Seed Productivity of Red Fescue Clones

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SUMMARY

Red fescue is a valuable perennial grass, suitable for the creation of extensive pastures and decorative purposes. Featuring good yields of fodder in the summer due to drought resistance and poor and dry soils. It has a slow initial development but forms a fine and dense sward. In 2014 at the Institute of Forage Crops - Pleven were created two polycrosses were established for the purpose of randomized and equivalent crossing and pollination of vegetatively propagated parent clones of red fescue.

The following scheme was used for each of them: 30 selected clones were propagated in 4 replicates - a total of 120 plants at a distance of 50 x 50 cm. An isolating strip of winter rye is provided.

During the period 2014-2017, seeds from each clone were harvested and the productivity of seeds and its components was taken into account: weight of seeds (g). Mean, minimum, maximum values, standard deviations, and variation
coefficient, by traits, parent components, and years are presented. According to method of Fransis and Kannenberg (1978) with mean seed productivity parameters and average variation coefficient, genotypes of each polycross exceeding the average polycross values were selected averaged over four consecutive years. Clones with the highest productivity by years and total over the survey period were identified. A total of 13 genotypes of red fescue are of interest to the breeding, and 9 with higher and more stable seed productivity than the average for the first polycross period are: 28, 23, 15, 13, 19, 18, 21, 24 and 9. For the second polycross, there are 15 genotypes of interest to the breeding, and 6 with higher and more stable seed productivity are: 27, 11, 10, 15, 14 and 21. Selected clones with the highest and most stable seed productivity will participate as parent components for the formation of synthetic populations, in subsequent crosses and will be stored as a gene pool.

Key words: red fescue, clones, polycross, productivity, seeds, coefficient of variation

INTRODUCTION
The genus Festuca L. involve very diverse grasses which are important components of natural, permanent, and intensively managed grasslands, lawns, and turfs, and are used for conservation purposes. Fine fescues are a group of cool season perennial grasses that are commercially and agronomically valued for forage, turf, landscape, and ornamental purposes (Peeters, 2004; Boelt and Studer, 2010; Rognli et al., 2010). Fine fescues have very fine and narrow leaves that minimize the water loss through transpiration and give them good drought tolerance. Fine fescues tolerate shade, drought, low pH (5.5–6.5), and low soil fertility (Beard 1973, Hanson et al. 1969), and require little to no additional inputs of fertilizer or
These grasses are predominantly used in the turf industry owing to their low maintenance and other agronomic features.

The genus *Festuca* L. is distributed mostly in the temperate zones of both hemispheres; most abundant all around the Northern Hemisphere (Jenkin 1959; Sampoux and Huyghe, 2009). In their native habitats, that include cool season regions of Europe, Asia, and North America, fine fescues occur on permanent grasslands used for forage. Red fescue (*Festuca rubra* L.) is a valuable perennial grass, suitable for the creation of extensive pastures and decorative purposes. Featuring good yields of fodder in the summer due to drought resistance and poor and dry soils. It has a slow initial development but forms a fine and dense sward (Katova, 2008; St. John et al., 2012).

The overall objective of a turfgrass breeding programme is to produce a variety which, under turf management, is both visually appealing and fit for purpose. In addition it is paramount to the success of any grass variety that it is commercially sustainable in the long term. Along with turf performance this success depends on the variety’s seed production potential.

Selection procedures for seed yield need to be integrated into variety selection programmes (Duller et al., 2010).

Breeding goals in fine fescues depend on whether the focus is on forage or on turf use.

For example, turf breeders may want high fibre content because it improves wear tolerance whereas forage breeders want low fibre content as it is associated with improved digestibility (Vogel et al., 1989; Katova and Naydenova, 2017).
Most breeding efforts in fine fescues are targeted to turf use. Single clone selection has improved the selection for disease resistance in several turfgrass species including fine fescues.

These plants are typically maintained for 1–2 years at a height of 5 cm before superior clones are selected for further improvement based on turf quality (i.e., fine leaf texture, high shoot density, dark green colour, clean mowing quality) and the absence of disease (Bonos et al. 2006).

The varieties of the fescue species are improved populations, developed by phenotypic selection of ecotypes or breeding populations or synthetics. Synthetics are usually constructed from parental clones or remnant seed following progeny testing using families, and this is sometimes combined with among-and-within family selection (Casler and Brummer, 2008). Phenotypic evaluation of clones has been and is being used in fescue breeding.

The main method in the breeding programs for the creation of synthetic varieties is polycross (Posselt, 2010). Clonal selection is usually effective for traits with high heritability, like heading date and disease susceptibility, but is unlikely to be effective for traits demonstrating genotype × environment interactions like herbage yield and persistency. Single clone selection has improved the selection for disease resistance in several turfgrass species including fine fescues, seed increased, and finally cultivar(s) released. Most of the earliest fescue cultivars were developed in this manner (Hopkins et al. 2007). The oldest Nordic, and possibly also European, cultivar, ‘Svalöfs Sena’ from Sweden, dates back to 1917 and some of the newer cultivars are still developed from ecotypes (Fjellheim and Rognli 2005).

Seed production is one of the
important steps in plant breeding since the commercial value of a cultivar is often determined by its seed yield capacity (Rognli 2007; Boelt and Studer, 2010; Ivanska et al., 2018). All fescue species have a dual flower induction requirement; they need vernalization and/or short days in the autumn to initiate reproductive development, and long days and moderate temperatures for stem elongation and flowering in the spring (Heide 1994).

Generally, little selection has been exerted on seed yield and seed yield components in forage grasses. Therefore, genetic variation and heritability for these traits are large (Rognli 2007).

Fang et al. (2004) studied phenotypic and genotypic variation for seed yield and related traits in a full-sib family of meadow fescue (Festuca pratensis Huds.) grown at two locations in Norway.

Their estimates of broad sense heritabilities (h2) for the traits were highest (0.80) for seed yield per plant, and seed yield per plant and reproductive components like seed weight per panicle and fertility exhibited the largest genotypic coefficients of variation (GCV %), being around 34%.

While breeding is a challenge in and of itself, the competitive production of a variety is strongly correlated to its seed yield. Hence, breeding for quality cannot compromise an acceptable seed yield.

As an added challenge for the breeder, there is a negative correlation between turf quality and seed yield for many turfgrass species.

In Bulgaria there is no established and registered variety of red fescue. The Institute of Forage Crops maintains a working collection of perennial grasses and works on breeding programs,
The aim is to determine seed productivity in red fescue clones, parental components in polycross, and a selection of the most productive and stable clones whose seed progeny form a Syn 1 generation.

MATERIAL AND METHODS

In 2014 at the Institute of Forage Crops - Pleven, two polycrosses were established for the purpose of randomized and equivalent crossing and pollination of vegetative propagated parent clones of red fescue. The following scheme was used for each of them: 30 selected clones were propagated vegetative in 4 replicates – a total of 120 plants at a distance of 50x50 cm. An isolating strip of winter rye is provided. During the period 2014-2017, seeds from each clone were harvested and the productivity of seeds was taken into account: weight of seeds (g). Mean, minimum, maximum values, standard deviations, and variation coefficient, by traits, parent components, and years are presented.

Statistical Data Processing: Computer data processing (using Excel, at P=0.05) involves a dispersion analysis. Seed productivity data are characterized by: limit values (min and max), arithmetic mean (x), standard deviation (SD) and coefficient of variation (CV,%). Variation is considered poor, moderate or strong at CV values, respectively: up to 10%; >10-20%, and >20% (Dimova and Marinkov, 1999).

According method of Fransis and Kannenberg (1978) with mean seed productivity parameters and average variation coefficient, genotypes of each polycross exceeding the average polycross values were selected averaged over four consecutive years. As basic
to основен критерий при отбор на елитни генотипове с използвани средните ритметични стойности по продуктивност на семен, g и CV, %.

results and discussion

It has been established that the productivity of seeds in red fescue varies depending on the species, genotype (variety or ecotype) and years. The highest average annual seed productivity at the first polycross red fescue clones was observed in 2015, i.e. the second year since the establishment of the polycross, followed by 2016 – the third year and 2014 – the first – with almost equal values, and the lowest in 2017 – the fourth year – by five to seven times lower (Table 1). In support of our results, Yoder (2000) established that while red fescue is a long-lived perennial, the seed production life of the stand is generally short, lasting only one to two years.

On rare occasions, a third year may be harvested. Due to its creeping ability, creeping red fescue tends to sod in quickly.

Seed head production is gradually suppressed as the stand ages and the number of vegetative tillers increases, making older stands unproductive.

Significant variations in genotypes (clones) are observed. The maximum productivity for seeds is 40.17 g for clone 28 (2015) (Table 1). On average, for a period of 4 years, the average seed productivity for the first polycross was 6.14 g. Ma (2012) reported close averages of plant seed productivity of red fescue genotypes in USA – from 6.95 g to 7.87 g in 2009 and from 0.07 g to 3.51 g in 2010.
Таблица 1. Средна продуктивност на семена и вариационни коефициенти на клонове червен валс тк (Festuca rubra L.) в периodu поликрос (2014-2017 г.)

<table>
<thead>
<tr>
<th>клонове червен валс тк (Festuca rubra L.) клонове червен валс тк (Festuca rubra L.)</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
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<td>CV, %</td>
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<td>CV, %</td>
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<td>1. 2-1-2</td>
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<td>71,69</td>
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<td>30,39</td>
<td>13,96</td>
<td>46,69</td>
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<tr>
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<td>77,78</td>
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<td>25,93</td>
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<tr>
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<td>0,30</td>
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<tr>
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<tr>
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<td>0,15</td>
<td>78,97</td>
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<td>77,22</td>
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<tr>
<td>min</td>
<td>0,15</td>
<td>18,76</td>
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<tr>
<td>max</td>
<td>16,05</td>
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<td>40,17</td>
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</tr>
<tr>
<td>average</td>
<td>3,12</td>
<td>68,73</td>
<td>14,83</td>
<td>54,46</td>
</tr>
<tr>
<td>STDEV</td>
<td>3,27</td>
<td>37,24</td>
<td>8,51</td>
<td>27,15</td>
</tr>
</tbody>
</table>

In our study, 12 genotypes (clones) in series exceeded the average yield of seeds for 2014 (3.12 g), with a minimum of 0.15 g and a maximum of 16.05 g (clone 5); for 2015, 10 clones have a higher yield than the average for...
тивност от средн 14,83 g при min e 4,67 g, max 40,17 g (клон 28); за 2016 – 9 клонове превишават в t средн 4,76 g, min e 0,28 g, max 40,17 g (клон 28). Рез 2017 г. 14 клонове имат по-висок продуктивност от средн 1,76 g при min e 0,12 g, max 7,14 g (клон 6). Първи клон polycross при min e 2,29 g, max 20,41 g (клон 28).

Table 2 shows the downward trend in average productivity for the entire survey period. Figure 1 shows the distribution of the clones by mean seed productivity for the whole period and CV, %. On average, for the first polycross for the period, seed productivity is 6.14 g, 13 clones have a higher productivity than the average for polycross at min 2.29 g and max 20.41 g (clone 28).

