the experiment, we found a strong *Phytodecta fornicata* attack, as shown on Photo 1. The control of the pest was inferred through earlier mowing without the use of chemical preparations.

Photo 1. *Phytodecta fornicata* attack damages

The tested preparations did not significantly affect the plants height. In both varieties they increase the height of the plants, but no varieties difference was observed (Figure 1). Despite of fact that Dorine variety forms higher stems than Prista in all cuts during the three experimental years, the difference in yield between the two varieties can be explained by the heavier stems (Figure 2), and same results obtained from Volonec et al. (1987), Teixeira et al. (2007), according to which the weight of the stems is one of the important components with a direct effect on the yield of green mass and hay in alfalfa.

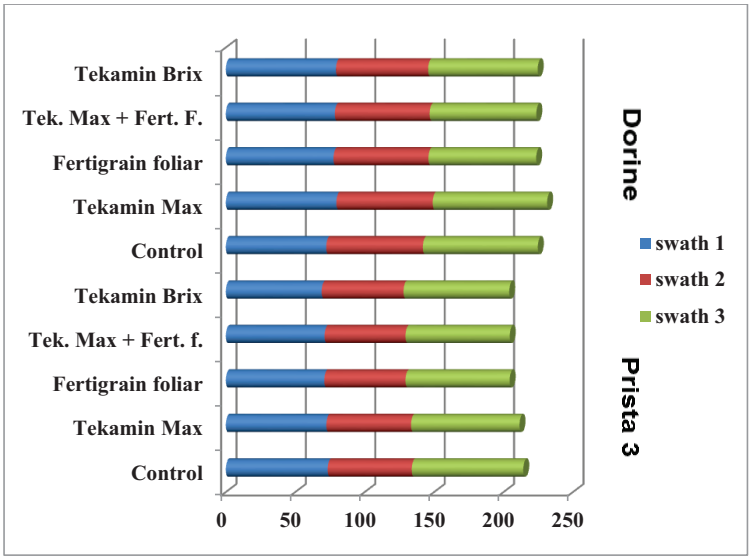

Figure 1. Plants height (average for the research period)

Table 1 shows that treated plants formed heavier stems than those in controls. In the first year spring sowing leads to heaviest stems in the second swath. In this indicator, best results were obtained when treated with Fertigrain Foliar - 24.6 and 25.2 kg ha^{-1} respectively at Prista 3 and Dorine.

Table 1. Stem weight for the period 2016-2018

Variants	Stem weight								
	2016			2017			2018		
	Swath 1	Swath 2	Swath 3	Swath 1	Swath 2	Swath 3	Swath 1	Swath 2	Swath 3
Prista 3									
Control	9.3a	16.9a	5.8a	11b	8.6a	8.3a	10.8b	8.6a	8.9a
Tekamin Max	11.8b	18.7b	8.8c	12.4c	13.5c	11.6c	11.9c	13.2c	10.8c
Fertigrain Foliar	11.1b	24.6d	9.2c	12.3c	9.9b	8.8b	12.6c	10.1b	9.3b
Tekamin Max + Fertigrain Foliar	11.2b	20.8c	7.7bc	11.3b	14.3cd	8.9b	10.8b	13.9cd	9.4b
Tekamin Brix	11.4b	23.5d	7.1b	9.4a	9.9b	8.7b	9.2a	9.7b	9.9b
Dorine									
Control	12.6a	18.2a	6.8a	7.8a	9.5a	9.3a	7.6a	9.7a	9.9a
Tekamin Max	13.2b	21.7b	7.5b	11.5c	13c	13.8d	11.7c	13.2c	14.1d
Fertigrain Foliar	13.2b	19a	8.1bc	9.9b	10.4ab	9.9a	9.6b	10.6ab	10.8ab
Tekamin Max + Fertigrain Foliar	13.8b	25.2c	7.4b	12.5cd	14.5d	12.4c	12.4cd	14d	12.4c
Tekamin Brix	12.7a	21.2b	7.1ab	10.5b	10.2a	11.1b	10.3b	9.9a	11.1b

The difference between the control and the treated variants is strongest in the second swath and decreases in third. During the second and third years, the difference in weight is greatest in the first and second cuts, and the effect of treatment is more pronounced in each subsequent year. This shows that fertilizer activity has increased with cumulation over the years, and this means that their systemic application strengthens the treatment effect.

