

(*Tetranychus atlanticus* Mc Gregor)

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Effect of water deficit and spider mites (*Tetranychus atlanticus* Mc Gregor) on productivity and stability in soybeans

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SUMMARY

Abiotic and biotic stress are factors with a great impact on world agriculture because of the enormous economic losses in regard to crop plants. In conditions of a pot experiment conducted in IFC-Pleven (2011-2012), a 10-day period of water deficit and attack by spider mites had a strong pronounced negative effect on the development of soybean (variety Richy). The reduction in productivity of biomass was by 16.5 and 21.0% respectively, and under the interaction of the two factors – by 41.9%. In regard to number and weight of the leaves per plant, and productivity of aboveground mass was found a significant effect of the mode of irrigation. A greater part of the total variation in terms of plant height and number of nodules had the factor spider mites. Soybean plants, which are developing in conditions of water deficit and attack of spider mites exhibited an increased ecological stability of productivity as

- compared to plants, grown under optimal environmental conditions. The stress conditions changed the extent and nature of the dependence between productivity and its main traits in soybeans. The correlations between the traits under an individual action of water deficit and spider mites were highly expressed, with high values, while under favorable conditions, they had considerably lower values.

Key words: water deficit, mites, productivity, stability, soybeans

INTRODUCTION

Plants grow and develop in environments where they are often exposed to different stress factors (Atkinson and Urwin, 2012). Abiotic stress factors such as drought, heat, salinity etc have a huge impact on the world farming. It has been suggested that they decrease average yields by >50% in most main crop species (Wang et al., 2003). Drought, which is connected to the greenhouse effect and is caused by the global atmosphere pollution, is one of the most unfavorable environmental stress factors (Yordanov et al., 2012).

Further, plants are an object of infestation by a vast range of pests and pathogens (fungi, bacteria, viruses, nematodes) and herbivorous insects (Hammond-Kosack and Jones, 2000). Biotic stress factors are a major focus of a number of researches due to the huge economic losses, which they cause in terms of crops (Atkinson and Urwin, 2012).

Any stress causes a set of manifestations (morphological, biochemical, physiological) from the side of the plant in order to prevent damages and to ensure a survival, but they usually result in reducing the growth and yield (Herms and Mattson, 1992).

Various stress factors often appear and act in combination (Niinemets, 2010).

(Atkinson and Urwin, 2012).

et al., 2003).

(Yordanov et al., 2012).

(Hammond-Kosack and Jones, 2000).

(Atkinson and Urwin, 2012).

(Herms and Mattson, 1992).

(Niinemets, 2010).

Urwin, 2012).

(Atkinson and Urwin, 2012).

Larcher (1987)

(Atkinson and

- Recent data shows that under the
- simultaneous action of stress factors, the
- plants respond differently compared with
- how they respond to individual stress
- (Atkinson and Urwin, 2012). There is a
- need for a change of focus in plant stress
- research, in order to understand the
- nature of multiple stress responses and to
- create avenues for plants (species,
- varieties) that are tolerant or less sensitive
- to multiple stresses and maintain high
- yields (Atkinson and Urwin, 2012).
- According to Larcher (1987), stress
- includes both destructive and constructive
- elements, and also stress is a selection
- factor as well as a driving force for
- improved resistance and adaptive
- evolution.

- The aim of this study was to study
- the effect of water deficit, spider mites and
- their interaction on productivity and
- stability parameters in soybeans.

MATERIAL AND METHODS

During the period 2011-2012 was conducted a pot experiment in a steel-glass greenhouse, at the IFC Pleven. Containers (type Wagner) have been used and in any one of them were grown 4 plants of soybeans (variety Richy). The development of the aboveground mass in soybeans and its related parameters were monitored under influence of factors water deficit (+WD) and mites (+M), and their interaction (+WD+M). The control of the experiment was variant in which plants were grown in conditions of optimal irrigation and in the absence of mites (-WD-M).

After sowing the seed and their germination, all plants received the same amount of water to be maintained the optimal soil moisture until the end of phase R5 (Febr and Cavinesi, 1977), when in a part of the variants was imposed water deficit by reducing with 1/2 of irrigation norm. After a 10-day drought, the optimum soil moisture was restored.

2011-2012

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(+ +).

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R5 (Febr and Cavinesi,

1977)

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Tetranychus atlanticus Mc Gregor
(Acari: Tetranychidae)

R1 (1.0 number/leaflet) and reached to 124 and 65 number/leaflet (respectively in conditions of water deficit and irrigation) at the end of stage R5.

R5. (- -):
(+);
(+ +).

(D) (Fischer and Maurer, 1978),
(D = 0.55).

R6 (g/plant), (cm), (number/plant).

(AOAC, 2010).

(bi) Finlay and Wilkinson (1963) (PP) Plaisted and Peterson (1959), Wricke (1965) Annicchiarico (1992). Plaisted and Peterson (1959)

Annicchiarico (Wi),

The population density of spider mites *Tetranychus atlanticus* Mc Gregor (Acari: Tetranychidae) was recorded at natural infestation background. They appeared at stage R1 (population density of average 1.0 number/leaflet) and reached to 124 and 65 number/leaflet (respectively in conditions of water deficit and irrigation) at the end of stage R5.

Variants – Control (-WD-A): irrigation, without mites; Water deficit (without mites)(+WD); Mites (under irrigation) (+A); Water deficit and Mites (+WD+M). Based on the imposed water deficit and the mite infestation, was calculated the coefficient of stress intensity (D) (Fischer and Maurer, 1978), whose value in conditions of this experiment was mean (D = 0.55).

The productivity of aboveground mass (g/plant), plant height (cm), the numbers of leaves per plant, leaf weight (g/plant), nodulation (number/plant), were reported at the end of phase R6. The content of crude protein in the leaves of soy plants was determined by the method of Kjeldahl (AOAC, 2010).

For statistical data processing was used dispersion analysis for each trait for determining the effects of the variants and their interaction. Stability of the variants for each studied trait was evaluated with two types of parameters: regression (bi) according to the model of Finlay and Wilkinson (1963) and variance - mean-variance component (PP) according to Plaisted and Peterson (1959); ecovalence (W^2) of Wricke (1965) and Annicchiarico (1992). According to Plaisted and Peterson (1959), the mean-variance component (PP), computed through pair-wise analysis, was a measure of a variety's contribution in the total interaction. The Annicchiarico's method uses a reliability index (Wi) which estimates the probability of a particular variant to present itself below the environmental average or below of the control variant used. The GGE biplot model was done through

GGE
 (PC1, PC2) (Yan, 2002).
 GENES 2009.7.0 Windows XP
 (Cruz, 2009).

using the numeric value of the first two principal components (Yan, 2002). All experimental data were processed statistically with using the computer software GENES 2009.7.0 for Windows XP (Cruz, 2009).

RESULTS AND DISCUSSION

Analysis of variance

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 / 65.60%
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 -
 (59.81%, 45.50%).
 -
 (14.04%)
 (6.37%).

The results of the analysis of variance of studied traits were presented in Table 1. For all traits, factors A (mode of irrigation) and B (mites) had a significant influence. Statistically significant was the interaction between the factors in terms of the foliage mass and nodulation. In regard to number and weight of the leaves per plant, and the productivity of aboveground mass, was found a significant effect of the mode of irrigation (Figure 1), as in the weight of leaves/plant it reached 65.60% of the total variation.

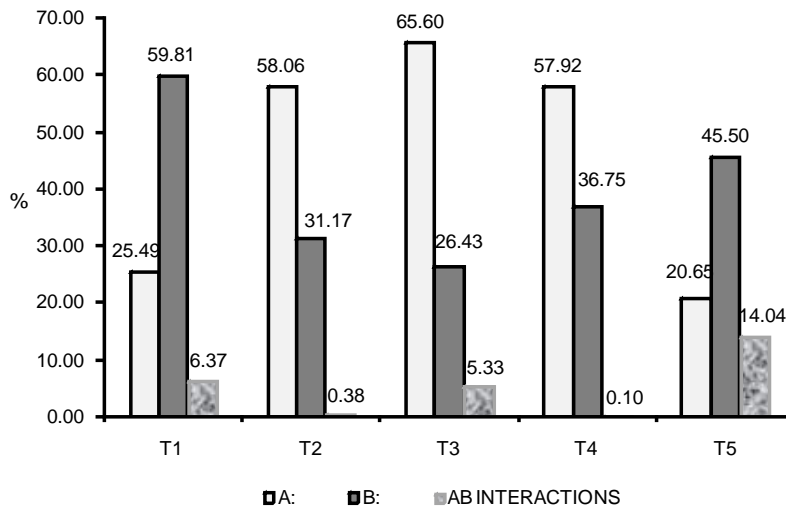
The traits, plant height and number of nodules, were influenced to a greater extent by the presence of mites (59.81%, 45.50%). The most pronounced was the percentage participation of the impact of the two factors interaction with respect to the nodulation (14.04%) and plant height (6.37%).

1.

Table 1. Analysis of variance with regard to the main traits in soybeans depending on the studied factors

Source of variation	Df	/Mean Squares				
		Plant height	Number of leaves	Leaf weight	Productivity of biomass	Number of nodules
Factor A: regime of irrigation	1	186.047**	79.3745** *	4.107***	61.5063***	110.262*
Factor B: spider mites	1	436.512***	42.6104**	1.65489***	39.0279***	243.00**
/Interaction A x B	1	46.5117	0.526055	0.333476* *	0.111143	75*
/Residual	8	7.58789	1.77637	0.020712	0.693097	13.2207
/Total (corrected)	11					

*p 0.5, **p 0.1, ***p 0.01



T1 - Plant height; T2- Number of leaves; T3- Leaf weigh; T4 – Productivityof biomass; T5 - Number of nodules

Fig. 1. Influence of water deficit, spider mites and their interaction on the manifestation of studied traits, % of the total variation

Racz (2003) determined the soybeans as demanding on the moisture culture, in which was established a considerable decrease in yield during periods with insufficient or unevenly distributed rainfall. According to other authors (Daryanto, 2015), it may be related to species which were characterized by the ability to maintain a high productivity in water deficit. Under conditions of the present experiment, the water deficit and spider mites attack led to a reduction in the productivity (g / plant) of soybean plants by 16.5 and 21.0%, respectively, and the interaction of these two factors - by 41.9% (Figure 2). The decreased productivity was determined by lower values of the major traits: height/plant, number and weight of leaves/plant, nodules/plant. The trait number of leaves per plant exhibited the highest sensitivity (respectively a decrease) with respect to the action of stress factors. The reduction

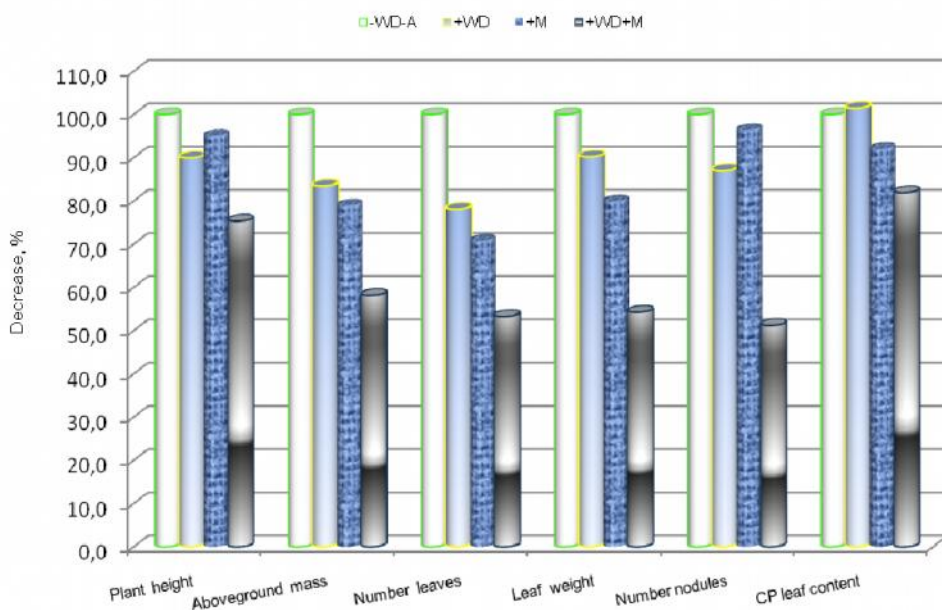
Productivity and related main traits

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(Frank and Berdahl, 2001; Xu et al., 2006).