On average, for the first polycross for the period, seed productivity is 6.14 g, 13 clones have a higher productivity than the average for polycross at min 2.29 g and max 20.41 g (clone 28).
Table 2. Ranking of Red Fescue (*Festuca rubra* L.) by Average Seed Productivity in First Polycross (2014-2017)

<table>
<thead>
<tr>
<th>Clon №</th>
<th>Average seed productivity, g/plant</th>
<th>Average CV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>20.41</td>
<td>30.74</td>
</tr>
<tr>
<td>23</td>
<td>10.16</td>
<td>41.95</td>
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<tr>
<td>15</td>
<td>9.70</td>
<td>58.50</td>
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<tr>
<td>18</td>
<td>8.61</td>
<td>58.76</td>
</tr>
<tr>
<td>7</td>
<td>8.32</td>
<td>70.94</td>
</tr>
<tr>
<td>13</td>
<td>8.31</td>
<td>26.41</td>
</tr>
<tr>
<td>27</td>
<td>8.31</td>
<td>69.12</td>
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<tr>
<td>19</td>
<td>7.65</td>
<td>42.11</td>
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<tr>
<td>6</td>
<td>7.47</td>
<td>69.57</td>
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<tr>
<td>12</td>
<td>7.04</td>
<td>70.58</td>
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<td>21</td>
<td>6.90</td>
<td>59.85</td>
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<td>9</td>
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<td>50.53</td>
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<tr>
<td>24</td>
<td>6.16</td>
<td>62.49</td>
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<td><strong>average</strong></td>
<td><strong>6.14</strong></td>
<td><strong>63.28</strong></td>
</tr>
<tr>
<td>10</td>
<td>6.09</td>
<td>53.75</td>
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<td>16</td>
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<td>48.86</td>
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<td>5</td>
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<td>5.37</td>
<td>83.34</td>
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<tr>
<td>22</td>
<td>4.78</td>
<td>91.63</td>
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<td>3.83</td>
<td>35.94</td>
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<tr>
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<td>3.83</td>
<td>78.84</td>
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<td>20</td>
<td>3.77</td>
<td>96.73</td>
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<td>37.76</td>
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<tr>
<td>3</td>
<td>2.29</td>
<td>95.11</td>
</tr>
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</table>
Fig. 1. Distribution of Red Fescue Clones by Seed Productivity and Stability - I polycross

The highest average annual productivity of seeds in red fescue clones of the second polycross was observed in 2015, the second year since the establishment of the polycross, followed by 2016 – the third year and 2017 – the fourth year with almost equal values, and the lowest in 2014 – the first year – by four to eight times lower (Table 3). Significant variations in genotypes (clones) are observed. The maximum yield for seeds is 15.58 g for clone 10 (2015) (Table 3).
### Table 3. Average Seed Productivity and Coefficient of Variation of Red Fescue (*Festuca rubra* L.) Clones from Second Polycross (2014-2017)

<table>
<thead>
<tr>
<th>Година</th>
<th>Average Yield (2014 - 2017)</th>
<th>CV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>49,90</td>
<td>7,65</td>
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<tr>
<td>2015</td>
<td>70,86</td>
<td>68,86</td>
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<tr>
<td>2016</td>
<td>54,70</td>
<td>112,04</td>
</tr>
<tr>
<td>2017</td>
<td>54,70</td>
<td>112,04</td>
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</table>

<table>
<thead>
<tr>
<th>Година</th>
<th>Total Average Seed Yield for (2014-2017)</th>
<th>CV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>49,90</td>
<td>7,65</td>
</tr>
<tr>
<td>2015</td>
<td>70,86</td>
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<tr>
<td>2016</td>
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<td>112,04</td>
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<td>2017</td>
<td>54,70</td>
<td>112,04</td>
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<table>
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<tr>
<th>Средни години</th>
<th>Average Seed Yield</th>
<th>CV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>70,86</td>
<td>68,86</td>
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<tr>
<td>2016</td>
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<td>112,04</td>
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<tr>
<th>Средни години</th>
<th>Total Average Seed Yield</th>
<th>CV, %</th>
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<tbody>
<tr>
<td>2015</td>
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<td>112,04</td>
</tr>
<tr>
<td>2017</td>
<td>54,70</td>
<td>112,04</td>
</tr>
</tbody>
</table>

**Table 3:** The average seed yield for the second polycross was 4.31 g. Sequentially, 10 genotypes (clones) exceeded the average yield of seeds for 4 years, respectively.
In 2014 (0.75 g), with a minimum of 0.00 g and a maximum of 2.83 g (clone 22); for 2015, 16 clones have a higher productivity than the average for polycross (9.34 g) at min e of 0.91 g and max 15.58 g (clone 10); for 2016-12 clones exceeded the average annual productivity for polycross (4.77 g, min e 0.51 g and max 13.89 g (clone 13). In 2017, 11 clones had a higher productivity than the average for polycross (2.38 g) at min e 0.04 g and max 10.68 g (clone 27) and 2 of the clones died or no seeds.

On average, for the second period, the yield of seeds on seeds is 4.31 grams, 13 clones have a higher yield than the average for polycross at min. 1.58 g, and max 10.18 g (clone 27). Table 4 shows the downward trend in average productivity for the entire survey period.

Figure 2 shows the distribution of clones by mean seed productivity for the whole period and CV, %. In the first quadrant are the stable clones with high seed productivity – 6 and in the second quadrant are the accessions with a high yield of seeds, but with a high coefficient of variation, i. e. unstable – 9 items.

A total of 15 genotypes of red fescue are of interest to the breeding. Six genotypes of red fescue with higher and stable seed productivity were selected from the mean value of the second polycross: 27, 10, 11, 14, 15, and 21 (Figure 2).
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Fig. 2. Distribution of Red Fescue Clones by Seed Productivity and Stability - II polycross

Comparison between the two polycrosses on seed productivity and the durability of the parental components shows higher average seed productivity in the first polycross and greater persistency of parental clones, without dropping any of them.

In conclusion, despite the high fluctuations in seed productivity due to environmental factors, there are genetic variations within and between the polycrosses for this trait that could be used by selection.

CONCLUSIONS

1. Seed productivity in red fescue has been found to vary with genotype (clone) and seasonal variations (years).
2. The red fescue clones with the highest seed productivity per year and a
3. The highest seed productivity per annum is recorded at first polycross red fescue clones in 2015 with a maximum value of 40.17 g for clone 28.

4. The average yields for seed production in 2015 (14.83 g) for red fescue are higher than those of 2014 (3.12 g), 2016 (4.67 g) and 2017 (1.76 g), respectively.

5. Red fescue genotypes (clones) were selected with a higher seed yield than the average annual polycross value.

6. A total of 13 genotypes of red fescue are of interest to the breeding, with 9 with higher and stable seed productivity than the average for the period of the first polycross: 28, 23, 15, 13, 19, 18, 21, 24 and 9.

7. A total of 15 genotypes of red fescue are of interest to the breeding, with 6 with higher and stable seed productivity than the average for the period of the second polycross: 27, 11, 10, 15, 14 and 21.

8. The clones with the highest and stable seed productivity will participate as:
   - parental components for the formation of synthetic populations,
   - in subsequent crosses and
   - will be stored as a gene pool.

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Integrated Plant Protection against Insect Pests in Alfalfa. Agrotechnical Method

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SUMMARY
The integrated pest management program in alfalfa can contain different levels of complexity. In the context of integrated plant protection, agrotechnical pest control includes various targeted and effective management solutions that can be tailored to specific climatic conditions and habitats.

The report provided a literature overview of agrotechnical methods that support and improve the biodiversity of natural biotopes because they help to create more diversified living conditions, offer better conditions for reproduction and propagation of useful species, increase the supply of nutrients, etc.

The paper is more focused on problems of environmental and landscape protection. In agrotechnical insect pest control, the biodiversity of both flora and fauna, as well as the diversity of crops cultivated, is greater than in conventional farming.
The Integrated Pest Management Program may contain different levels of complexity. Prokopy (1993) outlines four levels as the primary combines different tactics and methods against one pest in one crop.

The highest fourth level encompasses all important pests on crops in the farm using a common Integrated Control System based on a wide information network (consultancy services, regulators, industry, etc.) and in line with the social, cultural and environmental program of Agriculture.

An analysis of 62 research and development projects applying integrated management systems in 26 countries and covering more than 5 million agricultural households has shown that integrated pest management leads to a considerable reduction in pesticide use (Pretty, 2008).

More than 60% of the projects reported a substantial reduction in pesticide treatment (75% average decrease) and a significant yield increase (an average increase of 40%).

In field crops, including alfalfa, integrated control systems are based primarily on targeted and efficient use of pesticides, choice of appropriate varieties and crop rotation.

As a result of another large-scale study of 571 field and mixed farms, Bailey et al. (2009) offer integrated control systems consistent with good plant protection practice with reasonable levels of pesticide use, including presowing treatment, rotation between different classes of pesticides, and application of good agronomic practice such as appropriate...
Basic strategies for integrated management have been developed against key pests in alfalfa including the use of resistant varieties, biopesticides, irrigation system, crop rotation, mechanical and physical control, chemical control and biological agents.

It has suggested an optimal combination of methods and approaches with ecological, economic and effective adaptability in integrated pest management (Summers, 1998; Dewhurst et al., 2009; Krauss et al., 2010; Hilimire, 2011; Chasen et al., 2013).

Despite the successful implementation of integrated pest management strategies, the "bio-side" in them, based on the use of pheromone traps for insect monitoring (20%), application of predators and parasites for biological control (7%), as well as treatment with biopesticides is still low (Chandler et al., 2011).

Integrated management is based on specific biological knowledge and principles. It is defined as an intelligent choice that provides favorable economic, environmental and sociological consequences. It combines specific chemical, cultural and biological control methods to solve pest problems that exceeding the economic threshold of harmfulness.

This is a strategy and not specific and accurate methodology that refer heavily to judgment, adaptability, and necessity, followed by a balanced use of broad-based measures to control the most economically important pests. This control is preventive, long-term, using low-toxicity products to control pest density.

Its application to alfalfa is necessary for the implementation of effective and flexible pest control programs applicable
also for organic production.

Degooeyer et al. (1999) in the past century have identified integrated pest control as a system, including all possible tactics and approaches to protect plants from pests when the economic thresholds of harmfulness are exceeded and economic benefits within an environmentally friendly production system.

According to the latest entomological results, there is an increasing tendency of insect pest attack and continuous modification of phytophagous species structures influencing the potential forage production (Pustai et al., 2016). In order to develop strategies for the control and suitable development of plant technology, it is necessary knowledge of the whole complex of pests inhabiting alfalfa as the main forage crop.

In the context of integrated plant protection, biological and chemical pest control should be reasonably used to provide targeted and effective management solutions that can be adapted to specific climatic conditions and habitats (Gentz et al., 2010).

**AGROTECHNICAL METHOD**

Above all, alfalfa is a nitrogen-fixing culture and that is one of the most important agrotechnical meanings in the alfalfa cultivation. It has many ecologically important characteristics, including the ability to absorb atmospheric nitrogen, which is associated with rhizobial bacteria forming the root nodules.

This process creates a potential for reducing the nitrogen limitation induced by increased atmospheric CO₂ content (Soussana and Lüscher, 2007) and decrease the requirement for the use of
It is essential that balanced crop rotation prevents the development of diseases and pests, which can completely compromise next year’s harvest.

Alfalfa has substantial qualities that are important for organic farming due to its nutritional qualities, nitrogen fixation and adaptability (Torricelli, 2006).

Medicago sativa, also has a considerable meliorative effect by improving the physicochemical and biological properties of the soil, increases its fertility.

Its root system improves the texture of the soil, the foliage enriches the soil with organic matter, the stems and leaves prevent soil erosion (Flanders and Radcliffe, 2000). At the same time, it prevents the salinization in irrigated areas (Suttie, 2000; McDonald et al., 2003).