The differences in the stems weight due to the treatment, with few exceptions, are mathematically proven in both varieties. The only exception is the variant, treated with Tekamin Brix, where the results are contradictory and it can not be said, that treatment with the preparation influences the studied indicator for both varieties.

Many authors consider that the yield of green alfalfa is in positive correlation with the number of leaves. The leaves weigh and number are interrelated, increase the yield, and above all, the quality of the production. Our research confirms this and shows that the treatment proven increases the leaves number in all variants in Prista 3 and most in Dorine.

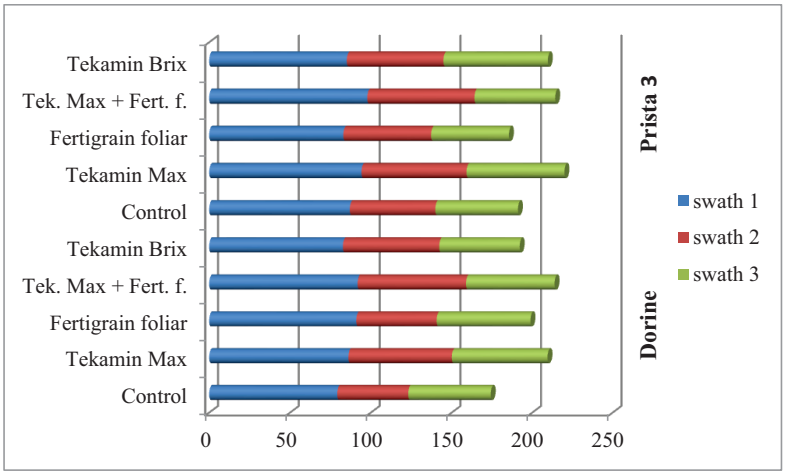

Figure 2. Number of leafs per plant (average for the research period)

Highest leaf number Prista variety forms when Tekamin Max is applied - 224, and Dorine - 216 when treated with the combination of preparations (Figure 2). On average, during the study, both varieties formed highest leaf number at first cut, and values nearly equaling the other two.

The results from Tekamin Brix treatment are quite controversial in both varieties, in some variants the values increase, while other decrease, which means that the preparation does not affect the number of the leaves.

The weight of the leaf is an important indicator for the crop yield formation, especially in well-foliated varieties. The results of Figure 3 show that the treated plants have heavier leaves than untreated, but the differences obtained in most cases are not mathematically proven, indicating that this indicator is largely influenced by climatic conditions. Values at the control are 5.4 g for the Bulgarian variety and 7.1 g for Dorine. Prista 3, realizes highest value when treated with Fertigrain Foliar - 8 g, and Dorine with combination (Tekamin Max + Fertigrain Foliar) - 11 g. The same tendency as the number of leaf counts at plants, treated with Teknamin Brix in both varieties is noted. Treatment does not lead to a one-way change which means, that this preparation does not affect the weight of the leaves.

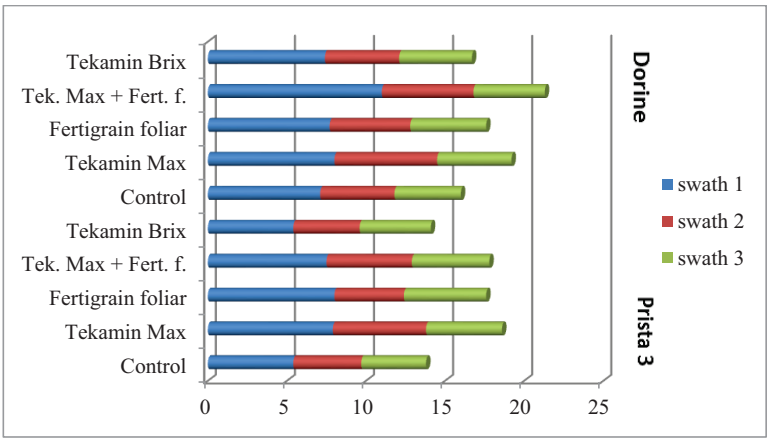

Figure 3. Leaf weight (Average for the research period)

The researched preparations increase the green mass yield in both varieties at all variants with some exceptions in 2017 - the third cut for Prista 3 and the first cut for Dorine but for the period of study in total the differences between the variants were statistically proven (Table 2).