Fadini et al. (2004)

of the foliage in a moisture shortage was the mechanism by which plants reduced the water loss (Frank and Berdahl, 2001; Xu et al., 2006). In the mites, it was a consequence of the damages they have caused in the process of feeding. Fadini et al. (2004) have described this process as a perforation of the lower epidermis cells followed by suction of the content of the cells. As a result, the chloroplasts of the affected cells disappeared, the other material coagulated, causing injuries to the surrounding cells and chlorotic spots.



. 2.

Tetranychus atlanticus

Fig. 2. Decrease in the values of studied parameters in soybeans in terms of water deficit and *Tetranychus atlanticus* infestation

-WD-A –

100%; +WD –

; +M –

; +WD +M –

-WD-A – the absolute values in terms of the control (irrigation, without mites) are accepted for 100%; +WD – water deficit; +M – mites; +WD +M – water deficit and mites

(7.9%)

The crude protein content in the leaves showed a decreasing trend (by 7.9%) under the influence of factor mites. "Puncturing" of cells through the stiletto of mites and the injection of saliva causes mechanical damage and changes in the biochemical processes of both the

(Tomczyk & Kropczynska, 1985).

(Sadras and Wilson, 1998).

(Akinci and Lösel, 2012).

(2).

(0.581)

(g/plant)

(r=0.957).

(r=0.500)

damaged and the undamaged adjacent cells (Tomczyk & Kropczynska, 1985).

This accelerated the aging of the leaves and thus caused a rapid loss of foliar nitrogen (Sadras and Wilson, 1998). As regards the water deficit, it was not observed any change in the protein biosynthesis. The data in the scientific literature were not unidirectional. Values of increase, decrease or without change were indicated, which was largely determined by the stress intensity (Akinci and Lösel, 2012).

Correlation analysis

The stress conditions altered the extent and nature of the dependence between productivity and other studied traits in soybeans (Table 2). The plant height, as well as other quantitative traits, was strongly influenced by the external environment. In favorable conditions, as those in the control variant, and under impact only of one of the stress factors, the value of the correlation coefficient, expressing the dependence of the trait with the productivity, was positive and high.

In soybean plants with imposed water deficit, the dependence had a higher value, which could be indicative of a stronger suppressive effect of the factor compared to the effect of the mites. With a mean positive value (0.581) was the correlation after interaction of the two factors.

The obtained data showed a positive correlation between the productivity of soybeans (g/plant) and the weight of the leaves in all variants, as the highest and statistically significant was the coefficient in the plants attacked by mites ($r = 0.957$). The trait, number of leaves/plant was also in positive correlation with the productivity. With a mean level of correlation ($r = 0.500$) was characterized the control variant and this one with an interaction of the two factors

(r=0.458),
 -
 (r=0.982)
 (r=0.927).

(r = 0.458), and with a high level - the variant with water deficit (r = 0.982) and the variant with mites (r = 0.927), respectively.

2.

Table 2. Correlations between productivity and main vegetative traits in soybeans in conditions of water deficit and mites

/Traits	Plant height	Number of leaves	Productivity	Weight of leaves
-WD-M				
/Number of leaves	0.400			
/Productivity	0.763	0.500		
/Weight of leaves	0.697	0.836	0.893	
/Number of nodules	-0.431	-0.795	-0.835	-0.939
+WD				
/Number of leaves	0.854			
/Productivity	0.829	0.982*		
/Weight of leaves	0.913	0.989*	0.957*	
/Number of nodules	0.279	-0.260	-0.266	-0.134
+M				
/Number of leaves	0.925			
/Productivity	0.980*	0.927		
/Weight of leaves	0.963*	0.937	0.905	
/Number of nodules	-0.010	0.238	0.170	-0.113
+WD+M				
/Number of leaves	0.987*			
/Productivity	0.581	0.458		
/Weight of leaves	0.994**	0.981*	0.539	
/Number of nodules	0.968*	0.937	0.731	0.939

-WD-A: irrigation, without mites; +WD: water deficit; +M: mites; +WD +M: water deficit and mites
 *, ** - significant at the 0.05, 0.01 level

Mihova & Petrova (2005)

The results of the analysis showed that the correlations between the traits under an individual action of abiotic and biotic stress were stronger expressed, by high values. Considerably lower were these values under favorable conditions (control variant) and under an interaction of the stress factors. A similar dependence was found by Mihova & Petrova (2005) at studying of barley lines in conditions of low temperatures. Low values of correlation coefficients showed that they could be violated more easily.

Stability analysis

The notion ecological plasticity determines the responsiveness to an improvement of growing conditions, as well as the trend to a decrease in the value expression of the trait under deterioration of cenotic environment i.e. under unfavorable conditions. The stability parameters of the plants by the various variants were presented in Table 3. According to those parameters, based on the dispersion model, the most stable in regard to the height were plants with imposed water deficit and mites (+ WD + M), followed by those in the conditions of mites attack (+ M). This was confirmed by their respective regression coefficients ($b_i=1.07$; $b_i=0.50$), although they were not statistically significant.

3.

Table 3. Stability parameters in soybeans in stress conditions

Variants	Finlay and	Wricke	Annicchiarico	Plaisted and
	Wilkinson (1963)	(1965)	(1992)	Peterson (1959)
	b_i	W^2	W_i	PP
/ Plant height				
+WD+M	1.07	0.284	82.92	3.242
+WD	2.18**	80.264	96.28	12.128
+M	0.50	14.091	104.06	4.776
-WD-M	0.24*	32.924	108.60	6.868
/ Number of leaves per plant				
+WD+M	0.95	0.035	68.63	0.874
+WD	-0.37*	24.605	94.42	3.604
+M	2.17	17.855	84.58	2.854
-WD-M	1.25	0.845	131.82	0.964
/ Weight of leaves per plant				
+WD+M	-0.30	0.181	64.42	-0.289
+WD	-0.34	0.192	107.49	-0.288
+M	3.03	0.442	92.97	-0.261
-WD-M	1.61	0.040	122.24	-0.305
/ Productivity				
+WD+M	0.15	2.734	73.24	0.290
+WD	0.69	0.375	102.25	0.028
+M	0.70	0.331	96.99	0.023
-WD-M	2.46	8.074	119.66	0.884

-WD-A: irrigation, without mites; +WD: water deficit; +M: mites; +WD +M: water deficit and mites

Wricke (1965) and Annicchiarico (1992)

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(bi=0.95), - - -

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GGE biplot
(3) GGE biplot

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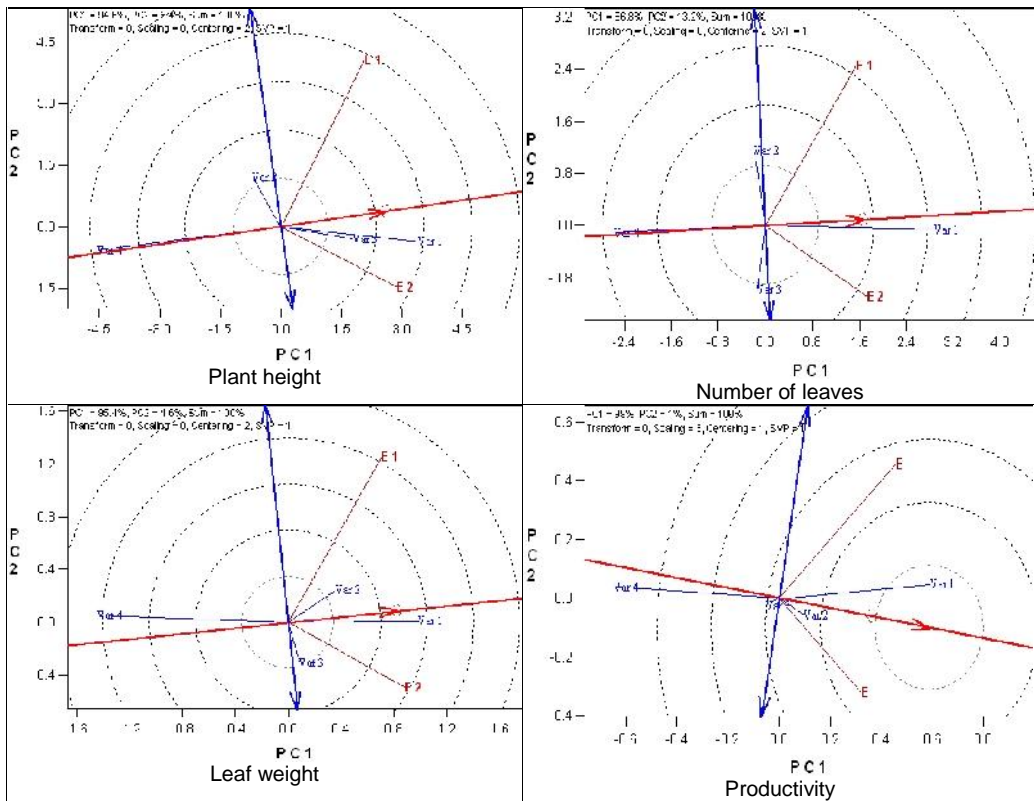
4 (+ +)
(- -)

Regarding number and weight of the leaves, as environmentally stable plants, according to the criteria of Wricke (1965) and Annicchiarico (1992), were determined those from variant -WD-M and variant +WD+M, although they differed in their responsiveness to the environmental conditions. The regression coefficient characterized variant +WD+M, as more stable in the number of leaves (bi=0.95), while variant -WD-M was more responsive under change of the growing conditions.

The plants, grown under stress conditions of variant +WD and variant +M, had the best estimate of stability on productivity, both by regression and variance type of parameters. The control variant was distinguished with the lowest stability regarding this trait.

GGE biplot analysis

The conducted GGE biplot analysis (Figure 3) allows being visualized the evaluation of dependencies between the tested variants (stress environments) and their interaction. In regard to plant height, the variants in which the stress factors acted individually were situated closest to the center of the concentric circles. This determined their position as the closest to an "ideal" variant. The long vector, connecting the center with variant 4 (+WD+M) and the control variant (-WD-M), indicates the greater their variability and instability. Their location confirms the assessment of variants based on the stability parameters.



. 3. GGE biplot

Fig. 3. GGE biplot analysis based on the studied traits in soybeans

Var 1 - Control (irrigation, without mites) (-WD-M); Var 2 - Water deficit (+WD); Var 3 - Mites (+M); Var 4 - Water deficit and mites (+WD+M); 1 - 2011, 2 - 2012

PC1
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PC1
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The high and positive value of the control in PC1 and tending to zero value of PC2, attest to a better leafiness and stability of plants of this variant with respect to the number of leaves.

The small negative values in PC1 define an intermediate position of the plants of the variants with imposed water deficit (variant 2) (+WD) and mite attack (variant 3) (+M). With the most unfavorable evaluation in this trait is the interaction water deficit x mites, which occupies the extreme left position in the chart.

With respect to the complex trait productivity/plant, the control variant (variant 1 in the figure) is located in close proximity to the "ideal" center. Variants

+ - , ,
 + + , - ,
 - , .

- with water deficit and mite attack(respectively 2 and 3 in the figure) are more distant from the center, as the variant + WD is more acceptable, suggesting that more essential impact on the expression of this trait has the attack of mites than the water deficit. The location of variant + VD + M in the coordinate system, its low productivity and the long vector, which it forms with the center, putting it in the most unfavorable position

CONCLUSIONS

(D = 0.55),
 16.5 21.0 % ,
 41.9% . , , , /

- The water deficit and spider mites were stress factors with strong pronounced negative impact on the development of soybeans. In conditions of the conducted pot experiment and intensity of stress (D = 0.55), they reduced the productivity of biomass by 16.5 and 21.0% respectively, and the interaction of the two factors - by 41.9%. The traits, height of plant, number and weight of leaves, number of nodules and productivity of biomass showed a significant interaction with the factors water deficit and mites. In terms of the number and weight of leaves and productivity was found a significant influence of the factor regime of irrigation. A larger part of the total variation in plant height and number of nodules had the factor mites.