As a result of numerous insects in alfalfa fields, the early harvesting of the regrowth, as well as their cultivation on strips with other suitable crops, makes it possible to reduce of the insect pest density and to support the distribution and feeding up of useful insects (Onstad and Shoemaker, 1984; Manglitz and Ratcliffe, 1988).

For example, recent reports investigating the density and damage by Hypera postica showed that biological agents are often insufficient to prevent the damage in alfalfa (Anonymous, 2012).
Insecticides such as a frequently used approach to control, kill the natural bio-agents of the weevil and allow secondary outbreaks of the weevil.

Therefore, harvesting 2-3 weeks earlier (after button stage) leads to a negligible yield reduction, with the average loss being only 5% and the average increase in crude protein is 1.9 percentage points in the forage (Catangui, 2001).

The application of mechanical shallow plowing and semi-chemical method are perspective and environmentally friendly methods for alternative crop protection against weevils which damage alfalfa seeds (Tychius aureolus) (Gombert et al., 2015).

Crop rotation is of great importance in reducing the insect pests and weeds numbers by preventing the increase of population density of specialized alfalfa phytophages.

In addition, keeping the spatial isolation of the seed field from other legumes, especially from the old alfalfa at a distance of 4-5 km, will substantially protect alfalfa crops from economically important insect pests (Popova, 1968).

The author found that in the first two to three years of alfalfa growing, Plagionotus floralis damaged 20-30% of the plants, and after 3-4 years – 60-80%.

Therefore she recommended fields to use no more than four years. Imprei et al. (2014) advise the establishment of an economic threshold of P. floralis damage by using fluorescent yellow traps with chemical lures.

They exude an aroma that will help in making decisions regarding the optimal application of agro-technical measures.

This method improves plant protection
practice in terms of both the economic and the environmentally friendly, protecting the environment.

In Serbia and Montenegro, the contribution to reducing populations and damage from economically important alfalfa pests like *Tychius flavus*, *Apion apricans*, *Apion aestivum*, *Adelphocoris lineolatus*, *Lygus* spp., *Bruchophagus roddi* and *Bruchophagus gubbis* is spatial isolation, crop rotation, sowing by spreading and weed removal (Petrovic, 2005).

Another agrotechnical method recommended in Serbia in insect controlling is the cultivation of alfalfa on the smaller cultivated area. They allow a stronger impact of predatory species on pests (Čamprag, 2010). According to the author, the larger size of the area leads to the mass emergence and distribution of some insects.

Some authors research the use of information related to some soil characteristics such as soil pH in KCl and humus content for predicting the density of phytophagous bugs in alfalfa.

They found that these soil characteristics may be useful in the regional pest control to predict the emergence of their future outbreaks (Kozina et al., 2015).

XiaoYan et al. (2016) recommend the potassium application which increases the alfalfa resistance to some pests (phytophagous thrips) as an effective control measure. According to the authors, the element improves the carbon to nitrogen ratio and reduces the free amino acid content.

Numerous studies related to the implementation of environmentally friendly approaches establishes that the system of farming – monocultural or multicultural, has a considerable impact on the insect
Straub et al. (2013) report that the damage caused by some sucking insect such as *Acrythosiphon pisum* and *Empoasca fabae* in the pure alfalfa stand in the United States is significantly higher in compared to the alfalfa mixture.

In addition, in mixed cultivation, the ratio between predator and prey occupies higher values and increases the predator activity and the pest vulnerability. Similar results reported by Feng et al. (2011), as mix cultivation of alfalfa in tea plantations is associated with the reduction of harmful species (77%), increasing the number of bioagents (10-17%) and minimal variation in quantity. In addition, the authors do not find any damage resulting in a reduction in the forage yield.

Dizaja et al. (2015) add that increasing the alfalfa ratio (*M. sativa*) to mixed stand with sainfoin (*Onobrychis sativa*) tends to increase the population density of *Hypera postica*.

For example, in mixed cultivation of alfalfa in a ratio of 80% with 30% sainfoin is realized the highest forage yield.

The *H. postica* damage is the least pronounced compared to other proportions with 100% alfalfa participation.

The reproductive capacity of *Empoasca fabae* as well as its spatial distribution decreases in the mix cultivation of alfalfa with cocksfoot, *Dactylis glomerata* (Straub et al., 2014). Also, the predatory bug *Nabis americofanus* is more effective and leads to a more pronounced decrease in the density of the cicada larvae in the polycultural, compared to the monoculture cultivation of alfalfa.

Nikolova et al. (2018a, b) research
(2018a, b) investigated the impact of the cultivation system of perennial legumes grown pure and in binary mixtures with cocksfoot on the damages caused by *Sitona* spp. and the chemical composition.

Authors find that damaged nodules by the *Sitona* larvae in mixtures decreased significantly on average by 33.5% (sainfoin + cocksfoot), by 50.3% (birdsfoot trefoil + cocksfoot) and by 55.6% (alfalfa + cocksfoot) compared to pure grown legumes. Knowledge of changes in plant diversity affecting the functioning of agroecosystems remains a major challenge.

Effect on the insect pest density and productivity, according to Kosachev (2002), has and line spacing.

In the seed field, the author recommends cultivation at 30 cm, that is related to the highest yield of alfalfa seeds which exceeding one by 68% at 15 cm and by 4.0% at 60 cm.

Another agrotechnical practice is the strip harvesting of alfalfa that has a considerable impact on different insect species. It provides more stability in the alfalfa ecosystem and prevents the emigration of many bioagents at harvest (Summers, 1976).

In such a system, the bioagent density increases, while that of insect pests, especially aphids, decreases (Anonymous, 1981). The model of strip harvesting is used to control many insect pests (Hossain et al., 2001; Weiser et al., 2003).

For example, in Iran, in strip harvesting, the number of aphids (*Acythosiphon risum* and *Theroiaphe trifolii*) decreases on average by 24 and 28% while the density of the predatory species (*Hippodamia variegata* Goeze, *Nabis* spp., *Deraeocoris* spp., *Orius* spp., *Geocoris* spp.) and aphid parasitoids
increases from 38 to 122% compared to traditional harvesting (Rakhshani et al., 2010).

Increasing biodiversity in an agro-system may favor pest control by changing the structure of monoculture in favor of natural bioagents and help to protect the flora and fauna (Gurr et al., 2003).

Populations of insect pests can also be reduced by the nutritional activity of predatory mites and spiders and some other small non-insect taxa (Qureshi et al., 2010).

Medicago sativa has a wide fauna of arthropods, but a small part of these species are pests, that seriously affect alfalfa production while a high part is predators and parasitoids (Anonymous, 1985). Many pest populations can be managed by improving habitat conditions and developing of the existing community of bioagents.

Modern integrated systems of pest control include the protection and improvement of conditions for the development of bioagents, predators, and parasitoids to suppress pest population (Landis et al., 2000).

To use the full potential of bioagents are required knowledge for their population dynamics and factors that affect them, including the role of habitats (Wratten et al., 2000).

The protection and improvement of predatory and parasitoid activity to decrease insect pest density are considered to be one of the most important approaches in modern practice (Landis et al., 2000).

Agricultural practices affect the interactions between natural bioagents with the host plant and/or their prey (Van
Creating an appropriate living environment for useful insects as a biological agent keeping approach focuses on limiting the impact of insecticides on natural agents (Smith, 2008). This method can be applied alone or as part of the integrated plant protection strategy.

The use of different plants such as bush, grass or other bordering on cultural crops as a habitat for many useful insects can provide a suitable location for reproduction in the long term as a valuable source of useful arthropods (Collins et al., 2003).

The establishment of an appropriate environment in the short term often includes creating flowering striated vegetation at the beginning of the main crop development. It provides a flowering resource for useful arthropods and increases their activity during vegetative development of the crop.

Permanent and diverse neighbor plant areas offer resources to biological agents as alternative prey or wintering sites (Rosenstock, 2010). These places contribute to a faster migrating into alfalfa and control of phytophagous insects, as higher predator density has in the outside areas of the crop compared to the inside.

According to the author, the predator/prey ratio (Coccinellidae, Carabidae / aphids) is considerably affected by the neighbouring type of greenery.

The highest ratio is observed in alfalfa in contiguity to the vines and the lowest one -
The variety and number of predatory coccinelids are equally distributed, while predatory carabids are more numerous and diverse at the end of alfalfa (0 m).

In this aspect, Ximenez-Embun et al. (2014) recommend creating a more diverse landscape to keep higher density and diversity of useful insects in alfalfa.

Nectar and pollen are the main resources of the flowers that attract useful insects and create favorable conditions for their development and reproduction. Nectar has a high content of sugars, proteins, amino acids, lipids and other substances (Pfiffner and Wyss, 2004), which are a valuable source of food for useful insects such as Coccinellidae, Chrysopidae and Tachinidae (Smith, 2008). The plant also has seed and plant juice as a food source for useful insects (Jervis, 2005).

At the same time, the main crop can also play a role as a suitable habitat for bioagents. For example, in Australia alfalfa is evaluated as a means of increasing the number of main predatory species suppressing the Helicoverpa sp. (Mensah and Sequeira, 2004).

The assured habitat can help to identify and support populations of predatory and prey by providing alternative prey and plant hosts (Pfiffner and Wyss, 2004).

It should be noted that the creation of an appropriate living environment increases the activity of endemic natural agents (typical of a region), but not of the introduced bioagents (Jervis, 2005).

Many studies find an increase in the density of useful insects in relation to host plants of pests. Researches to reduce the
Providing alternative insect hosts, as well as a favourable microclimate, including wintering havens would also ensure the presence of useful insects sufficiently.

The aim is to suppress the pest density in alfalfa crops when they exceed the economic threshold of harmfulness (Barbosa, 1998; Hossain et al., 2002).

Periodic cuttings in alfalfa reduce the possibility of biological control by causing direct bioagents death, due to lack of food sources or under unfavorable environmental conditions (Schaber et al., 1990).

Therefore, providing cultural havens for predators and prey in alfalfa such as strips also improves the conditions for useful insects. In this way, it can create a prerequisite for enhancing the biological control in alfalfa (Hossain et al., 2000 a, b, c).

A spatial model of Hossain et al. (2002) for the location of alfalfa strips as a haven for bioagents shows that the presence of strips at a distance of fewer than 30 m from the crop can be optimal for habitat provision of natural agents after harvesting of alfalfa.

**CONCLUSIONS**

- Agrotechnical methods support
and improve the biodiversity of natural biotopes, help to create more diversified living conditions, offer better conditions for reproduction and propagation of useful species, increase the supply of nutrients, etc. They are focused on problems of environmental and landscape protection.

The biodiversity of both flora and fauna, as well as the diversity of crops cultivated in agrotechnical insect pest control, is greater than in conventional farming.

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определяне пригодността за силажиране на основни плевели в гроценозите на фур жни култури

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SUMMARY

The weeds are a natural and indispensable part of agrophytocenoses in organic farming conditions. They can play a significant role in modern livestock farming if their appetite, nutritional value as feed, and their ability to preserve are determined.