As a result of the treatment, a variety difference is obtained. Dorin formes a higher green mass yield when treated with Tekamin Max, and Prista with the combination of Tekamin Max and Fertigrain Foliar. Highest yield Dorine realizes when treated with Tekamin Max (2016 - 4180 kg ha^{-1}; 2017 - 5550 kg ha^{-1}; 2018 – 5560 kg ha^{-1}) and Prista when treated with Tekamin Max and Fertigrain Foliar (2016 - 5385 kg ha^{-1}; 2017 - 6435 kg ha^{-1}; 2018 - 5679 kg ha^{-1}). Highest yield is obtained in the first swaths 2017 and 2018 and second in 2016.

Comparatively low yield, in the first cut in 2016 is due to strong attack by *Phytodecta fornicata* in the spring of 2016 (see Photo 1), which also required the earlier mowing of the culture. Any other attempt to solve the problem risked the complete compromise of production. In this way, on the one hand, some yield is kept, on the other - an adequate and effective plant protection is carried out without the use of chemical preparations.

Also interesting is the fact that in 2017 and 2018, the yield values of second and third swath are very similar in both study varieties. This is due to the abundant and well distributed rainfall throughout the vegetation.

Table 2. Green mass yield kg ha^{-1}

Variants	Green mass yield								
	2016			2017			2018		
	Swath 1	Swath 2	Swath 3	Swath 1	Swath 2	Swath 3	Swath 1	Swath 2	Swath 3
Prista 3									
Control	1270a	1675a	965a	2070a	1620b	1430a	1968a	1590b	1397a
Tekamin Max	1305b	1760b	1115c	2230c	1760c	1560b	2180c	1811c	1569c
Fertigrain Foliar	1315b	1760b	1155c	2135b	1690b	1450a	2096b	1702b	1387a
Tekamin Max + Fertigrain Foliar	1380c	1880c	1020b	2205c	1665b	1560b	2331c	1688b	1490b
Tekamin Brix	1385c	1725b	1020b	2090a	1405a	1435a	2146a	1496a	1401a
Dorine									
Control	1865a	1925a	1160a	1915a	1665a	1435a	1915a	1665a	1415a
Tekamin Max	1875a	2115c	1325c	2195c	1840c	1600c	2195c	1840c	1567b
Fertigrain Foliar	1850a	2040b	1345c	2185c	1760b	1455b	2185c	1760b	1411a
Tekamin Max + Fertigrain Foliar	1910b	2265d	1210b	2165c	1965d	1580c	2165c	1965d	1549b
Tekamin Brix	1860a	2055b	1195a	2075b	1660a	1460b	2075b	1660a	1440a

The Dorine variety exceeds Prista in green mass yield on average over the study period (Dorine - 5345 kg ha^{-1}, Prista - 4280 kg ha^{-1}). With small exceptions, the same logic is also observed in the results obtained in both the treated and the untreated variants, which gives us reason to characterize Dorine, as a more productive variety (Table 3). An exception to the above with respect to the green mass yield was observed in the treatment with Tekamine Brix in both studied varieties, both in swaths and in total for the researched period. The application of the preparation does not increase the yield, which co-ordinates with the results for leaves weight. This fact and the values observed in hay yields gives us a reason not to recommend the preparation for use in lucerne production.