- Soybean plants, which are developing in conditions of water deficit and attack of spider mites exhibited an increased ecological stability of productivity, both by regression and variance type of parameters as compared to plants, grown under optimal environmental conditions.

- The stress conditions altered the extent and nature of the dependence between productivity and main traits in soybeans. The correlations between the traits under an individual action of water deficit and spider mites were highly

, expressed, with high values, while under favorable conditions, they had considerably lower values.

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Permanence of independent and mixed grasslands of red fescue under conditions of the Central Balkan Mountain

I. Productivity

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SUMMARY

20 (1994-2013)

The study includes the results of a 20 year period (1994-2013) for the use of red fescue, grown alone and mixed with other meadow grasses. The grasslands are created in the region of the Central Balkan Mountain, on the eastern slope, at low and high degree of soil gleying

1995; 1997; 1999; 2001;

2003

When grasslands are placed on soils with low degree of gleying, there is a certain rhythm in the formation of the forage mass. In odd years 1995; 1997; 1999; 2001; 2003 yields were higher than those in the even years 1996; 1998; 2000; 2002.

1998; 2000; 2002

2010.

2011

2004; 2006; 2008;

2013

The sequence changed in 2004; 2006; 2008; 2010. In 2011 and 2013, yields were again higher than in 2012.

2012

The variation in the behavior of the grasses is found in the high degree of soil gleying, at the low part of the slope. Their

1995; 1999; 2004; 2006; 2008; 2010; 2011 .
 1997; 2000; 2001; 2002; 2003; 2007; 2009; 2012; 2013 .
 (1996; 2005), (1998)

(Ives et al., 2000).

(Kanneganti et al., 1998; Kolomeichenko, 2003).

(Koukoura, 1998; Kolomeichenko, 2003.)

“ ”
 (Ene and Mocanu 2013; Mitev and Naydenova 2008),

(Totev, 1984; Mitev, 1997; Goranova-Naydenova, 2002).

manifestation on soils with high degree of gleying has a different sequence than that of low degree of gleying. An increase was established in 1995; 1999; 2004; 2006; 2008; 2010; 2011. Decrease occurred in 1997; 2000; 2001; 2002; 2003; 2007; 2009; 2012; 2013. In some years was reported a gradual decrease (1996; 2005), while in others (1998) respectively there was an increase in productivity.

It is believed that this behavior stems from the presence or lack of synchronization of the particular plant/genetic material with the rhythm in Nature.

Key words: productivity, meadow grasses, slopes, Balkan Mountains, hypotheses

INTRODUCTION

Global climate change necessitates the selection of specific species combinations to provide such diversity in the grassland that the latter can resist the extreme ecological conditions of the habitat (Ives et al., 2000).

It should be pointed out that when selecting the components to create a meadow grassland, attention should be paid not only to the productivity and the economy, but also to its environmental impact (Kanneganti et al. 1998, Kolomeichenko, 2003, etc.).

The change in the transport of nutrients and the decomposition of the organic mass created (Koukoura, 1998, Kolomeichenko, 2003) allows for a "conservation approach to the restoration of degraded sites" (Ene and Mocanu 2013, Mitev and Naydenova 2008) in some regions of Bulgaria.

A number of studies carried out in our country show the impossibility of producing quality and long-lasting meadow grasslands through imported seeds (Totev, 1984; Mitev, 1997; Goranova-Naydenova, 2002, etc.). Many

(Kozhuharov, 1986).

(Goranova-Naydenova, 2002; Mitev, 1997).

(Mitev, 1997),
(Mitev, 1995; Georgieva et al., 2015; Katova, 2016),
(Mitev, 1995), (Churkova, 2006),
(Goranova-Naydenova, 2002), (Mitev, 2014).

(Wardle et al., 1987; Sanderson et al., 2004).

(Penkov, 1998).

(Mitev and Belperchinov, 2000).

$pH_{1/4.7}$; meqv/100 g. : l-0.6-1.0; n-0.3-0.8; + g-0.9-11.1.

$pH_{1/3.9-4.0}$; meqv/100 g. : l-1.3-1.6; n-0.6-1.3; + g-3.6-4.5.

areas of the Balkan Peninsula as a whole, and in particular Bulgaria, include a number of secondary centers of creation of new genetic material, directly linked to the main Alpine. They are all part of the general Balkan Forming Center (Kozhuharov, 1986). This created a prerequisite for the development of a wide-ranging selection program for the creation of varieties of locally grown grasses meeting the habitat conditions. (Goranova-Naydenova, 2002; Mitev, 1997). This is also true of the red fescue (Mitev, 1997), tall fescue (Mitev, 1995; Georgieva et al., 2015; Katova, 2016), Kentucky bluegrass (Mitev, 1995), red clover (Goranova-Naydenova, 2002), alfalfa (Mitev, 2014).

Each particular region has a peculiar specificity that can make it unique in the environment (Wardle et al., 1987; Sanderson et al., 2004).

The aim of the present study is to clarify certain aspects related to the sustainability of some artificial meadow grasslands with the participation of red fescue, when they are placed on the eastern slope of the Central Balkan Mountain, low and heavily gleyed soils.

MATERIAL AND METHODS

The grasses covered in this study are situated on the eastern slope of the mountain. The soil is pseudopodzolic, with a strong and low level of gleying (Penkov, 1998). The habitats covered are part of a larger scheme of ecological testing of cultivars and populations, which were created in the region, of meadow herbs of local origin (Mitev and Belperchinov, 2000). The low degree of enema, when the experience is set, is characterized by $pH_{1/4.7}$; Exchange cations in meqv/100 g soil: Al-0.6-1.0; Mn-0.3-0.8; Ca + Mg-0.9-11.1. The high degree of gleying is characterized by a $pH_{1/kcl}$ of 3.9-4.0; exchange cations in meqv/100 g. soil: Al-1.3-1.6; Mn-0.6-1.3; Ca + Mg-3.6-4.5.

1994 .. , 4 -
 , 4 m². ,
 , 800
 1 m².
 , 1/2; 1/3; 1/4
 .
 , , -
 80 g.h⁻¹ 80 g.h⁻¹,
 1995 ..
 N80 g.h⁻¹, 1995
 .
 -
 .
 : 1 .
 , 2 .
 + , 3 .
 + , 4 .
 + , 5 .
 + , 6 .
 + , 7 .
 + , 8 .
 + .
 (. Viola)
 (,),

The experience was set in the spring of 1994, using the block method, in 4 replications, with a plot size of 4 m². In soil that has been brought to a garden state, 800 germinating seeds are sown per 1 m². In mixed grasslands, the components are 1/2; 1/3; 1/4 of the sowing standards for individual crops according to the variants. They are sown scattered, by hand, as after sowing it is rolled. Every second year was fertilized with P80 kg.ha⁻¹ and K80 kg.ha⁻¹, from 1995, before the beginning of the vegetation of the grasses in the region. Each year the ground was fed with N80 kg.ha⁻¹, from 1995 in the beginning of vegetation of grasses.

Grasslands were cut in the phase of full tasseling-beginning of flowering of some grasses and budding-beginning of flowering of legumes. Forage dry matter yield was reported. These types of grasslands were studied: 1 var. red fescue-independently, 2 var. red fescue+tall fescue, 3 var. red fescue+Kentucky bluegrass, 4 var. red fescue+bird's-foot-trefoil, 5 var. red fescue+tall fescue+bird's-foot-trefoil, 6 var. red fescue+Kentucky bluegrass+bird's-foot-trefoil, 7 var. red fescue+Kentucky bluegrass+alfalfa, 8 var. red fescue+cock's foot+red clover+bird's-foot-trefoil.

The seeds are of local origin with the exception of those of red clover ('Viola') and cock's foot ('Dabrava'), which is a Bulgarian variety.

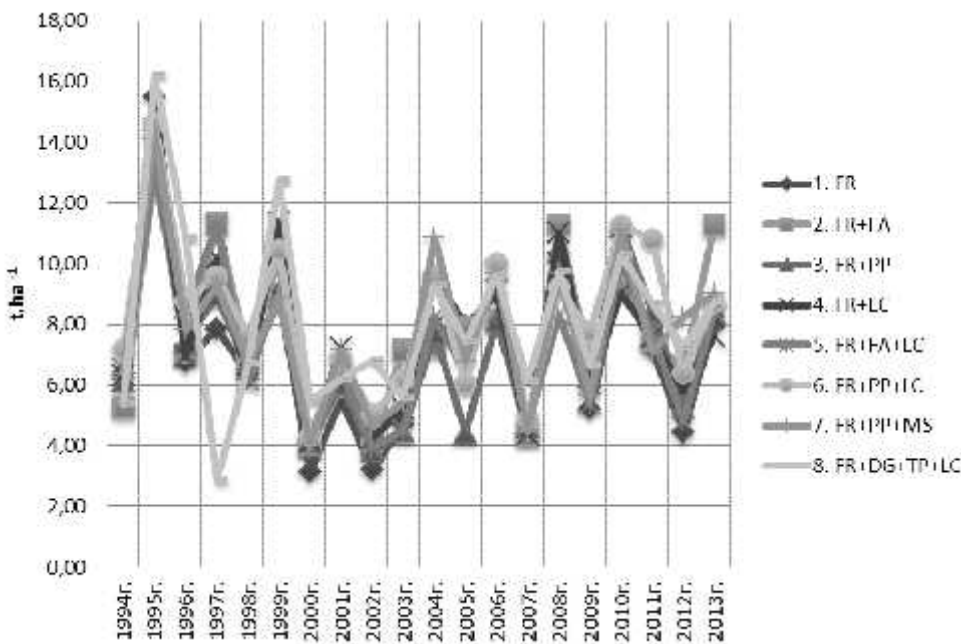
RESULTS AND DISCUSSION

When grasslands are located on soils with low gleying, a mountain slope with eastern exposure, a certain rhythm in the formation of feed mass in the variants is found (Figure 1). In odd years 1995; 1997; 1999; 2001; 2003 yields were higher than those in the even years 1996; 1998; 2000; 2002. The sequence changed in 2004; 2006; 2008; 2010. In

2002 .
 2004; 2006; 2008; 2010.
 2011 2013 .
 - ,
 2012 .
 1995 .
 ,
 16.22 t.ha⁻¹
 1997 . (2.84 t.ha⁻¹).
 ,
 (2013),
 (11.263 t.ha⁻¹),
 (1997) - 13.065 t.ha⁻¹.

the odd years 2011 and 2013, yields were again higher than in 2012. The highest productivity was found in 1995, with the exception of the combination of red and tall fescue.

The mixed grassland of red fescue, cock's foot, red clover and bird's-foot-trefoil, formed in this year a dry matter of 16.22 t.ha⁻¹. The decrease in productivity in that grassland in 1997 is impressive (2.84 t.ha⁻¹). The mixed grassland of red fescue and tall fescue, in the last year of the experiment (2013), formed approximately as much feed (11,263 t.ha⁻¹) as in the early years of the experiment (1997) - 13,065 t.ha⁻¹.



1. 1994-2013 .,
 t.ha⁻¹,
Fig. 1. Dry matter yield in years and variants for the period 1994-2013, in t.ha⁻¹, slightly gleyed soils

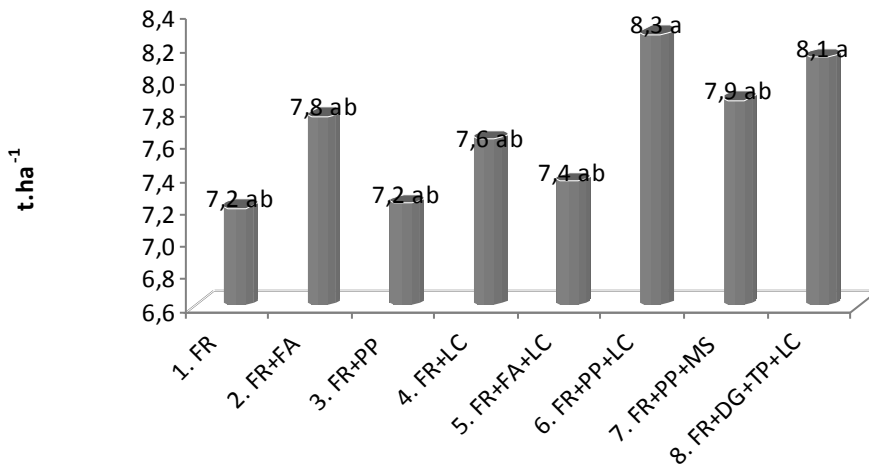
: 1. FR - ; 2. FR+FA - + ; 3.
 FR+PP - + ; 4. FR+LC + ; 5. FR+FA+LC -
 + ; FR+PP+MS - + ; 6. FR+PP+LC - +
 + ; FR+DG+TP+LC -

EXPLANATION: 1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue + bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue + bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; FR+PP+MS - red fescue + Kentucky bluegrass + alfalfa; FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil.