The purpose of this study is to determine the suitability for silage of primary weeds (Johnson grass /Sorghum halepense/, Redroot pigweed /Amaranthus retroflexus/, Field bindweed /Convolvulus arvensis/, Chicory /Cichorium intybus/ and Conyza canadensis /Erigeron canadense/) in the agrocenoses of forage crops, as well as their impact of silage preparation of the main crop in whose crops they meet. Weed biomass of each species is harvested in generative stems phase of grasses and button-start flowering of broadleaf weeds and silage is prepared by direct ensilage (without additives), silage after wilting and direct formic acid addition (HCOOH), in a general variation of the experiment 15.
Successful ensilage according to the pH values of these weeds is achieved with the addition of 0.5% formic acid or wilting of the mass before to ensilage or wilting the biomass before ensilage, which should be taken into account when ensiling the main forage crop and the proportion of the respective weed plants in it. With the best silage qualities, regardless of the way of ensilage, is the Chicory followed by Field bindweed. With low the lowest degree of ensilage is Redroot pigweed, while the Johnson grass and the Conyza canadensis occupy the middle position.

Key words: ensilage, weeds, formic acid

INTRODUCTION

Silage is an old method of preserving forages. It is used today as a mass distribution worldwide. In Bulgaria many of the methods and technologies for preserving have been improved in recent years. There are also improvements in places for silage, which adapt to the needs of large farms according to European requirements. Each ensilage is a process of natural conservation regardless of the type of raw material fermented under anaerobic conditions.

Lactic acid bacteria, combined with hydrocarbons in the raw silage mass, produce lactic acid, which is the preservative component of lactic acid fermentation, combined with the osmotic pressure of the plant juice (Kirov and Todorov, 1976).

Chemical preservatives addition a major role is played. When the humidity of the silage is below 60%, then the term silage after wilting is used. Silage has a number of advantages over other preservation methods.

Preserving nutrients when properly ensiled is much better than haymaking (Bazitov et al., 2013). Silage can also be...
prepared from several forages that are not suitable for natural drying and haying.

Silage changes the composition of the forage and its consumption by the animals with the presence of fermentation products: organic acids, ammonia, alcohol, increased amount of soluble protein, etc. (Kirilov, 2015).

Silage forages are taken with good appetite from sheep, stimulate milking and improve digestion and digestion of other feeds (Stoycheva, 2015). Ensuring high quality silage is a crucial prerequisite for cost-effective and environmentally livestock breeding (Weissbach and Honig, 1996; Bobb, 1998).

The term forage defines that can be fed to the animals, including roughage, green, preserved and concentrated/compound feeds, wastes from various industries, etc. (Todorov et al., 2004).

The presence of weed vegetation in forage areas is undesirable, but their share in organic feed production is significant.

The weeds are a natural and indispensable part of agrophytocenoses in organic farming conditions. They can play a significant role in modern livestock farming if their appetite, nutritional value as feed, and their ability to preserve are determined.

In this context, many researchers and specialists are paying more attention to weeds in terms of their impact on the yield and nutritional value of feed, especially in organic feed.

This study compared the suitability of silage for different weed species: Redroot pigweed /Amaranthus retroflexus/, Johnson grass /Sorghum halepense/, Field bindweed /Convolvulus arvensis/, Chicory /Cichorium intybus/ and Conyza
Convolvulus arvensis L. and Canadian sow thistle (Erigeron canadensis), which are the main entrants in the areas of forage crops and differ significantly in terms of chemical composition and appetite. Various weeds have been found to have the potential to be used as forage sources (Georgieva and Kirilov, 2016; Kirilov et al., 2016).

The purpose of this study is to determine the suitability for silage of primary weeds (Johnson grass /Sorghum halepense/, Redroot pigweed /Amaranthus retroflexus/, Field bindweed /Convolvulus arvensis/, Chicory /Cichorium intybus/ and Conyza canadensis /Erigeron canadense/) in the agrocensoses of forage crops, as well as their impact of silage preparation of the main crop in whose crops they meet.

MATERIAL AND METHODS

For the task, mass was collected and 15 variants of silages of five types of weeds were prepared: Johnson grass, Redroot pigweed, Field bindweed, Chicory and Conyza canadensis.

Of each kind of weed, silage is prepared in three variants:
1. Direct silage – without additives
2. Silage after wilting
3. Direct ensilage with formic acid addition (HCOOH) at concentration of 0.5%

Silages were prepared in 0.8 l glass jars which were sealed with screw caps. The slicing length of the silage mass is 3-4 mm divided into three parts of each weed species.

One part was ensiled immediately – directly, another with 0.5% formic acid added, and the rest was set to fades at the sun and was ensilage in the next day.

Silages were opened 45 days after their preparation. The surface layer (4-5 cm from the jar) was removed, the samples were analyzed from the rest of
RESULTS AND DISCUSSION

The fermentation indexes of weed silages are shown in Table 1. The feed variation in terms of silage capacity is largely due to the differences in dry matter composition.

While in high humidity silage, preservation is due to the accumulation of organic acids in fermentation and lowering of pH, the most important being the content of sugars and buffer substances.

In our studies, the dry matter values for the first variant – silage without additives were 12.43% for the Redroot pigweed, to 22.44% for the Conyza canadensis, i.e. the humidity of the ensilaged material is over 77%, suggesting that the critical pH values are from 4.0 to 4.2.

Since it is known that the higher the humidity of the ensilaged raw material, the lower the pH values, in order to obtain stable silage without the possibility of developing secondary fatty acid fermentation, it is necessary to lower the pH below the critical value.

The resulting higher pH values in this study are native to poor quality silages, most likely due to the lower sugar content and higher buffer capacity in the weeds studied, which negatively affects the fermentation processes and the quality of silage.
This fact should be taken into account when ensilaging the main forage crop, which should have higher sugar content (Bazitov et al., 2014; 2017), with a higher prevalence of weeds.

The fermentation process depends of the dry matter content, so the observance of certain conditions in the stages of ensilage is of the great importance for the correct fermentation process in consequence.

It is known that growth of microorganisms is slowed down in the ensiling of forages with lower humidity. This was also observed in variant 2 of our study where it was found that after increasing the DM content in silage weed mass by up to 47%, pH values decreased by up to 10% on average for all weed species studied.

<table>
<thead>
<tr>
<th>Weed / Вид плевел</th>
<th>Variant 1 (silage - without additives) / Вариант 1 (сенаж)</th>
<th>Variant 2 (silage after wilting) / Вариант 2 (сенаж после съхване)</th>
<th>Variant 3 (silage + HCOOH) / Вариант 3 (сенаж + HCOOH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redroot pigweed</td>
<td>12,430 / 5,880 / 0,076</td>
<td>18,110 / 4,410 / 0,031</td>
<td>12,110 / 3,920 / 0,007</td>
</tr>
<tr>
<td>Chicory</td>
<td>19,570 / 4,690 / 0,023</td>
<td>52,110 / 4,250 / 0,023</td>
<td>21,930 / 3,820 / 0,009</td>
</tr>
<tr>
<td>Field bindweed</td>
<td>15,160 / 4,570 / 0,056</td>
<td>37,860 / 4,270 / 0,038</td>
<td>16,210 / 3,950 / 0,016</td>
</tr>
<tr>
<td>Johnson grass</td>
<td>23,720 / 4,810 / 0,045</td>
<td>43,200 / 4,780 / 0,494</td>
<td>24,490 / 3,960 / 0,023</td>
</tr>
<tr>
<td>Conyza canadensis</td>
<td>22,440 / 4,860 / 0,037</td>
<td>45,050 / 4,640 / 0,026</td>
<td>23,400 / 4,230 / 0,013</td>
</tr>
</tbody>
</table>

Table 1. Fermentation indicators of weed silages
Microorganisms that can grow well at low pH (molds and yeasts) are aerobes. Increasing the acidity of silage is a result of the development of microorganisms that degrade carbohydrates to organic acids (lactic acid) that make lower the silage pH (Kirov and Todorov, 1976).

There is a tendency to improve the ability to ensilage the weed mass after wilting. A similar trend was observed in variant 3, after direct ensiling by addition of formic acid (HCOOH), with a concentration of 0.5% in the weed mass.

It is known that raw materials containing less sugars and high storage capacity at their natural humidity, it is not impossible to conserve them without using preservative agents.

For this, fermentation processes can be improved by using chemical preservatives such as formic acid, which has two-sided action – make lowers pH and acts bacteriostatically.

In our study, it is observed that even high humidity of silage material (over 80%), the critical pH value is save at optimal levels (pH = 4.0), which is a prerequisite for good ensilage, according to this indicator.

Table 2 presents the results of pH values of silage of different weed species.

<table>
<thead>
<tr>
<th>Weed</th>
<th>pH silage - without additives</th>
<th>pH silage after wilting</th>
<th>Addition of HCOOH (0.5%)</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redroot pigweed</td>
<td>5.880</td>
<td>4.410</td>
<td>3.920</td>
<td>4.740</td>
</tr>
<tr>
<td>Johnson grass</td>
<td>4.810</td>
<td>4.780</td>
<td>3.960</td>
<td>4.520</td>
</tr>
<tr>
<td>Field bindweed</td>
<td>4.570</td>
<td>4.270</td>
<td>3.950</td>
<td>4.260</td>
</tr>
<tr>
<td>Chicory</td>
<td>4.690</td>
<td>4.250</td>
<td>3.820</td>
<td>4.250</td>
</tr>
</tbody>
</table>
н р от сил жи н р злични видове плевели, т т к получението резулт -
ти се вижд , че с н й-добри сил жи
к честв , нез висимо от н чин н
сил жир не, тов е цикорият , следв -
н от поветиц т . по-лоши сил жи
възможности се отлич в т б лур ,
следв н от к н дск т злотетниц . й-
труден з сил жир не се ок зв щир ,
cр внен с ост н лите 4 вид плевели.

то зи контекст дел н плеве-
лите в основните фу жи култури би
могъл д се определи к т о един от
многоф ктори, ок зв щи влияние з
оптим лю протич н е н фермент -
цият при сил жир не.

✓ тойностните н р н сил жи-
te, приготвени директно от б лур,
k н дск злотетниц , щир, поветиц и
цикория с присъщи з сил жи с лошо
к чество.
✓ спешно сил жир не, според
стойностните н р н тези плевели, се
постиг с доб вк н 0,5% мр вчен
киселин или з вяхв не н м с т
преди сил жир не, което трябв д се
им предвид при сил жир не н
основн т фур жи култур и дел н
съответните плевелни р стения в нея.
✓ н й-добри сил жи к честв ,
нез висимо от н чин н сил жир не,
tов е цикорият , следв н от повети-
ц т . по-лоши сил жи възможности
се отлич в т б лур и к н дск т
злотетниц .
✓ й-труден з сил жир не е
щир .

From the results obtained, can be seen
that with the best silage qualities,
regardless of the way of ensilage, this is
the Chicory followed by the Field
bindweed. With worse silage options is
Johnson grass, followed by the Conyza
canadensis. The most difficult for
ensilage is the Redroot pigweed
compared to the other 4 types of weeds.

In this context, the proportion of
weeds in the main forage crops could be
identified as one of the many factors
influencing optimum fermentation
during ensilage.

CONCLUSIONS
✓ The pH values of silage prepared
directly from Johnson grass, Conyza
Canadensis, Redroot pigweed, Field
bindweed and Chicory are native for poor
quality silages.
✓ Successful ensilage according to
the pH values of these weeds is achieved
with the addition of 0.5% formic acid or
wilting of the mass before to ensilage or
wilting the biomass before ensilage, which
should be taken into account when
ensiling the main forage crop and the
proportion of the respective weed plants
in it.
✓ With the best silage qualities,
regardless of the way of ensilage, is the
Chicory followed by Field bindweed.
Johnson grass and the Conyza
canadensis occupy the middle position.
✓ With the lowest degree of
ensilage is Redroot pigweed.