Table 3. Hay yield kg ha^{-1}

Variants	Hay weigth								
	2016			2017			2018		
	Swath 1	Swath 2	Swath 3	Swath 1	Swath 2	Swath 3	Swath 1	Swath 2	Swath 3
Prista 3									
Control	381a	486.75a	260.6a	558.9a	453.6a	328.9a	1968a	1590b	1397a
Tekamin Max	444.3b	756.8c	379.1c	892c	585.6c	455.6c	2180c	1811c	1569c
Fertigrain Foliar	447.1b	739.2c	427.35c	683.2b	547.7b	348a	2096b	1702b	1387a
Tekamin Max + Fertigrain Foliar	496.8c	827.2d	347.4b	860c	546.1b	449c	2331c	1688b	1490b
Tekamin Brix	484.75c	621b	336.6b	568.8a	435.6a	394.2b	2146a	1496a	1401a
Dorine									
Control	578.2a	785.3a	336.4a	600.7a	500a	389.2a	588a	515a	400.2a
Tekamin Max	603.5ab	909.5b	490.25b	768.3c	607.2b	432b	734.9c	599.1c	451.3b
Fertigrain Foliar	629b	877.2b	484.2b	742.9c	651.2c	363.8a	728.1c	644.4b	389.8a
Tekamin Max + Fertigrain Foliar	691.9c	1019.3c	471.9b	779.4c	707.4d	471.2bc	769.4c	697.3d	479c
Tekamin Brix	632.4b	801.5a	361.35a	643.3b	481.4a	365a	601 a	476.2a	406.6a

The results for hay yield fully correspond to the ones obtained about the green mass. The treatment with preparations leads to an increase the values of the investigated indicator, both in swaths and total for the study period.

This once again confirms the positive influence of treatment on the productivity of the crop and gives us reason to recommend the preparations in our tried doses for use in the practice of alfalfa production. Regardless of the climatically different years, one-way results are clearly visible in both varieties. Again, the highest values were obtained at variants, treated with Tekamin Max at Prista and the combination of Tekamin Max + Fertigrain Foliar at Dorine, with the differences being mathematically proven (Table 4).

Dorine variety significantly exceeds Prista in the first year of the study. This is probably due to the fact that the introduction of Rhizobium bacteria has a strong influence on the initial development of the culture. Dorine variety has a higher crude protein content in the green biomass, compared to Prista 3 in all studied variants. The highest values for both varieties are obtained after treatment with Tekamin Max (23.73) for Dorine variety and 22.18 for Prista 3. In both varieties the treatment increases the protein content.

The treatment did not affect the cellulose content of both tested varieties, regardless of the preparations used. The Dorine variety exceeds Prista 3, but this is due to the heavier stems, which is also confirmed by stem weight data as well as by the yields of green mass.

The quality of lucerne is also determined by the common sugars content. Our studies show an increase in the indicator as a result of treatment in all combinations.

Table 4. Quality parameters of alfalfa green mass (average for the research period)

Variants	Crude protein	Common sugars	Cellulose
	% to an absolutely dry matter		
Dorine			
Control	21.68	4.66	32.28
Tekamin Max	23.73	5.31	32.33
Fertigrain Foliar	22.81	7.36	34.12
Tekamin Brix	23.00	5.63	32.88
Prista 3			
Control	19.24	4.38	32.52
Tekamin Max	22.18	6.12	33.81
Fertigrain Foliar	21.75	6.21	32.57
Tekamin Brix	19.87	6.06	31.22

Sugars increased most significantly with Fertigrain Foliar aplications in both varieties (7.36% for Dorine and 7.36% for Prista 3). The obtained data are confirmed over the hole study period, indicating that Fertigrain foliar increases the sugar content and therefore the quality of lucerne plants.

CONCLUSIONS

The application of the tested products increases the stems weight of both varieties, Dorine forms heavier stems than Prista 3.

There is proven increasing of number and weight of leaves in all treated variants by swaths in Prista 3 and in two at Dorine.

The use of the Tekamine products has been shown to increase both green and hay yield for both studied varieties on one hand and the quality of above-ground biomass on the other, so they can be used in practice for alfalfa production. Highest results for both varieties were obtained by treatment with Tekamin Max and Fertigrain Foliar.

Dorine variety exceed Prista 3 in green mass and hay yield for all 3 researched years.

Using Yellow Jacket Rhizobium coating for seeds on sandy soils increases crop yield, and improve establishment on this variety under difficult conditions.

Using new technology, as adding high levels of effective Rhizobia, essential minerals and trace elements, is easy to improve establishment and increase forage production.

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