2013 .),
(2).

20 . (1994-

On average, for a period of 20 years (1994 to 2013), the productivity of the self-grown red fescue is equal to that of the mixed grassland of red fescue and Kentucky bluegrass, as well as that with red fescue, tall fescue and bird's-foot-trefoil (Figure 2). The excess of the two-component grassland of red fescue with tall fescue, as well as that of red fescue with bird's-foot-trefoil, compared to them is insignificant. It is greater in combination of red fescue, Kentucky bluegrass with bird's-foot trefoil, or with alfalfa, as well as with red fescue, cock's foot, red clover and bird's-foot trefoil.



. 2. t.ha-1 1994-2013 .,

Fig. 2. Average yield in t.ha⁻¹ in variants for the period 1994-2013, slightly gleyed soils

: 1. FR - ; 2. FR+FA - ; 3. FR+PP - + ; 4. FR+LC + ; 5. FR+FA+LC - + ; 6. FR+PP+LC - + ; 7. FR+PP+MS - + ; 8. FR+DG+TP+LC - +

EXPLANATION: 1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue+bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue+bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; FR+PP=MS - red fescue + Kentucky bluegrass + alfalfa; FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil.

* (ANOVA),

(LSD_{0.05}).

Stratgraphics Plus v.2.1.

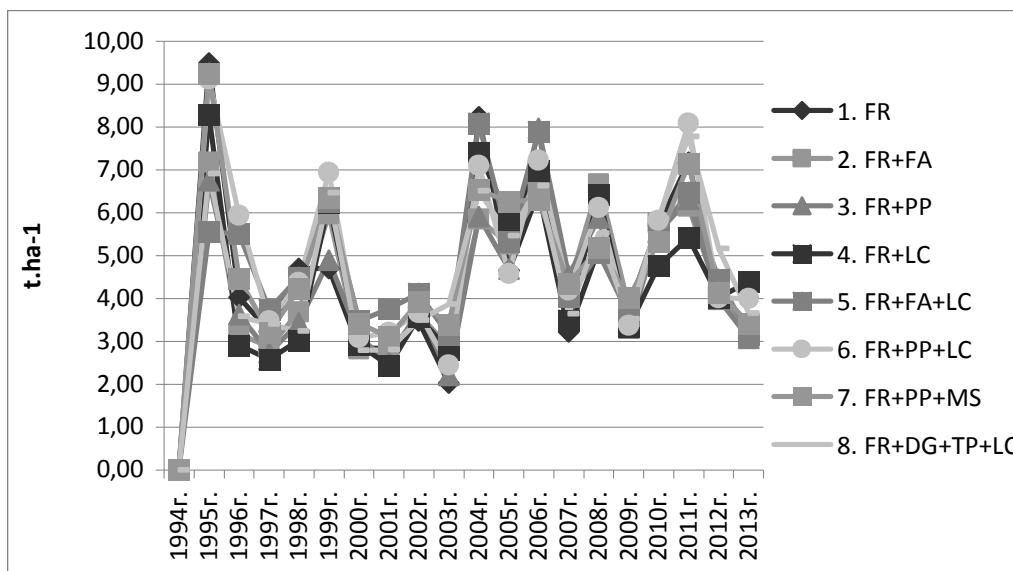
*Statistical variance analysis (ANOVA), a multiple comparison of mean values through the least statistically proven differences (LSD 0.05). Data is processed with Stratgraphics Plus v.2.1 statistical software.

There is different sequence in the manifestations of grassland in terms of productivity on soils with high degree of soil gleying, eastern exposure of the slope, in comparison with that at a low degree of soil gleying (Figure 3). An increase was established in 1995; 1999; 2004; 2006; 2008; 2010; 2011. Decrease occurred in 1997; 2000; 2001; 2002; 2003; 2007; 2009; 2012; 2013. In some years was reported a gradual decrease (1996; 2005), while in others (1998) respectively there was an increase in productivity.

(3).
1995; 1999; 2004; 2006; 2008;
2010; 2011 .
1997; 2000; 2001; 2002; 2003; 2007;
2009; 2012; 2013 .

(1996; 2005),

(1998)



. 3.
t.ha⁻¹,

1994-2013 ..

Fig. 3. Dry matter yield in years and variants for the period 1994-2003, in t.ha⁻¹, strongly gleyed soils

: 1. FR - ; 2. FR+FA - + ; 3.
FR+PP - + ; 4. FR+LC + ; 5. FR+FA+LC - +
+ ; FR+PP+MS - + ; 6. FR+PP+LC - +
+ ; FR+DG+TP+LC -

EXPLANATION: 1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue+bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue +bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; FR+PP+MS - red fescue + Kentucky bluegrass + alfalfa; FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil.

(9.50 t.ha⁻¹),
 t.ha⁻¹),
 (9.255 t.ha⁻¹)
 1995 .
 (7.97 t.ha⁻¹)
),
 2004 . (11
),
 (18
).

(Wong, 1997; Baggot, 2000;
 Madzharov et al, 2002).

(Mitev and
 Naydenova 2016).

(Mitev and
 Naydenova, 2012).

4).

" (Totev and Valkov, 1988).

The highest yield of red fescue, independently grown (9.50 t.ha⁻¹), in combination of red and tall fescue (7.175 t.ha⁻¹), or red fescue and bird's-foot-trefoil (8.29 t.ha⁻¹), or red fescue, Kentucky bluegrass and bird's-foot-trefoil (9.125 t.ha⁻¹), or red fescue, Kentucky bluegrass and alfalfa (9.255 t.ha⁻¹) was found in 1995. In joint cultivation of red fescue with Kentucky bluegrass (7.97 t.ha⁻¹) in 2006 (13th vegetation), of red fescue, tall fescue and bird's-foot-trefoil (8.09.5 t.ha⁻¹) in 2004 (11th vegetation), of red fescue, cock's foot, red clover and bird's-foot-trefoil (7.783 t.ha⁻¹) in 2011 (18th vegetation).

The Earth as a part of the system of the Universe is subjected to a constant energy impact, with a certain rhythm (Wong, 1997; Baggot, 2000; Madzharov et al., 2002, etc.). This issue is discussed in details in another author's study (Mitev and Naydenova 2016). It might be assumed that the environmental components, in this case soil variation with the corresponding biotic and abiotic part, variety in sunshine, irregular humidification, etc. relate accordingly to this effect. All this create prerequisites for differences in the manifestation of the particular plant / genetic material under their influence (Mitev and Naydenova, 2012).

Red fescue, when is grown alone, is slightly superior in productivity to its mixed grasslands with tall fescue, Kentucky bluegrass, with bird's-foot-trefoil (Figure 4). The three-component mixtures also exceeded them insignificantly in productive terms. The four-component grass mixture of red fescue, cock's foot, red clover and bird's-foot-trefoil is "differentiated as the best known for the region of the Central Balkan Mountain" (Totev and Valkov, 1988).

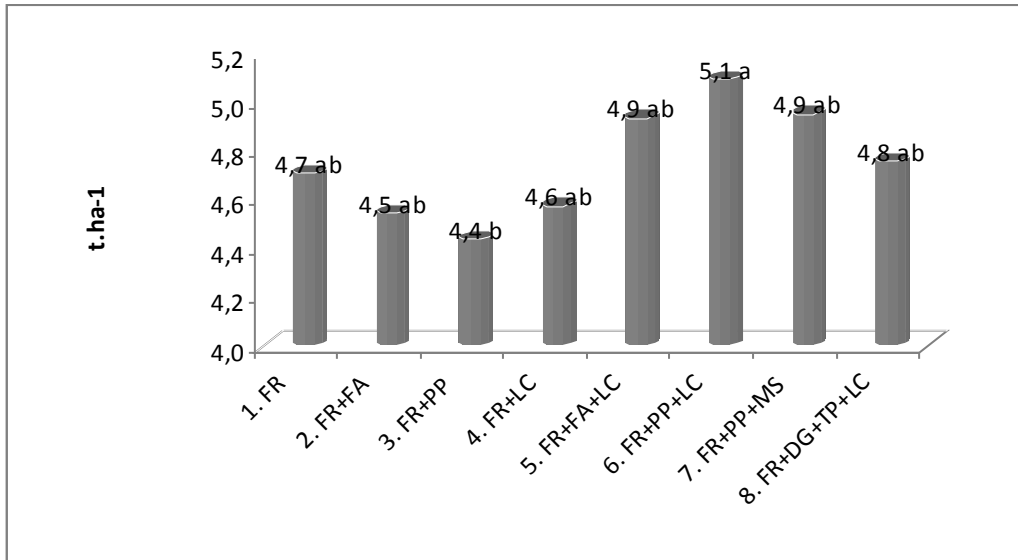


Fig. 4. Average yield in t.ha⁻¹ in variants, strongly gleyed soils in the period 1994-2013

1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue+bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue+bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; FR+PP+MS - red fescue + Kentucky bluegrass + alfalfa; FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil.

EXPLANATION: 1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue+bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue+bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; FR+PP+MS - red fescue + Kentucky bluegrass + alfalfa; FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil.

(ANOVA),

*Statistical variance analysis (ANOVA), a multiple comparison of mean values through the least statistically proven differences (LSD 0.05). Data is processed with Stratgraphics Plus v.2.1 statistical software.

Stratgraphics Plus v.2.1.

Under the conditions of heavily gleyed, pseudopodzolic soils, eastern slopes, it does not show an advantage during the study period in productive terms, in comparison with the independently grown red fescue. On average, over the first three years of use, the superiority over the other combinations involved in the study also emerged. However, following the average productivity for the first four years, the situation is changing in favor of red fescue, cultivated together with bird's-foot-trefoil, or red fescue, Kentucky

(Mc Gilchrist and Trenbath, 1971)

(Martin and Field, 1984).

(Casler and Valgenbach, 1990),

(Mitev and Yasheva 1998; Wardle, 1987),

(Mitev and Petrov, 1999).

bluegrass and bird's-foot-trefoil, for example.

There is an understanding that the increased competitive ability of species, expressed through their aggressiveness (Mc Gilchrist and Trenbath, 1971) creates conditions for increased productivity of the grasses (Martin and Field, 1984).

The issue of the role of competition (Casler and Valgenbach, 1990), indifference or mutual assistance (Mitev and Yasheva 1998; Wardle, 1987) in the relationship between some grasses is arguable (Mitev and Petrov, 1999).