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Effect of Growth Regulators on *Agropyron desertorum* (Fisch.) Schultes

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**SUMMARY**

During the 2014 and 2015 was conducted a randomized field experiment with three growth regulators with a retardant activity applied in three doses CCC 750 SL (750 g/l chlormequat chloride) – 60, 120 and 180 ml/da, Toprex 375 SC (250 g/l difenoconazole + 125 g/l paclobutrazole) – 25, 50 and 75 ml/da and Moddus Evo (250 g/l trinexapacethyl) – 30, 60 and 90 ml/da in the experimental field of the Institute of Forage Crops - Pleven. The experiment was performed by perpendicularly method in non-irrigating conditions with standard wheatgrass (*Agropyron desertorum* (Fisch.) Schultes) (Standard Wheatgrass) variety “Morava”.

It was found that CCC 750 SL, Toprex 375 SC and Moddus Evo at the applied doses did not have a phytotoxicity effects on *Agropyron desertorum* (Fisch.) Schultes. The treatment of *Agropyron desertorum* (Fisch.) Schultes in the seed production year with growth regulators 750 L, Toprex 375 SC and Moddus Evo had a...
INTRODUCTION

In recent years, research had focused on solving the problem of lodging in cereal crops, which is a factor in reducing yield, deteriorating grain quality and hampering mechanized harvesting of the seeds (Syahputra et al., 2016; Shah et al., 2017).

According to the study of Sui-Kwong et al. (2011); Berry and Spink (2012); Berry (2013) and Rajapaksa et al. (2018) the lodging of the cereal stems is due to the complexity of a number of factors including biological specificity, variety specificity, morphological (structural), as well as under and impact of weather, agro-technical and environmental conditions.

Plant growth regulators (with retardant activity) are widely used in contemporary agriculture to promote and for reduction plant height growth and save of lodging crops, yield and grain quality in a number of cereal crops (Lang et al., 2012).

Sporadic and contradictory are...
reports of the use of plant growth regulators (with retardant activity) in standard wheatgrass (Agropyron desertorum (Fisch.) Schultes).

According to studies Eisvand et al. (2010) и Schrabauer et al. (2014) a biological property of the species of the genus Agropyron, and other members of the group of perennial grasses, is the sowing of the lodging stems during seeds formation in years secured by precipitation and intensive fertilization.

Limited studies in Bulgaria and abroad are an argument for establishing the physiological effect and assessing the economic effect after treatment with the growth regulators (with retardant activity) CCC 750 SL (750 g/l chlormequat chloride), Toplex 375 SC (250 g/l difenoconazole + 125 g/l paclobutrazole) and Moddus Evo (250 g/l trinexapac-ethyl) in the in standard wheatgrass (Agropyron desertorum (Fisch.) Schultes).

The objective of this study was to determine plant growth regulators (with retardant activity) for standard wheatgrass (Agropyron desertorum (Fisch.) Schultes) to be applied during stand seed production in variety "Morava".

MATERIAL AND METHODS

The studies were conducted during the period 2014-2015 in the experimental field of the Institute for Forage Crops, Pleven on leached black ground under non-irrigated conditions. The field trial were conducted perpendicularly methods in three replicates with a harvest area of 5 m².

For the field experiment was used, the first Bulgarian variety "Morava" standard wheatgrass (Agropyron desertorum (Fisch.) Schultes) created at the Institute of Forage Crops - Pleven. The variety is distinguished by its high productivity, ecological stability (winter-resistant and dry-resistant), leaf resistant and long-lasting, with multifunctional
The plant growth regulators were applied with a spraying machine "PTP 18" at 40 l/da with a conical nozzle, pressure $P_{\text{max}}$ 3 bar, $V_{\text{max}}$ 1.64 l, and $Q_{\text{max}}$ 0.63 l/min, in growth stage BBCH – 23-31 (Hess et al., 1997) of the standard wheatgrass.

The following metrics are reported: The phytotoxicity was determined according to the logarithmic scale of EWRS (score 1 - no damage, score 9 - completely depleted plants) and Crop vigor (CV) (score 0 - Completely depleted plants and score 100 Plants are no

<table>
<thead>
<tr>
<th>Продукт / Product</th>
<th>Фитоактивност / Active ingredients</th>
<th>50%</th>
<th>100%</th>
<th>150%</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 CCC 750 SL</td>
<td>750 g/l хлормекв т хлорид</td>
<td>60</td>
<td>120</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>750 g/l chlormequat chloride</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>опрекс 375</td>
<td>250 g/l дифенокон зол + 125 g/l п клобутр зол</td>
<td>25</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Toprex 375 SC</td>
<td>250 g/l difenoconazole + 125 g/l paclobutrazol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>одус во</td>
<td>250 g/l тринекс п кетил</td>
<td>30</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>Moddus Evo</td>
<td>250 g/l trienexapachetyl</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Percent of the registered dose of the product by the manufacturer

Внасянето на растежните регулатори е извършвано с гръбна пръскачка "PTP 18" при разход на работен разтвор 40 l/da с конична дюза, налягане $P_{\text{max}}$ 3 bar, $V_{\text{max}}$ 1.64 l, and $Q_{\text{max}}$ 0.63 l/min, във фенофаза BBCH – 23-31 (Hess et al., 1997) на стандартния житняк – Agropyron desertorum (Fisch.) Schultes (бирля 1).
damage) Stall et al., 1989 at 7, 14, 20, 30 and 45 days after treatment (DAT). Lodging scores was determined by visual observation on a 1-9 score (1 score no lodging and 9 score completely lodged) in growth stage BBCH - 83 of the plants according to the method of Vera et al. (2012).

For each variant of the treatments, 30 number plants were analyzed by the following biometric features: plant height and length of panicle, cm; total weight of panicle and seed weight from one panicle, g; number of seeds from one panicle, num.

For determined vitality and seeds germination for all treatment in laboratory conditions in Petri dishes (90 mm) were placed 100 seeds of all treatment between filter paper and 3 ml are added of distilled water. The samples are incubated in a thermostat at 22 ± 2 °C for five days. Each treatment consisted of five replicates including the control treatment.

The following indicators are determined for all experimental variants: percent of germination in (%), length of the rot, coleoptile and seedling, cm and formed fresh biomass in g per rot, coleoptile and seedling, g. Length was measured using graph paper and the weight was recorded on an analytical balance.

The plant development index (GI) was determined according to the method of Gariglio et al. (2002):

\[
GI = \left( \frac{G}{G_0} \right) \cdot \left( \frac{L}{L_0} \right) \cdot 100
\]

where \( G \) and \( G_0 \) – germinated seeds respectively for the options and control variant %; \( L \) – average length (cm) of seedlings in treatment transformed into percentage as against the control treatment; \( L_0 \) – average length (cm) of the seedlings in the control treatment taken as 100%.
The percentage of germinated seeds in each treatment was previously transformed

\[ Y = \arcsin\sqrt{\left(\frac{x_{\%}}{100}\right)} \]

(Anant, 1996).

The mathematical-statistical processing of the experimental data was performed with the software product STATGRAPHICS Plus for Windows Ver. 2.1 and STATISTICA Ver. 10.

Plant protection, fertilization and all other agronomic practices during cultivation of standard wheatgrass for all experimental plots were carried out uniform in accordance with agro-technical requirements of culture.

RESULTS AND DISCUSSION

Estimating the complex effect of some major meteorological factors, rainfall amount and average monthly air temperatures, the studied years 2014 and 2015 are with favorable conditions, with the biological requirements for standard  

\[ (Agropyron desertorum \ (Fisch.) \ Schultes) \]

during the intensive growing season (III-IX) respectively \((l_{arDM}) 29.6, 25.4 \) (Table 2).

The total rainfall amount and average monthly air temperatures during the period of intense growth of the standard during (III-IV) during the study years vary in narrow range, respectively from 18.1 to 18.3 °C and from 428.7 to 447.6 mm. The agrometeorological conditions during the years of study showed temperature deviations from −0.4 to +3.3 °C and stronger variability in the rainfall amount from 52.5 to 314.8%, as compared to values for the period 1964-2013 (Table 2).
Table 2. Meteorological indicators during the growing period of Agropyron desertorum (Fisch.) Schultes

<table>
<thead>
<tr>
<th>Period</th>
<th>The average monthly temperature of the air, °C</th>
<th>Average for III-IX, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-VII</td>
<td>2014: 9.7 14.9 16.7 20.6 23.1 23.7 17.9</td>
<td>18.1</td>
</tr>
<tr>
<td></td>
<td>2015: 6.8 12.2 18.8 20.7 25.5 24.4 20</td>
<td>18.3</td>
</tr>
<tr>
<td></td>
<td>III-IX</td>
<td>6.4 12.0 17.7 21.2 23.4 22.9 18.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>Average for III-IX, mm</th>
<th>Amount for III-IX, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-VII</td>
<td>2014: 39.7 32.3 83 54.3 71.8 23.9 142.6</td>
<td>447.6</td>
</tr>
<tr>
<td></td>
<td>2015: 76.9 43.6 30.6 95.9 21.5 29.9 130.3</td>
<td>428.7</td>
</tr>
<tr>
<td></td>
<td>III-IX</td>
<td>35.6 48.7 62.9 63.7 61.5 45.5 45.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>De Martonne aridity index, LAI-DM</th>
<th>De Martonne aridity index, LAI-DM</th>
<th>Average for III-IX</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-VII</td>
<td>2014: 46.8 15.6 37.3 21.3 26</td>
<td>8.5 61.3 29.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015: 48.9 23.6 12.8 37.5</td>
<td>7.3 10.4 52.1</td>
<td>25.4</td>
</tr>
<tr>
<td></td>
<td>III-IX</td>
<td>26 26.6 27.3 24.5 22.1</td>
<td>16.6 19.2</td>
</tr>
</tbody>
</table>

Plant growth regulators (with retardant activity) CCC 750 SL, Toprex 375 SC and Moddus Evo in the applied dosage (Table 1) in growth stage BBCH-23-31 did not have a phytotoxicity effect (score 1) (Table 3) and crop vigor on the standard wheatgrass. Similar results are obtained with respect to the viability of the culture (Table 3).
Table 3. Influence of growth regulators (with retardant activity) on the vitality of the standard wheatgrass \textit{(Agropyron desertorum} (Fisch.) Schultes) average for the period

<table>
<thead>
<tr>
<th>Treatments</th>
<th>03 /Dose ml/da</th>
<th>7 DAA</th>
<th>14 DAA</th>
<th>20 DAA</th>
<th>30 DAA</th>
<th>45 DAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CCC 750 SL</td>
<td>60</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Toprex 375 SC</td>
<td>25</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>50</td>
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<tr>
<td>Moddus Evo</td>
<td>30</td>
<td>1</td>
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<td>1</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>90</td>
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</table>

<table>
<thead>
<tr>
<th>Treatments</th>
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<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>45</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>CCC 750 SL</td>
<td>60</td>
<td>45</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>50</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>45</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Toprex 375 SC</td>
<td>25</td>
<td>50</td>
<td>65</td>
<td>90</td>
<td>100</td>
<td>100</td>
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<tr>
<td></td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>50</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Moddus Evo</td>
<td>30</td>
<td>50</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>50</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>50</td>
<td>60</td>
<td>85</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Legend: EWRS (European Weed Research), Ball 1 - no damage, and at score 9 - culture is completely destroyed; DBA - day before treatment; DAA - days after application; crop vigor 100 - no damage, and 0 - the culture is completely destroyed.

The height of the plants and the degree of lodging of the standard wheatgrass after treatment with retardants ranges – from 1.2 to 4.5 score and from 74.2 to 100.0 cm respectively. From the data shown in Table 4 it can be seen that application of CCC 750 SL, Toprex 375...