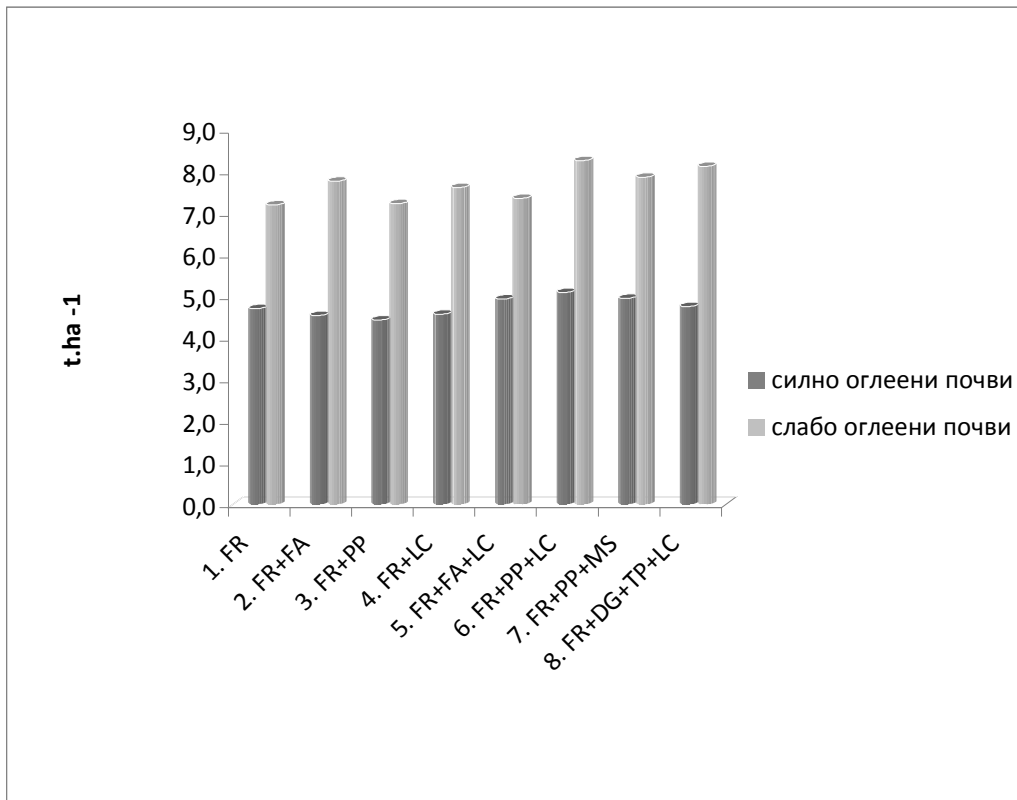


Fig. 5. Comparison of average yields on slightly and strongly gleyed soils, t.ha⁻¹

1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR+LC - red fescue + bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue + bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; 7. FR+PP+MS - red fescue + Kentucky bluegrass + alfalfa; 8. FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil.

EXPLANATION: 1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue+bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue+bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; 7. FR+PP+MS - red fescue + Kentucky bluegrass + alfalfa; 8. FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil.

(1994-2013 .)

7.199 t.ha⁻¹

8.26 t.ha⁻¹

4.435 t.ha⁻¹

5.09 t.ha⁻¹

1995; 1997; 1999; 2001; 2003 .

1996; 1998; 2000;

2002 .

2004; 2006; 2008; 2010. 2011

2013 .

2012 .

1995; 1999; 2004;

2006; 2008; 2010; 2011 .

1997; 2000; 2001; 2002; 2003; 2007;

2009; 2012; 2013 .

(1996; 2005),

(1998)

(1994-2013 .)

On average, during the survey period (1994-2013), the productivity of grasses on slightly gleyed soils is higher than that of heavily soiled ones (Figure 5). The yields on slightly gleyed soiled range from 7.199 t.ha⁻¹ in the case of independently grown red fescue, to 8.26 t.ha⁻¹, in the mixed cultivation of red fescue, Kentucky bluegrass and bird's-foot-trefoil. The yields on heavily gleyed soils are in the range of 4.435 t.ha⁻¹ with mixed grasslands of red fescue and tall fescue, up to 5.09 t.ha⁻¹ in combined cultivation of red fescue, Kentucky bluegrass and bird's-foot-trefoil

CONCLUSIONS

When grasslands are located on soils with low gleying, at a mountain slope with eastern exposure, a certain rhythm in the formation of feed mass in the variants is found. In odd years 1995; 1997; 1999; 2001; 2003 yields were higher than those in the even years 1996; 1998; 2000; 2002. The sequence changed in 2004; 2006; 2008; 2010. In 2011 and 2013, yields were again higher than in 2012.

There is different sequence in the manifestations of grassland in terms of productivity on soils with high degree of soil gleying, eastern exposure of the slope, in comparison with that at a low degree of soil gleying. An increase was established in 1995; 1999; 2004; 2006; 2008; 2010; 2011. Decrease occurred in 1997; 2000; 2001; 2002; 2003; 2007; 2009; 2012; 2013. In some years was reported a gradual decrease (1996; 2005), while in others (1998) respectively there was an increase in productivity.

On average, during the survey period (1994-2013), the productivity of grasslands on slightly gleyed soils was higher than that of heavily gleyed soils'

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II.

1, 2*

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Permanence of independent and mixed grasslands of red fescue under conditions of the Central Balkan mountain

II. Botanical composition

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SUMMARY

20 (1994-2013)

The study includes the results of a 20-year period (1994 - 2013) for the use of red fescue, grown alone and mixed with other meadow grasses. The grasslands have been created in the region of the Central Balkan Mountain, on the eastern slope, at low and high degree of soil gleying

The species composition of grasslands is a variable. It is in a direct connection with the habitat of each of them. The meadow grasses of local origin dominated over most time of the experiment. Red fescue is a component that determines the structure of the grasslands. There was self-sowing of other meadow species of a local origin. At the end of the reporting period (2006-2013), a significant weed infestation occurred with representatives of genus *Centaurea* on slightly gleyed soils. Their share in 2013 in mixed grassland of

58.4%,

50.2%.

- red fescue and Kentucky bluegrass reached 58.4%, and that of red and tall fescue reached up to 50.2%. Created grasslands on heavily gleyed soils show the ability of self-recovery and self-purification from weeds.

It is believed that this behavior stems from the presence or lack of synchronization of the particular plant / genetic material with the rhythm in Nature.

Key words: composition of grasslands, slopes, Balkan Mountains, hypothesis

INTRODUCTION

(Schmid, 2002).

- The question of the impact of species diversity on the yield of grasslands is extremely complex (Schmid, 2002). Different authors prefer to focus on one of its aspects. The cultivation of single or mixed grasses with a fewer or greater number of components is determined by specific habitat conditions (Sanderson et al., 2004).

(Sanderson et al., 2004).

The dispute over the advantages and disadvantages of creating single and mixed grasslands has had more than a 100-year history (Darwin, 1872).

(Darwin, 1872).

Many areas of the Balkan Peninsula as a whole, and in particular Bulgaria, include a number of secondary centers of creation of new genetic material, directly linked to the main one in the Alps. They are all part of the general Balkan genetic material creation center (Kozhuharov, 1986). Meadow species of local origin are a serious source of new cultivars (Goranova-Naydenova 2002; Mitev, 1997). They have the advantage of forming high-productive and long-lasting grasses, together with other species, under the specific habitat conditions (Naydenova and Mitev, 2008; Mitev et al., 2013 etc.).

(Goranova-Naydenova 2002; Mitev, 1997)).

(Naydenova and Mitev, 2008; Mitev et al., 2013).

The aim of the present study is to clarify certain aspects related to the sustainability of some artificial meadow

grasslands with the participation of red fescue, when they are located on the eastern slope of the Central Balkan Mountain, on slightly and heavily gleyed soils.

MATERIAL AND METHODS

The grasses covered in this study are situated on the eastern slope of the mountain. The soil is a pseudopodzolic, with a strong and low level of gleying (Penkov, 1998). The habitats covered are part of a larger scheme of ecological testing of cultivars and populations of meadow grasses of local origin, which were created in the region, (Mitev and Belperchinov, 2000). The slightly gleyed soils, at setting of the experiment, are characterized by pH_{kcl} - 4.7; the exchange cations in meqv/ 100 g soil: Al-0.6-1.0; Mn-0.3-0.8; Ca + Mg-0.9-11.1. The high degree of gleying is characterized by pH_{kcl} of 3.9-4.0; exchange cations in meqv / 100 g soil: Al-1.3-1.6; Mn-0.6-1.3; Ca + Mg-3.6-4.5.

The experiment was set in the spring of 1994, using the block method, in 4 replications, with a plot size of 4 m². In soil that has been brought to a garden state, 800 germinating seeds were sown per 1 m². In mixed grasslands, the components are 1/2; 1/3; 1/4 of the sowing standards for individual crops according to the variants. They were sown in a scattered method by hand, as after sowing it was rolled. Every second year, the experiment was fertilized with P80 kg.ha⁻¹ and K80 kg.ha⁻¹, reported from 1995, before the beginning of the vegetation of the grasses in the region. Each year, the ground was fed with N80 kg.ha⁻¹, since 1995 in the beginning of vegetation of grasses. Grasslands were cut in the phase of full tasseling-beginning of flowering of some grasses and budding-beginning of flowering of legumes. Botanical composition of grassland was reported. These types of grasslands were studied: 1 var. red

: 1 .
 - , 2 .
 + , 3 .
 + , 4 .
 + , 5 .
 + , 6 .
 + , 7 .
 + , 8 .
 +
 +
 (. Viola)
 (.) ,

fescue-independently, 2 var. red fescue + tall fescue, 3 var. red fescue + Kentucky bluegrass, 4 var. red fescue + bird's-foot-trefoil, 5 var. red fescue + tall fescue + bird's-foot-trefoil, 6 var. red fescue + Kentucky bluegrass + bird's-foot-trefoil, 7 var. red fescue + Kentucky bluegrass + alfalfa, 8 var. red fescue + cock's foot + red clover + bird's-foot-trefoil.

The seeds are of local origin with the exception of those of red clover ('Viola') and cock's foot ('Dabrava'), which is a Bulgarian cultivar.

RESULTS AND DISCUSSION

(1).
 , 91.7%
 1999 .
 (2001-2003),
 ú.
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 . -
 2001 . – 77.8%.
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 .
 ,
 (Mitev, 1995).
 ,
 /
 ,
 (Mitev
 and Naydenova, 2012).
 (Mitev, unpublished).

Red fescue is a structure determining component in the conditions of the experiment. When it is sown as a single culture on slightly gleyed soils, it reached up to 91.7% of the total forage mass in 1999. There are periods when its participation decreased (2001-2003), then it was followed by its increase. Red fescue is entirely dominant in its joint cultivation with Kentucky bluegrass. It gained the largest participation in the conditions of the experiment in 2001 – 77.8%. It also dominates in its joint cultivation with bird's-foot-trefoil, as well as in its joint cultivation with Kentucky bluegrass and bird's-foot-trefoil. The presence of Kentucky bluegrass is also rather weak in its joint cultivation with red fescue and alfalfa. In an experiment carried out with the last two grass combinations in a previous period, a significant presence of Kentucky bluegrass was found in the total forage yield (Mitev, 1995). It can be assumed that the difference is due both to the period of formation of the particular plant/genetic material and when it begins its life cycle, according to the rhythm in Nature (Mitev and Naydenova, 2012).

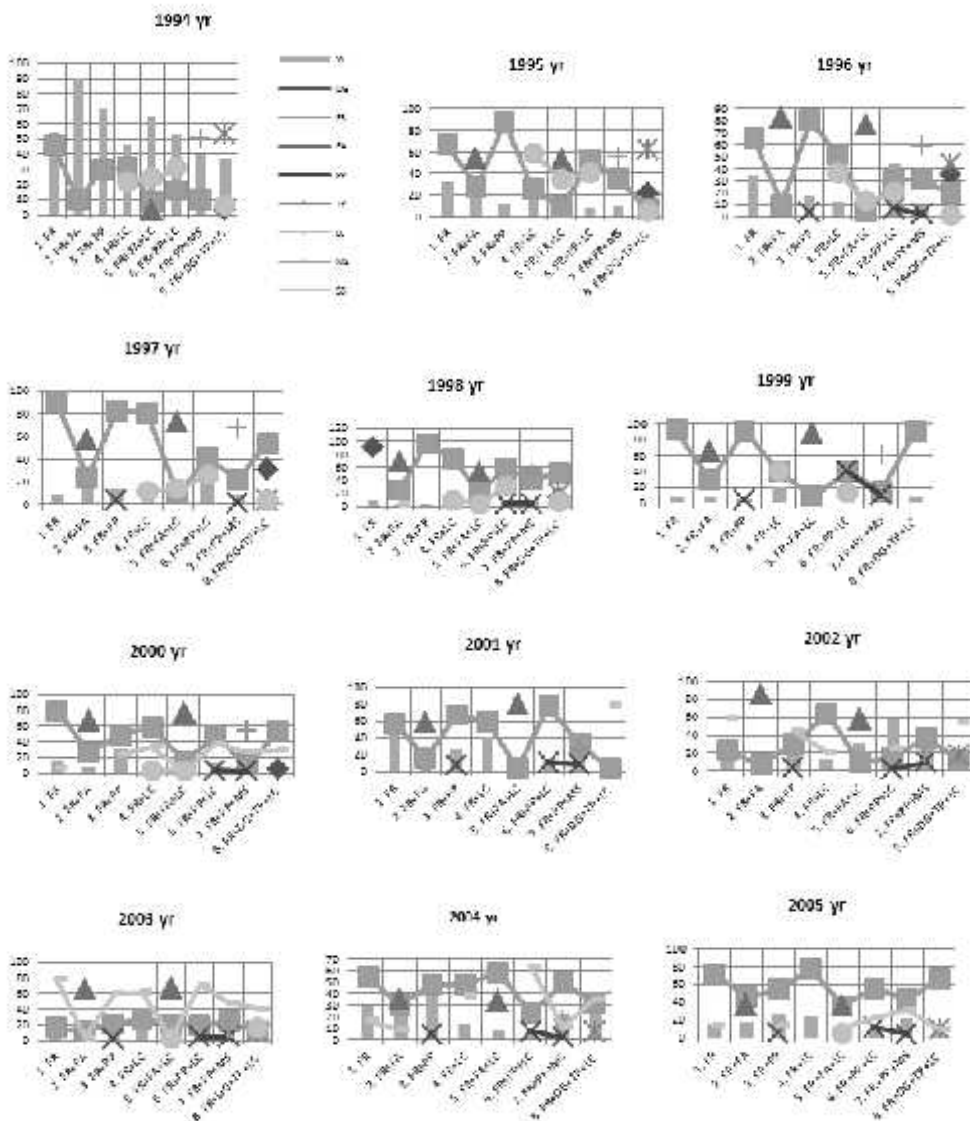
This specificity inevitably influences the formation of relations in the grasslands (Mitev, unpublished). Red fescue was in depressed condition during the initial