**Table 4. Structural elements of productivity in standard wheatgrass (Agropyron desertorum (Fisch.) Schultes) depending on the type of plant growth regulators and the applied doses**

<table>
<thead>
<tr>
<th>Years</th>
<th>Treatment</th>
<th>oz./Dose, ml/da</th>
<th>M'</th>
<th>SH</th>
<th>LP</th>
<th>NSC</th>
<th>TNS</th>
<th>BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Control untreated</td>
<td>2.2</td>
<td>91.0c</td>
<td>6.7a</td>
<td>63.1b</td>
<td>3056.0a</td>
<td>67.4a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>750 CCC 750 SL</td>
<td>60</td>
<td>3.1</td>
<td>87.2b</td>
<td>6.9a</td>
<td>63.4b</td>
<td>3133.3b</td>
<td>78.0b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>120</td>
<td>1.8</td>
<td>78.0a</td>
<td>6.7a</td>
<td>61.0b</td>
<td>3106.7b</td>
<td>78.7b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>180</td>
<td>1.2</td>
<td>78.4a</td>
<td>6.9a</td>
<td>59.0ab</td>
<td>3229.3bc</td>
<td>74.7b</td>
</tr>
<tr>
<td></td>
<td>750 CCC 750 SC</td>
<td>25</td>
<td>4.5</td>
<td>100.0d</td>
<td>7.8ab</td>
<td>67.2ab</td>
<td>3895.7c</td>
<td>81.7c</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>1.5</td>
<td>80.7ab</td>
<td>6.8a</td>
<td>63.8b</td>
<td>3090.7a</td>
<td>73.3b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75</td>
<td>1.2</td>
<td>74.0a</td>
<td>6.5a</td>
<td>53.8a</td>
<td>3019.0a</td>
<td>76.0b</td>
</tr>
<tr>
<td></td>
<td>750 CCC 750 SC</td>
<td>30</td>
<td>2.5</td>
<td>93.2d</td>
<td>6.4a</td>
<td>63.4b</td>
<td>2888.4a</td>
<td>71.4b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60</td>
<td>1.8</td>
<td>89.4ab</td>
<td>6.5a</td>
<td>63.0b</td>
<td>2853.8a</td>
<td>76.3b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75</td>
<td>1.2</td>
<td>82.4ab</td>
<td>6.8a</td>
<td>61.0ab</td>
<td>2964.5a</td>
<td>74.7b</td>
</tr>
<tr>
<td>2015</td>
<td>Control untreated</td>
<td>2.8</td>
<td>97.9b</td>
<td>5.7a</td>
<td>59.4a</td>
<td>2318.7a</td>
<td>65.9a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>750 CCC 750 SL</td>
<td>60</td>
<td>3.0</td>
<td>97.2b</td>
<td>5.8a</td>
<td>59.8a</td>
<td>2490.7a</td>
<td>67.2ab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>120</td>
<td>2.8</td>
<td>89.3ab</td>
<td>5.2a</td>
<td>57.2a</td>
<td>2545.3a</td>
<td>60.1ab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>180</td>
<td>2.3</td>
<td>84.1a</td>
<td>5.5a</td>
<td>57.2a</td>
<td>2433.3a</td>
<td>65.0a</td>
</tr>
<tr>
<td></td>
<td>750 CCC 750 SC</td>
<td>25</td>
<td>2.6</td>
<td>91.0ab</td>
<td>5.7a</td>
<td>53.1a</td>
<td>2318.7a</td>
<td>76.5b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>2.2</td>
<td>100.0c</td>
<td>5.8a</td>
<td>57.2a</td>
<td>2365.3a</td>
<td>63.7a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75</td>
<td>1.3</td>
<td>80.7a</td>
<td>5.4a</td>
<td>55.8a</td>
<td>2713.3ab</td>
<td>62.8a</td>
</tr>
<tr>
<td></td>
<td>750 CCC 750 SC</td>
<td>30</td>
<td>2.4</td>
<td>96.3b</td>
<td>5.7a</td>
<td>57.6a</td>
<td>2710.5ab</td>
<td>66.5ab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60</td>
<td>2.1</td>
<td>91.2ab</td>
<td>5.8a</td>
<td>57.4a</td>
<td>2635.3ab</td>
<td>64.7a</td>
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<tr>
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<td></td>
<td>90</td>
<td>1.3</td>
<td>89.6ab</td>
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<td>2713.3ab</td>
<td>65.6a</td>
</tr>
<tr>
<td>2016</td>
<td>Control untreated</td>
<td>2.5</td>
<td>94.5b</td>
<td>6.2a</td>
<td>61.3b</td>
<td>2687.3ab</td>
<td>66.7a</td>
<td></td>
</tr>
</tbody>
</table>

Legend: M' – height of plants, cm; LP – length of panicle, cm; NSC – number of seeds from one panicle, num.; TNS – total number of productive stems per m²; BY – biological yield, kg/da; a, b, c, d – statistically significant differences P<0.05.
The degree of lodging and the inhibition height of the stem in the standard wheatgrass variety Morava is in a negative correlation dependence with the applied dose of retardant \( r \) ranged from -0.904 to -0.990 in terms of the degree of lodging and for the stem height inhibiting from -0.846 to -0.992.

With increasing doses of retardants, was found to disproportionately reduce height of the plants, with the differences are statistically significantly, compared to the control variant (\( P=0.05 \)) at higher dosages.

The higher applied doses on CCC 750 SL, Toprex 375 SC and Moddus Evo significantly reduced the height of the standard wheatgrass. In the trial this reduction ranged from 1.8 to 18.7\% compared to the control variant. For the specific agrometeorological conditions, a relatively stronger retardant effect in the standard wheatgrass was reported after treatment with Toprex 375 SC – from -9.9 to 18.7\% (from 74.0 to 100.0 cm) and CCC 750 SL – from 0.7 to 14.3\% (from 78.0 to 97.2 cm) and weaker in Moddus Evo - from -2.4 to 12.2\% (from 82.4 to 96.3 cm).

From biochemical aspect it has been found that the active substances of (chlormequat chloride, paclobutrazole and trinexapac ethyl) of the retardants tested blocks the synthesis of gibberellins, plant hormones responsible for the elongation of plant (Santner et al., 2012). As a result, the reduction in plant growth (Rademacher, 2000).

The total number of productive stems depends on agrometeorological conditions (\( r \) of 0.702 to 0.988) and on the biological characteristics of the standard wheatgrass and is independent of the type and dose of applied growth regulators (\( r \) is in the range of 0.268 to 0.415) (Table 4).

The application of CCC 750 SL, Toprex 375 SC and Moddus Evo has not statistically significant effect on of some
върху някои от проучвните качества (дължина на класа, брой класчета в един клас и общ брой стебла на м²) при пустинния житняк. При конкретните геометеорологични условия на изследването нето приложените ретардани CCC 750 SL, Toprex 375 SC и Moddus Evo имаше статистически значимо стимулиращо действие (от 1.9 до 21.2%) при увеличение на добив от семена от пустинен житняк.


Резултатите от извършените дисперсионни анализи за установяване влиянието на проучванияте фактори на структурните елементи на продуктивността и добив от семена от пустинен житняк в зависимост от вида и дозата на приложените растежни регулятори с ретардантен ефект, показват, че най-голям дял от общото изменение (η²) е дял на агрометеорологичните условия (фактор A) – η² от 19.6 до 66.5%, средно 42.5%, следван от фактор C (концентрация) – η² от 2.2 до 6.3%, средно 3.7%. Тойностите на взаимодействието на проучванияте фактори на растежните регулятори и дозата имат относително по-малък дял на изменение – η² от 2.2 до 6.3%, средно 3.7%.

Similar results are obtained in the experimental work of Emam and Moaied (2000), Pourmohammad et al. (2014) and Murtic et al. (2017) according to them applied retardants (chlormequat chloride, paclobutrazole and trienexapachetyl) in some cereal crops, showed statistically significant stimulating effect on the formation of grain yields.

According to Bragg et al. (1984) and Tesfahun (2018) the main reason for the increase in yield after retardant treatment is due to the stimulating effect of transporting cytokines from roots to leaves, which increases the photosynthetic potential and is a prerequisite for the formation of the higher yield.

The results of the dispersion analysis performed to determine the influence of the studied factors on the structural elements of productivity and yield formation in standard wheatgrass of the depending on the species and doses of the applied plant growth regulator (with retardant effect) in show that the largest share of the total variation (η²) is due to the agrometeorological conditions (factor A) – η² from 19.6 to 66.5%, average 42.5%, followed by a factor C (concentration) – from 2.2 of 8.6 to 46.1%, an average of 24.1%, and a relatively lesser of growth regulator (factor B) – from 2.2 to 6.3%, average 3.7%. The values of the variants in the interaction of the studied factors AxC and BxC occupy a high share of the overall variation - r²average 42.1 and 62.5%,
от общото в рир не - \( \eta^2 \text{средно} \) съответно 42.1 и 62.5%, където р злижите с ст тистически док з ни (P=0.05), относително н и-м лък дял з ем въз имовъжк т х - \( \eta^2 \) от 8.2 до 19.2%, средно 14.9%, к то р злижите с ст тистически недок з ни.

пр веният първичен скрининг пок зв, че след трети р н пуст-тен житняк с р стежки регул т ор (750, опрекс 375 и одус во) с ред рд нтн ктивност не ок зв т ст тисически док з но инхи-бир щ ефект върху къллемост н семен т и първо ч лното р звите н култур т - GI в рир в гр ниците от 83.3 до 101.9% (Tiquia et al., 1996) (Т блиц 5).

Таблица 5. Влияние на растежни регулатори върху кълняемостта и първоначалното развитие на Agropyron desertorum (Fisch.) Schultes при л бор турни условия

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Dose, ml/da</th>
<th>Germination %</th>
<th>Length, cm</th>
<th>Weight, g</th>
<th>GI</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 CCC 750 SL</td>
<td>Control</td>
<td>76.8a</td>
<td>2.9a</td>
<td>2.0a</td>
<td>4.9a</td>
</tr>
<tr>
<td>60</td>
<td>73.7a</td>
<td>2.9a</td>
<td>2.0a</td>
<td>4.9a</td>
<td>0.002a</td>
</tr>
<tr>
<td>120</td>
<td>73.7a</td>
<td>2.3a</td>
<td>2.8a</td>
<td>5.1a</td>
<td>0.002a</td>
</tr>
<tr>
<td>180</td>
<td>77.1a</td>
<td>2.9a</td>
<td>1.9a</td>
<td>4.8a</td>
<td>0.002a</td>
</tr>
<tr>
<td>опрекс 375 Toprex 375 SC</td>
<td>25</td>
<td>73.8a</td>
<td>3.0a</td>
<td>2.0a</td>
<td>5.0a</td>
</tr>
<tr>
<td>50</td>
<td>68.3a</td>
<td>2.8a</td>
<td>1.8a</td>
<td>4.6a</td>
<td>0.001a</td>
</tr>
<tr>
<td>75</td>
<td>69.6a</td>
<td>2.9a</td>
<td>2.0a</td>
<td>4.9a</td>
<td>0.002a</td>
</tr>
<tr>
<td>опрекс 375 Toprex 375 SC</td>
<td>30</td>
<td>71.0a</td>
<td>2.8a</td>
<td>1.9a</td>
<td>4.7a</td>
</tr>
<tr>
<td>60</td>
<td>69.6a</td>
<td>2.8a</td>
<td>2.0a</td>
<td>4.8a</td>
<td>0.001a</td>
</tr>
<tr>
<td>90</td>
<td>70.4a</td>
<td>2.9a</td>
<td>1.9a</td>
<td>4.8a</td>
<td>0.001a</td>
</tr>
</tbody>
</table>

Legend: GI - plant development index; a, b, c, d – statistically significant differences P=0.05.

Similar results reported by Pando and Shrivastava (1987) in sunflower and Rajala and Peltonen-Sainio (2001), Pourmohammad et al. (2013), Pirasteh-Anoshehp et al. (2014) and Murtc et al. (2017) or a number of cereal crops.

According to them the positive effects of retardants on the increase yield and quality of cereals is the result of reduced dynamics of the vegetative growth of plants, alteration of the root and stem...
Растежните регулатори (с ретардантна активност) CCC 750 CL (750 g/l члормекват хлорид) – 60, 120 и 180 ml/da. Опърекс 375 (250 g/l дифенокон зол + 125 g/l паклобутразол) – 25, 50 и 75 ml/da и одус во (250 g/l триенекс п кетил) – 30, 60 и 90 ml/da приложени във фенофаза BBCH – 23-31 в годината на семеобразуване са с висока селективност (б.л. 1) към пустинен житняк (Agropyron desertorum (Fisch.) Schultes) сорт „Морава”. ССС 750 SL, Топрекс 375 SC и Моддус Ево оказват статистически значителна инхибаторна ефект върху височината на пустинния житняк. Относително по-слаб ретардантен ефект е отчетен след третиране с Топрекс 375 SC – от 9.9 до 18.7% (от 74.0 до 100.0 cm) и ССС 750 SL – от 0.7 до 14.3% (от 78.0 до 97.2 cm) и по-слаб при Моддус Ево – от 2.4 до 12.2% (от 82.4 до 96.3 cm) в зависимост от приложените дози.

ССС 750 SL, Топрекс 375 SC и Моддус Ево не оказват инхибаторен ефект върху покълването на семената и първоначалното развитие на пустинния житняк – GI варира в границите от 83.3 до 101.9% във всички случаи.

**CONCLUSIONS**

Growth regulators (with retardant activity) CCC 750 CL (750 g/l chlormequat chloride) - 60, 120 and 180 ml/da. Topotex 375 SC (250 g/l difenoconazole + 125 g/l paclobutrazole) - 25, 50 and 75 ml/da and Modus Evo (250 g/l trienexapacate) - 30 60 and 90 ml/da applied the year of seeds formation are highly selective (1 score) to standard wheatgrass (Agropyron desertorum (Fisch.) Schultes) variety “Morava”.

750 L, Toprex 375 SC and Moddus Evo had a statistically significant inhibitory effect on the standard wheatgrass height. A more relatively stronger retardant effect was reported after treatment with Toprex 375 SC – from -9.9 to 18.7% (from 74.0 to 100.0 cm) and CCC 750 SL – from 0.7 to 14.3% (from 78.0 to 97.2 cm) and weaker in Moddus Evo – from -2.4 to 12.2% (from 82.4 to 96.3 cm), in depending on the applied doses.

CCC 750 SL, Toprex 375 SC and Moddus Evo did not have an inhibition effect on the seed germination and initial development of standard wheatgrass - GI ranges from 83.3 to 101.9% at all doses applications.

/ REFERENCES /


SUMMARY
The article reviews the information from literary sources for alfalfa longhorn beetle (Plagionotus floralis Pall.) – a pest of alfalfa (Medicago sativa L.).

Systematic affiliation data are provided; the synonyms known in the literature; the distribution range around the world and in Bulgaria; historical data, as well as its appearance in our country; morphology; phenology; biological features and picture of damage; the impact that damage occurs on alfalfa yields and biochemical changes in the plant; ways and means of insect control – agrotechnical, physico-mechanical, macro-biological methods, as well as the use of resistant varieties and biologically active substances.

Key words: alfalfa longhorn beetle, Plagionotus floralis, alfalfa, Medicago sativa
According to Kasatkin (2005), the treatment of the genus *Plagionotus* Mulsant, 1842, is ambiguous, as the reason for the disputes is the position of *Plagionotus floralis* (Pallas, 1773). Based on the constitution of the internal sac of aedeagus (endophallus), he considers that *Echinocerus* Mulsant, 1863, is a completely independent genus, not a synonym of *Plagionotus* Mulsant, 1842. The *Plagionotus* Mulsant genus, 1842, is divided into three genera *Plagionotus* Mulsant, 1842; *Neoplagionotus* Kasatkin, 2005 and *Paraplagionotus* Kasatkin, 2005.

Sama (2008) after a very careful comparative study of the morphology of species of the three genera, incl. *Pl. floralis* as a representative of *Paraplagionotus* does not find any significant difference, except in the shape of the pronotum (as wide, as long in *Pl. floralis*). Therefore, the author gave *Echinocerus* Mulsant, 1863, *Neoplagionotus* Kasatkin, 2005 and *Paraplagionotus* Kasatkin, 2005 as synonyms of genus *Plagionotus* Mulsant, 1842. This opinion was repeated in Löbl and Smetana (2010).

According to Özdikmen and Turgut (2009) and Özdikmen and Ali (2016), the taxonomic features referred by Kasatkin (2005) are very important, incl. that larvae develops in different host plants. They offer the genus *Plagionotus* to be divided into three subgenera: *Echinocerus* Mulsant, 1863; *Neoplagionotus* Kasatkin, 2005 and *Plagionotus* Mulsant, 1842. The species *Plagionotus floralis* to refer to subgenus *Echinocerus* and the proposed new name is *Paraplagionotus* Kasatkin, 2005 *floralis* Pallas, 1773.

In the world, the genus *Plagionotus* includes 11 species (Biological Library, 2009-2019), 7 of which were reported in Europe, and only four of them are found in Bulgaria - *Plagionotus arcuatus* (Linnaeus 1758), *Plagionotus bobelayei* (Brullé 1832), *Plagionotus detritus* (Linnaeus 1758) and *Plagionotus floralis* (Pallas 1776) (faunaeur.org/species_list.php, 2019).

Alfalfa longhorn beetle is described as a new species of Pallas (1773) as *Cerambyx floralis*, observed during an expedition in 1771 in Russia’s Central province - the Volga region, the Ural, the Western Siberia, the Altai, and the Baikal region (Kolchinski 1996). It is known in the scientific literature with 12 synonyms, the most common being: *Echinocerus floralis* (Pallas) Villiers 1978, *Paraplagionotus floralis* (Pallas) Kasatkin 2005, *Clytus floralis* (Pallas) Mulsant 1862, *Cerambyx floralis* Pallas 1773, *Clytus abruptus* Kraatz 1870, *Clytus pruinosus* Kraatz 1870 (Taxonomy, 2013; Catalogueoflife.org, 2019).

*Plagionotus floralis* Pall. is a widespread alfalfa pest in Europe - from Portugal to the Ural Mountain, Asia Minor, Caucasus, Northern Iran, Siberia, the Middle East, Syria, Jordan, Israel (Katalin, 1960; Danilevsky, 2015; Sama et al., 2010; faunaeur.org/species_list.php, 14.12.2016).

Data about alfalfa longhorn beetle, mainly from faunistic studies, are reported by other authors for the following countries:

- Ukraine (Vassiliev, 1914; Fedorov, 1925; Bartenev, 2003)
- Russia (Ivanov and Medvedev, 1970)
- Austria (Adlbauer and Skofitsch, 1979; Steiner, 1999; Adlbauer, 2001)
- Romania (Serafim, 1993; Ungureanu et al., 2008; Serafim and Maican, 2008)
- Italy (Fattorini, 1988; Biscaccianti, 2004)
- Serbia and Montenegro (Pil, 2004/2005; Pil and Stanković, 2006; Pil and Stojanović, 2007; Nikčević, 2008)
- Croatia (Koren and Perović, 2010)
- Greece (Dascălu et al., 2012)
- Hungary (Kovács, 1997; Kovács et al., 2001; Sár and Dudás, 2002; Lőkkös, 2003)
- Poland (Gutowski, 1990; Kurzawa, 2017)
- France (Brustel et al., 2002)
In Bulgaria the alfalfa longhorn beetle is widely distributed and occurs up to about 1300 m above sea level (Angelov, 1995). It was first time observed in 1928 and 1929 and was reported by Chorbajiev (1930, 1932), who also gives evidence of a massive attack in the districts of Shumen, Pleven, Sofia, Plovdiv and in the regions of Chirpan, Svilengrad and Panagyurishte.

The next 30 years information about *Pl. floralis* in entomological literature is not published. New research on the pest began in 1960-65, a prerequisite of which is the increased distribution, number and damage of the larvae in different settlements in Bulgaria.

For the same period, Makarov (1965) included the alfalfa longhorn beetle in the lists of established harmful insect pests in the area of the Agricultural Research Institute "Obrazcov Chiflik” near Rousse.

After this period, for 34 years, data about *Pl. floralis* is not published again in Bulgaria. In recent years there have been reports in the literature about the spread of the pest in new regions of the country give Georgiev et al. (2002), Georgiev and Stojanova (2003), Angelova et al. (2010), Topalov et al. (2014).

Data about the phenoology, biology, and picture of the damage in Hungary is reported by Baranyovits (1944). According to the author’s observations, the beetle imaging begin at the end of May or the beginning of June. Laying eggs and embryonic development were monitored in laboratory conditions, and it was found that the embryonic stage was 15 days. In Romania, the morphological features of the alfalfa longhorn beetle larvae and the picture of the damage are described by Kemenesy and Manninger (1968).

In China, Xinjiang province, damage from alfalfa longhorn beetle on alfalfa and clover was observed, which required an investigation into the phenology and biology of the pest. The authors find that in this area *Pl. floralis* has one generation a year, adults are imagined in July, and the embryonic stage lasts 6-8 days (Fu and Xie, 1986).

A short description of the morphology, biology and the picture of the damage of the alfalfa longhorn beetle in our country are made by Chorbadjiev (1930, 1932), Popov et al. (1958), Dirimanov (1962) and Angelov (1995), but more extensive information about the development and harmful activity of the pest, and the ways of insect control gives Makarov (1968). The author follows the phenological development of *Pl. floralis* and finds that adult individuals appear in mid-June and meet in alfalfa blocks till the end of July. The larvae hatch in June-July and end the development around mid-May next year.

Zhekova (2018) establishes a clear sexual dimorphism expressed in the proven bigger average of the length and
на дължината и теглото на женските индивиди в сръдствие с мъжките, където и р злично оцветяване не н пъвото нтенно членче, основното членче, бедреното пръстенче и бедрото н трите двойки кр к. основ т н тези признаци втори изчислява положения индекс, който в рир през годините. ст новяв, че мъжките индивиди пон сат по-добре неблагоприятни климатични условия в сръдствие с женските.

одни н Sama et al. (2010) л рките н люцерновия сечко се хрънят в стъблата и корените н р злични видове тревисти р стения, прин длежки ко семействт Fabaceae (Medicago sativa L.), Euphorbiaceae (Onobrychis, Amananthus, Camelia, Melilotus, Euphorbia gerardiana Jacq.), Asteraceae (Achillea millefolium L.) и др. поред Chorbadzhev (1930) и Makarov (1968), л рките изядж т почти цял т вътрешност н центрния корен н люцерновите р стения от шийк т до 5-10 см н долу, която се изпълва със стърготини. един корен з вършв р звитието си един л рв, според Zhekova and Petkova (2010) повече от един, върху п р стения изост в т вр звитието си, д в т полем лъж добив, постепенно изсъхв т и люцерновите полет се прераждат. поред Makarov (1968) люцерновият сечко, ко голямият люцернов хоботник, е един от основните причини з бързото прераждане и з гив не н люцерновите посеви.