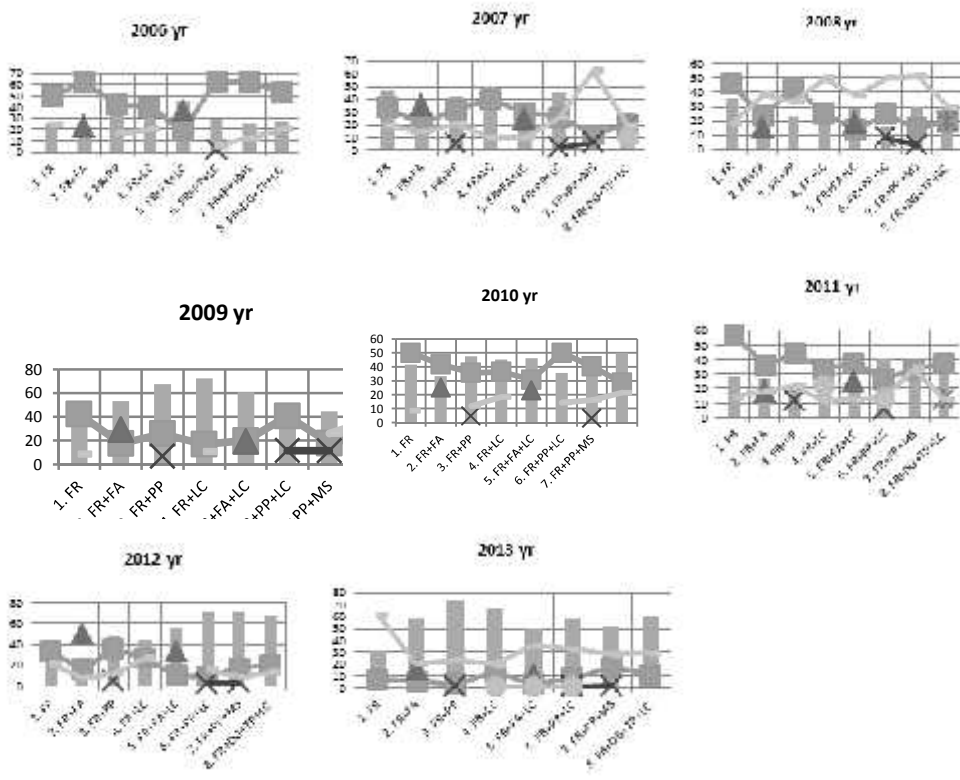
Ú period of its joint cultivation with the tall fescue.

2001-2003

The decrease in its share in the grassland in 2001-2003 suggests that the period was not particularly favourable for its greater growth and development. Since 2008, sown grasses had a poor performance in the total forage yield.

2008





1. , 1994-2013 .
Fig. 1. Botanical composition of grasslands in %, first regrowth, slightly gleyed soils, 1994-2013

EXPLANATION: 1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue+bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue+bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; 7. FR+PP+MC - red fescue + Kentucky bluegrass + alfalfa; 8. FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil

Tall fescue dominated also in its joint cultivation with tall fescue and bird's-foot-trefoil during the first 10 years (1994-2003) of the reported period. The small share of cock's foot and bird's-foot trefoil, in the grassland in their joint cultivation with red fescue and red clover, provoke the willingness to reconsider the appropriateness of this combination, "distinguished as the best for the Central Balkan Mountain" (Totev and Valkov, 1988). We believe that, under the

“ (Totev and Valkov, 1988).
 (2 2)))
 - 92.0%,
 88.0%
 ú,
 (, 1996).
 2000 .
 (*Trifolium repens* L.),
 (*Medicago lupulina* L.),
 (*Trifolium campestre* Schreb.),
 (*Trifolium agrarium* L.)
 (Tracy and Sanderson, 2004).
 (Mitev and Naydenova,
 2012; Mitev et al., 2013),
 (Tracy and Sanderson, 1999).

conditions of our experiment, there is a certain incompatibility (2x2) between grass (cock's foot and red fescue) and legume (red clover and bird's-foot-trefoil) components. Their selection should be based on the long-term nature of the interests.

These results could be compared with others from a previous authors' experiment on slightly gleyed soils, but on a flat terrain where the cock's foot had the full prevalence of 92.0% at the second vegetation and 88.0% at the third. Its aggressiveness, however, does not provide superiority in the productivity of the four-component grassland over the mixed ones of red fescue and bird's-foot-trefoil, red fescue, tall fescue and bird's-foot-trefoil. Its production is less in comparison to the red fescue, Kentucky bluegrass and bird's-foot-trefoil (Mitev, 1996).

Since 2000, there has been a general self-sowing in the created grassland of other meadow grasses of local origin. This is achieved at the expense of seeds of white clover (*Trifolium repens* L.), black medick (*Medicago lupulina* L.), low hop clover (*Trifolium campestre* Schreb.), large hop clover (*Trifolium agrarium* L.) etc., which exist in the soil. Geographic location is known to affect the amount of seed available, creating prerequisites for this phenomenon (Tracy and Sanderson, 2004). The presence of self-sown white clover is found in other authors' publications (Mitev and Naydenova, 2012; Mitev et al., 2013) and in the area of the Rocky Mountains in the United States (Tracy and Sanderson, 1999). The sown and self-sown grasses counteract the realization of the local weed complex.

Over the years of the present study, the weed species have changed. Their share has been greater in

60.7%, 2013 50.2%.

(2013), 58.4%.

Centaurea. (2008-2013), (2)

(Callaway and Ridenour, 2004).

Centaurea maculosa (*Centaurea diffusa* ((Asia Minor: Turkey, Syria), the Balkans: Bulgaria, Greece, Romania, Ukraine, and southern Russia).

(Bais et al., 2002, 2003; Callaway and Aschehough, 2000). Bais et al., (2003)

C. maculosa

grasslands on slightly gleyed soils in the last third of the experiment. The weed infestation in the mixed grassland of red fescue, tall fescue and bird's-foot-trefoil, in 2009 reached 60.7%, and in 2013 it was 50.2%. In the last year of the present study (2013), the proportion of weeds in the grassland of red fescue, Kentucky bluegrass and bird's-foot-trefoil rose up to 58.4%. In this habitat, representatives of genus *Centaurea* are widely spread. In recent years of the experiment (2008-2013), a significant presence of centaury has been found. At a high degree (Figure 2) of gleying, only individual representatives are encountered. The reasons for the heterogeneity of the observed phenomenon should be sought. It is noteworthy that rhizospheric flora and fauna react to the effect by releasing into the surrounding area a number of biologically active compounds. This process leads to a change in the chemical and biochemical nature of the soil (Callaway and Ridenour, 2004).

In a series of experiments, the allelopathic effects have been studied of widely distributed species, such as *Centaurea maculosa* (spotted knapweed, native to Eastern Europe) and *Centaurea diffusa* (white knapweed, native to Asia Minor and the Balkans)(Asia Minor: Turkey, Syria), the Balkans: Bulgaria, Greece, Romania, Ukraine, and southern Russia). These species conquer ever larger areas in the United States and Canada.

There is an influence both over the extension of roots of grasses and also a change in the activity of their rhizosphere (Bais et al., 2002, 2003, Callaway and Aschehough, 2000). Bais et al., (2003) show the allelopathic effect of *C. maculosa* by integrating an ecological, physiological, biochemical, cellular and genetic approach. When comparing, in vascular experiments, the manifestations of American and European grass

(Bais et al., 2003)

()

Centaurea maculosa

(2).

ú

(2004; 2005; 2009 .)

ú 1998 .

88.5%, 2008 . (15

) – 67.7%.

ú

ú

73.9% 1999 .,

63.2% 2002 .,

2012 . (19

).

ú 2001 .

66.7%, 2009 . (16

61.3.

ú

1999 . ú 87.5%

(19

)

67.6%.

species, they establish greater resilience to those of Europe. These authors (Bais et al., 2003) challenge the traditional understanding of the role of allelopathy, mainly in the field of competition for environmental resources. They highlight the importance of the biochemical potential of these (weed) species, which directly affect the genetics of the accompanying grasses. In this way, *Centaurea maculosa* suppresses their basic life processes.

Red fescue is a component that determines the structure of grasslands when they are located on heavily gleyed soils (Figure 2). In its independent sowing and growing, it dominated with few exceptions (2004; 2005; 2009) for the period of study. Its share in 1998 reached up to 88.5% and in 2008 (15th vegetation) to 67.7%. These exceptions indicate the possibility of the grassland for self-purification from weeds and for self-restoration.

This ability is valid not only for the self-grown red fescue, but also for the grass combinations in which it is included. Red fescue dominates when it is mixed with Kentucky bluegrass, with bird's-foot-trefoil, as well as with these two sown together. Its presence in their three-component grassland reached 73.9% in 1999, to 63.2% in 2002, and to 70.2% in 2012 (19th vegetation).

The tall fescue determines the herbaceous component when mixed with red fescue and bird's-foot-trefoil. Its share in 2001 reached 66.7% and in 2009 (16th vegetation) up to 61.3%. Once again, red fescue is the dominant component when mixing it with Kentucky bluegrass and alfalfa. In 1999, its share was 87.5% of the total forage yield. In 2012 (19th vegetation), its presence was 67.6%.

Alfalfa quickly drops out of the grasslands. It is true that the alfalfa

2002). (Bouton, 1996; Sledge et al.,

()

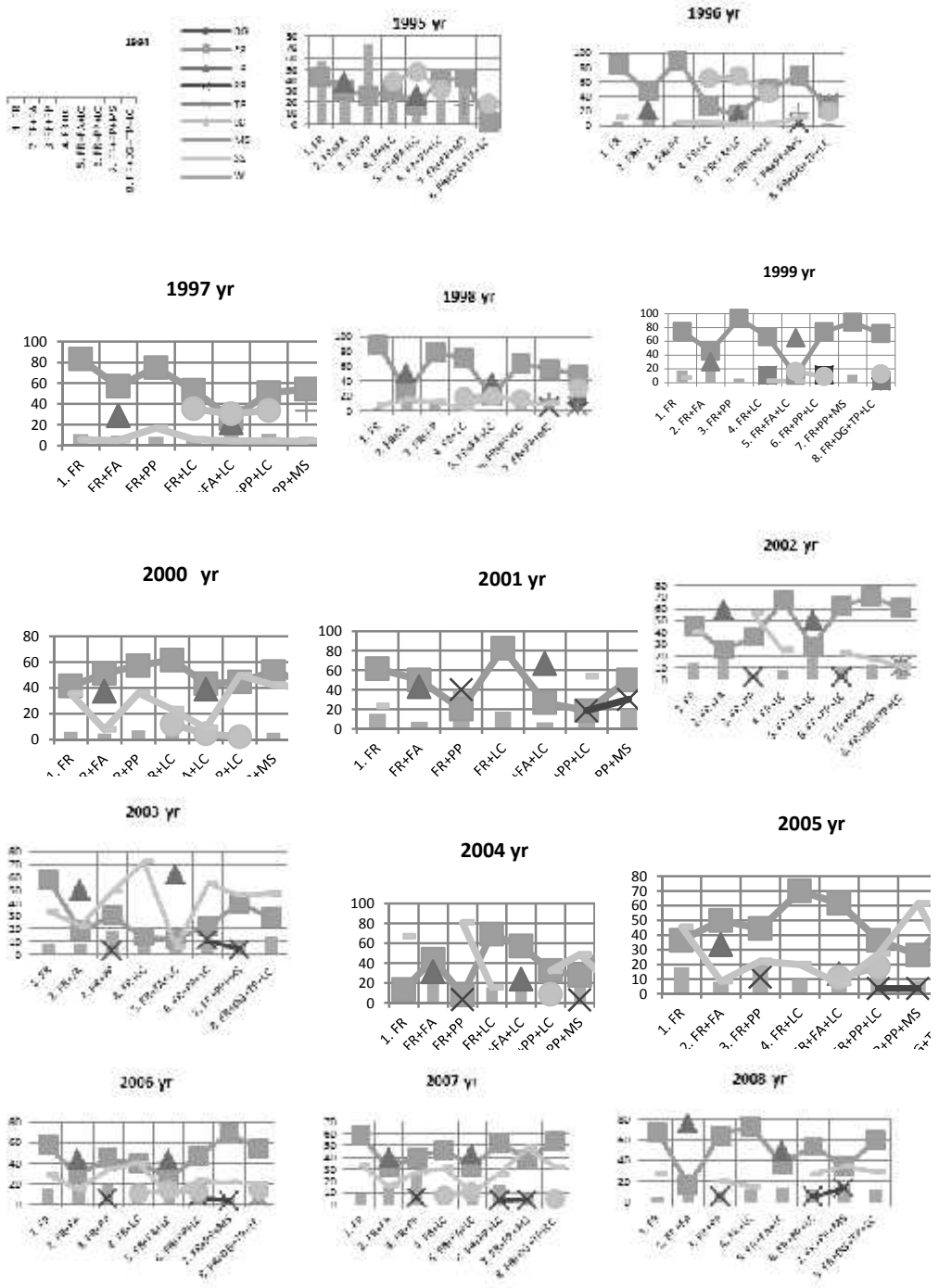
1997 .
(2013 .). 71.4% (1999 .),
62.5% (2011 .).

2004 .
80.6%; 2009 . 58.7%.

presence of genetic control has been found to be tolerant to acidic soils with increased alumina content (Bouton, 1996; Sledge et al., 2002). It is a fact that we have run a series of selections to increase that tolerance. This is a part of our program to create suitable alfalfa cultivars for cultivation on pseudopodzolic soils. Alfalfa population, which we selected, located on slightly gleyed soils, has managed to keep within certain limits for eleven years.

In areas adjacent to the experiments, there are terrains extremely saturated with clay, high soil acidity and microelements (manganese and aluminum) in concentrations that are toxic to the crops so that no vegetation is found on them. Certainly, it is not appropriate to create and grow mixed grasslands of red fescue, cock's foot, red clover and bird's-foot-trefoil on heavily gleyed, pseudopodzolic soils with eastern exposure. Cock's foot, red clover and bird's-foot trefoil dropped off quickly from the grasslands. Red fescue dominated with little exceptions from 1997 to the end of the reported period (2013). Its share in individual years reached 71.4% (1999), and 62.5% (2011).

Self-sowing of other meadow grasses with local origin in the established artificial grasslands is a variable. The formation of a two-component grass mixture of red and tall fescue, as well as a three-component of these two species, together with bird's-foot-trefoil, decreased the self-sowing rate. Self-sowing is a kind of alternative to artificially created grasses. When sown species decrease their participation in grasslands then the proportion of self-sowing increases. In 2004, the self-sowing rate in the grassland of red fescue reached up to 80.6%; and in 2009 up to 58.7%.



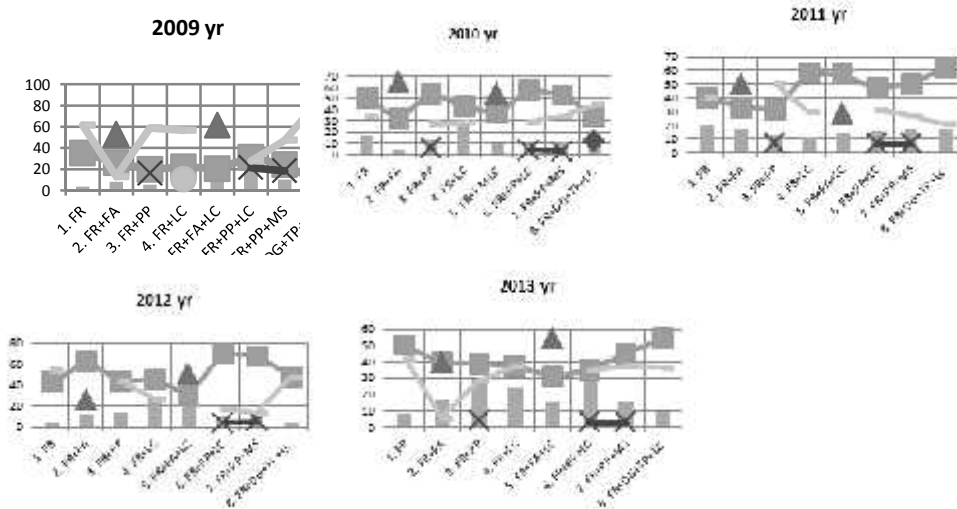


Fig. 2. Botanical composition, first regrowth, in %, highly gleyed soils, 1994-2013

EXPLANATION: 1. FR - red fescue; 2. FR+FA - red fescue + tall fescue; 3. FR+PP - red fescue + Kentucky bluegrass; 4. FR + LC red fescue+bird's-foot-trefoil; 5. FR+FA+LC - red fescue + tall fescue+bird's-foot-trefoil; 6. FR+PP+LC - red fescue + Kentucky bluegrass + bird's-foot-trefoil; 7. FR+PP+MS - red fescue + Kentucky bluegrass + alfalfa; 8. FR+DG+TP+LC - red fescue + cock's foot + red clover + bird's-foot-trefoil

Taken together, they counteract the growth and development of the local weed complex. Self-sowing of other meadow grasses of local origin is usually increased after the legume component dropped off. Analogical behaviour is found in another author's experiment when the level of self-sowing, especially of meadow grasses, is increased when the sown legumes dropped off. Self-sowing of grasses in abandoned arable land, as a part of the experiment, occurs in a lower rate, in comparison with those in which legumes are sown (Mitev et al., 2013).

(Mitev et al., 2013).

The weed infestation of grasslands is poorly expressed. In the year of grasslands' establishment (1994) was carried out a "sanitary mowing" to reduce the level of weed infestation. After 1995

2010 .
 10.6%,
 16.7%
 3.6%,
 2009 .
 2011 . – 11.8%.
 2010 . 2009
 2012 . – 4.2%.

the level of weed infestation was low. Exceptions are also found. In 2010, the weeds in the grassland of red fescue and bird's-foot-trefoil took 28.6% of the total weight. In 2009, however, they were 10.6% and in 2011 – 11.8%. There were 16.7% of weeds in 2010 in the grassland of red fescue, independently grown. In 2009, however, they were 3.6% and in 2012 – 4.2%.

CONCLUSIONS

The composition content of grasslands is a variable. It is in a direct connection with the habitat of each of them.

91.7%
 1999 .,
 96.0% 1998 .
 2013 .),
 (2006-
 (Centaurea). 2013 .
 58.4%,
 50.2%.

Red fescue is a component that determines the structure of the grasslands. Its share in its independent grassland reached 91.7% in 1999, with a low degree of soil gleying. In a mixture with Kentucky bluegrass, it reached 96.0% in 1998. It is a predominant species when it was mixed with a bird's-foot-trefoil, with Kentucky bluegrass and bird's-foot-trefoil or alfalfa. Tall fescue dominates the two- and three-component mixtures with it, in the first decade of the reporting period. The next decade, the red fescue took the precedence. The behavior of the species when sown on heavily gleyed soils is basically the same as found in poorly gleying.

There was self-sowing of other meadow species of local origin.

At the end of the reporting period (2006-2013), a significant weed infestation occurred with representatives of genus *Centaurea* on slightly gleyed soils. Their share in 2013, in mixed grassland of red fescue and Kentucky bluegrass, reached 58.4%, and that of red and tall fescue reached up to 50.2%. Created grasslands on heavily gleyed soils show the ability of self-recovery and self-purification from weeds.

It is believed that this behaviour stems from the presence or lack of

/ - | synchronization of the particular plant /
genetic material with the rhythm in Nature.

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Reaction of different sugar beet genotypes to organic fertilization

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SUMMARY

The effect of leaves treatment with a complex of organic fertilizers – 0.5% Arbanassyecosyst + 0.7% Aminobest on the productivity, the sugar content and the biological sugar yield of standard varieties (Diex and Peshtera), multigerm pollinators and their hybrids with two diploid MS lines of sugar beet has been studied in the present research. The period of testing – 2014-2015 – includes two seasons with differing agro-climatic conditions and duration of the vegetation. It was established a positive effect of the application of the complex of organic fertilizers on the root yield and biological sugar yield in the drought conditions of 2015. The average root yield from the treated with organic fertilizers variants (3828.8 kg/da) is significantly higher than the yield of the control variants (2882.4 kg/da). With insufficient differences in the sugar content of the tested variants the yield of biological sugar of the variants treated with the organic fertilizers complex (570.3 kg/da) is proven higher than the yield of the control variants (434.4 kg/da).

Key words: organic fertilizers, sugar beet, sugar content, yield

INTRODUCTION

L.) (*Beta vulgaris* L.) is a technical crop, which is grown for the production of crystal sugar, sweet syrups, and the high content of aminoacids in the biomass is a precondition for its use as a raw material in livestock breeding (Vladimirov, 1973).

The sugar beet is with the highest energy value among the root crops, and the digestibility is 75%. The root's dry matter includes 70-75% carbohydrates, pectin-2.5%, nitrogenous substance-0.12-0.26%, organic acids, soluble ashes, Na, Ca etc. (Agribusiness Handbooks, 1999).

Valuable forage for livestock breeding are the leaves, tap-roots, the beet harrows and the molasses. For industrial purposes from the molasses is obtained alcohol, citric, lactic, glycolic acids, glycerin, betain, bread yeast, yeasts etc. (Uchkunov, 2008).

For restriction of the phytotoxic effects of chemistry and for increase of the adaptive capabilities of the plants the efforts of the agricultural science are directed to finding and application of bio-substances (Boraste et al., 2009; Yakimov, 2013).

The organic fertilization of the cultivated crops is becoming more and more actual. The aim of the biological agriculture is the creation of integrated, ecological and economically resistant system for obtainment of agricultural production (Stacey, 2003).

The application of bio-fertilizers challenges an increase of the entire physiological-biochemical activity of plants, improves their condition, which brings to better overcoming of biotic and abiotic stress (Panayotov et al., 2003; Georgieva and Nikolova, 2011). They are cheap, effective and renewable source of plant nutritional substances, which successfully complete the chemical fertilizers (Boraste et al., 2009).

The sugar beet (*Beta vulgaris* L.) is a technical crop, which is grown for the production of crystal sugar, sweet syrups, and the high content of aminoacids in the biomass is a precondition for its use as a raw material in livestock breeding (Vladimirov, 1973).

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(Nassar et al., 2005; El-Tarabily and Sivasithamparam, 2006; Cloete et al., 2009).

(Gomaa and Mohamed, 2007; Eman et al., 2008).

((Yakimov, 2013).

A great number of recent studies show that the growth of the root plants could be directly or indirectly enforced by yeasts in the rhizosphere (Nassar et al., 2005; El-Tarabily and Sivasithamparam, 2006; Cloete et al., 2009). Great variety of soil yeasts have been studied for their potential as bio-fertilizers (Gomaa and Mohamed, 2007; Eman et al., 2008). They regulate the intensity of nutrition substances assimilation from the soil by increase of the absorbing capability of the root system, which brings to realization of the genetic potential of the plants (Yakimov, 2013).

The aim of the present research is to study the influence of new bio-regulators on the productivity, sugar content and biological sugar yield of varieties and hybrids of sugar beet.

MATERIAL AND METHODS

The research is carried out in the experimental fields of Agricultural Institute-Shumen, during 2014-2015. The field experiments are arranged by the long plot method, in four repetitions, with a harvest plot of 10.8 m², on carbonate black soil with a slightly alkaline reaction of the soil solution.

The sowing is manual, at 70 cm distance between rows (10000 plants per da), made on 20.04 during the two years of tests. The variants are treated once with organic fertilizers in the phase of leaf rosette forming (8-10 real leaf), with a knapsack sprayer and with a solution of 25.0 l/da. The harvest is manual – during the third decade of September.

The combination of organic fertilizers 0.5% Arbanassyecosyst and 0.7% Aminobest was tested for the sugar beet varieties Diex (2x) and Peshtera (3x), the multigerm pollinators M-Dx (2x) and M5319 (4x) and hybrids (2x and 3x) of these pollinators with two monogerm diploid MS lines (MS222 and MS201).

2014-2015

10.8 m².

70 cm
(10000 - /da) 20.04

(8-10),

25 l/da.

0.7% 0.5%

(2x) (3x),

(2) 5319R (4x) (2x 3x)

(222 201).

* Bacillus subtilis, Bacillus licheniformis, Azotobacter chroococcum and vinelandii – in 200 ml/da dose.
 9,50-12,50 %; pH 9,0-13,0; 1,65 %
 ; 4,02 %
 ; : 0,40-0,75 %;
 : P: 0,10-0,25 %;
 : 0,55-0,70 %; Na: 0,2-0,37 %; Ca: 0,001-0,003 %; Mg: 0,009-0,013 %; Cu: 0,002-0,003 %; Zn: 0,0003-0,0006 %; Mn: 0,0005-0,0009 %; Fe: 0,001-0,003 %; Ni<0.0005; Cd<0.00003; Hg<0.000005; Cr<0.00003; b<0.0005 – 200 ml/da.

) e (kg/da),
 (%) (kg/da).

1988).

(1).

310.0 mm,

537.7 mm,

(226.5 mm)

The content of the applied fertilizers is:

*Arbanassyecosyst – contains several Bacillus subtilis strains, as well as the bacteria Bacillus licheniformis, Azotobacter chroococcum and vinelandii – in 200 ml/da dose.

*Aminobest – dry matter 9.5-12.5%, pH 9.0-13.0, 1.65% humine compounds, 4.02% amino acids, 0.4-0.75% total nitrogen, micro and macro-elements – P – 0.1-0.25%, K – 0.55-0.70%, Na – 0.20-0.37%, Ca – 0.001-0.003%, Mg-0.009-0.013%, Cu – 0.002-0.003%, Zn – 0.0003-0.0006%, Mn – 0.0005-0.0009%, Fe – 0.001-0.003%; heavy metals: Ni<0.0005; Cd<0.00003; Hg<0.000005; Cr<0.00003; b<0.0005 – in a dose of 200 ml/da.

The comparison between the treated with the organic fertilizers complex varieties, hybrids and pollinators of sugar beet and the relevant control variants (without foliar fertilization with the organic fertilizers complex) is by the indices root yield (kg/da), sugar content (%) and biological sugar yield (kg/da). The sugar content of the tested hybrids is measured according to the cold digestion method in the chemical-technological laboratory of the Agricultural Institute- Shumen.

Data received are statistically treated by dispersion analysis according to Lidanski (1988).

RESULTS AND DISCUSSION

In the first year of study the quantity of the fallen rainfalls during the vegetation period significantly exceeds the agro-climatic norm (Table 1). The sum of rainfalls for the six months is 537.7 mm, with a norm of 310.0 mm, And the most serious are the rainfalls in May (226.5 mm) and especially those, fallen in the last decade of the month.

1.
2014-2015 .

Table 1. Meteorological conditions in Agricultural institute-Shumen during 2014-2015

Year	Month	Rainfalls				Air temperature	
		/ Decades			/ Sum	/ Norm	/ Mean
2014	V	-	33.8	10.6	44.4	41.0	11.5
	V	26.0	52.9	147.6	226.5	64.0	15.1
	V	37.0	19.9	14.6	71.5	75.0	19.3
	VII	2.2	4.4	63.9	70.5	60.0	21.9
	VIII	29.0	37.3	4.0	70.3	42.0	22.5
	IX	54.3	0.2	-	54.5	28.0	17.5
/ Total for the period					537.7		
2015	V	32.6	10.5	10.0	53.1	41.0	14.6
	V	6.3	3.2	6.3	15.8	64.0	20.8
	V	2.5	18.6	3.0	24.1	75.0	23.6
	VII	2.3	6.6	-	8.9	60.0	27.1
	VIII	0.6	8.8	15.2	24.6	42.0	28.4
	IX	1.1	40.2	-	41.3	28.0	22.8
/ Total for the period					167.8		

(2).

(, -Dx,
MS222 x M-Dx, MS201 x M-Dx)

(2984.3 kg/da)
(3093.8 kg/da)

M5319R (

- 14.1%

14.5%

).

- In such a climatic situation the
- productivity of the tested diploid hybrids
- and pollinator flattens up with that of the
- triploid hybrids (Table 2). It could be
- noted the slight excess in the root yield
- from the treated with foliar fertilizers
- diploid variants (Diex, M-Dx, MS222 x M-
- Dx, MS201 x M-Dx) compared to the
- yield of the relevant non-treated variants.

- But proved differences between treated
- with organic fertilizers variants (2984.3
- kg/da) and the relevant control variants
- (3093.8 kg/da) are not registered. There
- are no reported significant differences in
- the sugar content too.

- Here the higher values of the index for
- the triploid hybrids of the tetraploid
- pollinator M5319R (the pollinator is with
- the highest sugar content among all the
- tested variants – 14.1% sugar content of
- the control variant and 14.5% of the
- variant treated with organic fertilizers) are
- normal. However we could note the

MS222 x M-Dx (2x)
(3x),

higher values of sugar content of the treated variants of the hybrids MS222 x M-Dx (2x) and Peshtera (3x), but we do not have the reason to state, that this is due basically to the applied foliar fertilizers.

T 2.

, 2014

Table 2. Productivity, sugar content and biological sugar yield of varieties, hybrids and parental components of sugar beet, treated with foliar organic fertilizers, 2014

Variant	Root yield kg/da		Sugar content %		Biological sugar yield kg/da	
	Non-treated.	Treated	Non-treated	Treated	Non-treated	Treated
Diex-2	3196	3244	13.2	13.2	423	426
M Diex-2x	3143	3327	13.1	13.0	410	433
MS 222 x -Dx	3500	3202	13.0	13.8	456	441
MS 201 x -Dx	2524	3006	13.4	13.4	338	402
Peshtera-3	3429	3149	13.3	13.9	456	440
5319R-4x	3101	2357	14.1	14.5	438	342
MS 222 x 5319	3030	3089	13.5	13.4	410	414
MS 201 x 5319	2827	2500	13.9	13.6	391	340
Mean	3093.8	2984.3	13.4	13.6	415.3	404.8
GD 1 %	804		0.84		108	
P %	5.02		1.96		4.13	

MS201 x M-Dx e
(402 kg/da)
(338 kg/da).

The biological sugar yield is a resultant index. Data received for the tested hybrids and pollinators do not show somewhat a special effect from the foliar organic fertilizers' application, there are no proved differences between the variants treated with Arbanassyecosyst and Aminobest, and the control variants. The treated variant of the hybrid MS201 x M-Dx is with significantly higher yield of biological sugar (402 kg/da) than the non-treated variant of that hybrid (338 kg/da). This is due to the quite higher root yield from the treated variant in the climatic conditions in this year of testing.

M5319R

At the same time a significantly lower biological sugar yield in comparison with the treated variant is realized by the non-treated tetraploid pollinator M5319R (the

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 . ,
 .
 2014 . ,
 .
 a ,
 167.8 mm, -
 .
 ,
 -
 -
 kg/da
 2882.4 kg/da (3).
 -
 .
 0.2%

- same variant is also with significantly lower root yield). This diversity of the reaction of the above mentioned variants could not be due to the application of foliar organic fertilizers. The more that the mean value of the biological sugar yield from all the tested treated variants is almost the same with that of the relevant control variants.

- The 2014 test data show, that in the conditions of heavier vegetation rainfalls the application of the foliar organic fertilizers combination in the sugar beets is not advisable.

- The next year of testing is with radically opposed climatic conditions during the vegetation period. The significantly higher air temperatures during vegetation, compared to those in the previous year, are accompanied with significant drought during the period May-September. The sum of vegetation rainfalls is barely 167.8 mm, almost double lower than the normal for sugar beet development. The presence of sufficient soil moisture in April allowed uniform germination in the experimental plots, but the remaining part of vegetation passed with a sensitive water deficiency.

- In these conditions is registered significantly higher root yield from the treated with foliar fertilizers variants – the mean root yield value of the treated variants is 3828.8 kg/da while the average yield from the non-treated control variants is 2882.4 kg/da (3). Definitely in this case the treatment with bio-fertilizers increases the intensity of nutritional substances' assimilation from the soil by increase of the absorbing capabilities of the root system. The sugar content of the treated variants is with 0.2% lower than the average value of the control variants, and this is normal having in mind the well known negative correlation between the indices root yield and sugar content.

MS222 x M5319 - But for the hybrid MS222 x M5319 is registered significantly higher sugar content of the treated variant (15.8%) compared to the control variant (14.5%), which speaks about a clear positive genotypic reaction of the hybrid to the applied complex of organic fertilizers.

(15.8%) e - (14.5%), -

T 3. , , 2015

Table 3. Productivity, sugar content and biological sugar yield of varieties, hybrids and parental components of sugar beet, treated with foliar organic fertilizers, 2015

Variant	Root yield kg/da		Sugar content %		Biological sugar yield kg/da	
	Non-treated	Treated	Non-treated	Treated	Non-treated	Treated
Diex-2	3117	4175	14.8	14.2	461	593
M Diex-2x	2777	3003	14.8	14.6	411	438
MS 222 x -Dx	2574	4004	14.7	14.4	378	577
MS 201 x -Dx	2860	3718	14.8	14.0	423	521
Peshtera-3	3146	4147	16.0	15.3	503	634
5319R-4x	3003	3861	15.5	15.2	465	587
MS 222 x 5319	2717	3575	14.5	15.8	394	565
MS 201 x 5319	2865	4147	15.5	15.6	440	647
Mean	2882.4	3828.8	15.1	14.9	434.4	570.3
GD 1 %	783		0.62		78	
P %	7.09		1.31		6.89	

(570.3 kg/da) - MS
 (434.4 kg/da). -
 222 – MS
 MS222 x M-Dx -
 577 kg/da 378 kg/da -
 565 kg/da -
 MS222 x M5319 394 kg/da -
 2015

The mean value of the biological sugar yield of all treated variants (570.3 kg/da) exceeds significantly that from the non-treated control variants in the experiment (434.4 kg/da). Logically the excess is the greatest for the diploid and triploid hybrids of MS 222 – from the treated variant of the diploid hybrid MS222 x M-Dx is realized a yield of 577 kg/da, with 378 kg/da from the control variant of the hybrid, respectively 565 kg/da from the treated triploid variant MS222 x M5319 with 394 kg/da from the control triploid variant. Only for the diploid pollinator of the variety Diex the excess in the biological sugar yield for the treated variant is not proved. These data from the tests in the extremely dry 2015 show a

- definite positive effect of the foliar organic
- fertilizers Arbanassyecosyst and
- Aminobest application on the productivity
- of the tested sugar beet hybrids and

pollinators.

CONCLUSIONS

- The foliar fertilization with the complex of organic fertilizers Arbanassyecosyst and Aminobest has a positive effect on the yield of roots and biological sugar in years with drought during the vegetation period of the sugar beet.

- The application of the same complex of organic fertilizers is not reasonable in case of prognosis for significant quantities of vegetation rainfalls.

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