осъщото з ключение достиг т и други втори. Petkova et al. (2005) съществува, че н лява н продуктивност и дълготраеност н люцерновите посеви може да бъде предизвикан от фототогенни органи и, което и от неприятели, които индуцират изменения в биохимичния състав н люцерновият сечко. блюденият н вторите през последните години върху р пространствено н льоето и люцерновия сечко и повредите от л рките док зв т, че видът е в женния втори прераждането з гив не н люцерновите р стения.

Plagionotus floralis е сред по-върховините върху р прераждането з гив не н люцерновите р стения. According to Sama et al. (2010), the larvae of the alfalfa longhorn beetle are fed to the stems and roots of different types of grassy plants belonging to the families Fabaceae (Medicago sativa L.), Euphorbiaceae (Onobrychis, Amananthus, Camelia, Melilotus, Euphorbia gerardiana Jacq.), Asteraceae (Achillea millefolium L.) and others.

According to Chorbadjiev (1930) and Makarov (1968), larvae eaten almost the entire interior of the central root of alfalfa plants from the neck to 5-10 cm below, which is filled with sawdust. In one root a larva ends its development, but according to Zhekova and Petkova (2010) more than one. The damaged plants are lagging behind in their development, yielding less, gradually drying out, and alfalfa fields dilutions. According to Makarov (1968), the alfalfa longhorn beetle, as well as the clover leaf weevil, are one of the main reasons for the rapid dilution and destruction of alfalfa crops.

The same conclusion is reached by other authors. Petkova et al. (2005) consider that the reduction in productivity and persistence of alfalfa crops can be caused by phytopathogenic organisms as well as by pests that induce alterations in the biochemical composition of alfalfa. Observations by authors in recent years on the distribution of alfalfa longhorn beetle and damage from the larvae have shown that the species is an important factor in the premature destruction of alfalfa plants.

Plagionotus floralis is one of the
the most important insect alfalfa pests in the areas of Saratov and Krasnodar in Russia (Sakharov, 1923; Kowal et al., 1998), the Nakhichevan Autonomous Province of Azerbaijan (Talybo et al., 2017) and to a large extent responsible for the dilution of the old alfalfa crops in Romania (Mitrjuskin, 1940) and Serbia (Đukić and Erić, 1995). At the roots of alfalfa, larvae channel canals by preferring plants with thick roots, so the damage is important for older alfalfa.

Similar is the opinion of other authors, according to them the older and weedy alfalfa are preferred by the adult individuals because the flowering plants in them are a source of food. In the village of Dulovo (Silistra region) in two-three years old alfalfa Popova (1968) observed 20-30% damage from alfalfa longhorn beetle, and after the third year – 60-80%.

Based on these data, the author recommends that alfalfa crops should not be used for more than four years. For damage up to 100% of *Pl. floralis* in the older alfalfa in the villages of Markovo and Opalchenets (Chirpan district) and for average losses in the attacked areas between 10 and 30% reported also Chorbadjiev (1930, 1932). Information about 70-80% of damaged plants in 6-7 year old alfalfa in Kubrat gives Makarov (1968). For the Rousse region, Zhekova (2018) reported 18% of damaged plants in standard crops (12,5cm distance between rows) and 32% of damaged plants in wide rows (70 cm distance between rows) crops, confirming the trend for higher percentages of damaged plants in older crops (3-4 yrs).

According to Bócsa (1979) and Bozsik (2010, 2013) in Hungary the alfalfa longhorn beetle rarely causes damage to the alfalfa roots and is a pest with little importance in the old alfalfa crops.

The species is common in the country, but
its population density is low and the damage to alfalfa plants does not affect the yield of green matter and dry matter. A similar opinion is expressed by Paskalev (1977), according to him certain species of insects can become harmful only in certain ecological conditions.

An important factor in limiting the damage caused by the larvae of alfalfa longhorn beetle is the irrigation. In scientific literature it is reported that in the irrigated alfalfa the quantity of damaged plants is many times less than that of the non-irrigated. According to Grigorov (1974), the density of larvae of the alfalfa longhorn beetle is higher in non-irrigated areas, resulting in damage to 50-70% compared to 1.5% damage to irrigated fields.

Similar results were published by Ponomarenko (1940) for Volga and Noushad and Kazemi (1995) for Azerbaijan proving that three-year-old alfalfa without irrigation, where the roots are bigger and coarser, are more attacked by the larvae.

Opposite conclusions reported Tamer et al. (1997) and Khamraev (2003) from the observations carried out in the provinces of Ankara and Konya (Turkey), and Korezm and Karakalpakstan (Uzbekistan). The authors found that alfalfa damage was greatest in irrigated alfalfa, where the attack reached 50%, compared to those grown under non-irrigated conditions where the damage was significantly lower (5%).

According to Ponomarenko (1944) and Makarov (1968), growing alfalfa for seed production is a prerequisite for increasing numbers of Pl. floralis, which requires to keep alfalfa crops clean from the enemy and the weed plants which provide food for the beetles. Similar is the Bozsik’s (2010, 2013) opinion that excessive use of old, diluted and heavy
когото прек леното използв не н ст ри, р зредени и силно з плевелени люцерни бл голпийтв ст рзмног в нето и възможн т вред от люцерновия сечко.

рез многогодишни проучвния върху ентомоф ун т н люцерн т Порова (1968) док зв , че редув нето н културите в сеитбооборот , изпол-зв нето н площите с люцерн не повече от четири години и отделянето н семенните уч стъци н 1,5-2,0 km, още по-добре н 4-5 km от другите уч стъци с бобови култури, особено от ст рите люцерни, в ен чителен степен оп зв т люцерн т з семе от много неприятели, в т.ч. и от люцерновия сечко.

енетично детермини н т устой-чивост н р стеният към н секоми трябв д се използв , колкото тов е възможно, з щото предост вя по-сигурно и по-ефикасно средство з з щит н новите сортове от н секоми. орб т срещу н секомите, които не се вялят от тези мерки, трябв д се води с химически средства (Yankulov, 1996).

поред Nikolova and Kertikova (2008) използв нето н толер нтни (сл -бо чувствителни) сортове и обр зи люцерн е един от н й-сигурните методи з борб с вредните н секоми, к кто и в жно звено от интегри н т систем з оп зв н културните р стения от неприятели. ъзд в нето и отглежд нето н устойчиви сортове люцерн им особено голямо зн чение в борб т срещу почвените неприяте-ли. ри тях основн т вред н сят л рвите, които водят скрит н чин н живот, и пор ди борб т с тези видове е много трудн . езеру тите от проучв ният н втори върху почвените неприятели при люцерн т пок зв т, че с нисък процент н повре-д от л рв т н люцерновия сечко с сортовете ,, р ,, (17,4%) и ,, рист 2 ,, (28,6%). о-сильно н п дн ти с инди-виду линте р стения, отглежд ни н по-голям хр нитен площ, при които н п денято е средно 62,0%, док то при посевите е зн чително по-ниско –

Through many years of research on the entomofauna of alfalfa Popova (1968) proves that rotation of crops, the use of alfalfa crops for no more than four years and the separation of seed areas at 1.5-2.0 km, and even better 4-5 km from other legumes, especially from the old alfalfa crops, largely protect the alfalfa from a lot of enemies, incl. and the alfalfa longhorn beetle.

Genetically determined plant-to-insect resistance should be used as much as possible because it provides a safer and more efficient means of protecting new varieties of insects. The control of insects that are not affected by these measures must be carried out with chemical means (Yankulov, 1996).

According to Nikolova and Kertikova (2008) the use of tolerant (slightly sensitive) varieties and alfalfa samples is one of the safest methods for control of harmful insects, as well as an important unit of the integrated system for protecting crops from pests.

The creation and cultivation of resistant alfalfa varieties is particularly important in the control against soil pests. In them, the main damage is caused by the larvae that lead a hidden way of life, and therefore the control of these species is very difficult. The results of the authors’ studies on alfalfa pests in the alfalfa show that the Daria (17.4%) and Prista 2 (28.6%) varieties have a low percentage of damage to the alfalfa longhorn beetle.

The individual plants grown on a larger food area, where the attack is on average 62.0% are more attacked, while in the standard crops are significantly lower – 27.3%. The "Dara" and "Prista 2" varieties
27.3%. The varieties "Dara" and "Prista 2" have a low degree of mixed damage from soil pests and may be suitable germplasm for tolerance to Pl. floralis.

In the study of six germplasms in CVT, Zhekova (2017) reported that the best complex results show the germplasm SP-SP 08-1, which warrants inclusion in selection programs related to the search for genes for high productivity of alfalfa and for tolerance of crop to pests.

When comparing the results of the biochemical analysis of healthy roots with those damaged by alfalfa longhorn beetle and root rot, it was found that under both stress factors the metabolic response of plants was unidirectional.

The content of raw fiber, calcium and total phenols increases and the content of phosphorus, magnesium and sugars decrease. The differences between effect of root rot and damage by alfalfa longhorn beetle are that in root rot roots the content of raw protein and saponins decreases (Ilieva, 1996; Jurzysta, 1979), and in the case of the damaged by the larvae increases (Petkova et al., 2005).

The results show significant non-specificity in plant responses in the studied pathogen and pest indicators. It is possible that the magnitude and nature of responses will depend mainly on the degree of damage caused by the stress factors and the degree of resistance of the plants to the same (Edreva, 1989).

Saponins in alfalfa belong to the group of triterpenoid saponins and are mainly concentrated in the roots, with genetic differences in their concentration in the different varieties and regrowth (Bickoff et al., 1972; Nowacka and Oleszek, 1994; Nozzolillo et al., 1997; Yazdi-Samadi et al., 2004; Georgieva et al., 2012; Nikolova et al., 2012; Nikolova et al., 2015). The presence of saponins in
alfalfa is associated with resistance to some pests and pathogens (Pedersen et al., 1976; Sutherland et al., 1982; Gorski et al., 1991; Tava et al., 1992; Tava and Odoardi, 1996; Sylwia et al., 2006; Chaib, 2010).

Some biological agents are also responsible for limiting the population density of alfalfa longhorn beetle, among which the ectoparasitoids of the Braconidae (Hymenoptera) are effective control. According to Mitrjuskin (1940) in Romania on the larvae of Pl. floralis parasite the species *Bracon lautos* Szepl. According to the author, the spread of the parasitoid and the removal of attacked plants are the only effective methods of destroying the enemy. Parasited larvae of *Pl. floralis* from *B. lautos* were established by Tanasijevic (1962) in alfalfa in Serbia and Macedonia. In China, as the most important natural enemies of alfalfa longhorn beetle, are reported *Corvus frugilegus* L. and the ectoparasitoid *Microbracon* sp. [Bracon sp.] (Fu and Xie, 1986).

In Turkey on the larvaes of *Pl. floralis* has identified another type of ectoparasitoid of the genus *Bracon* - *Bracon nigriventris* Wesmael 1838, which is also reported as a new species for the country (Beyarslan et al., 2005). According to the authors, the parasite is found in the Palearctic zone – the Caucasus, Central Asia, Kazakhstan, Mongolia, Russia, Western Europe, and hosts are alfalfa longhorn beetle and others insect species.

Žikić et al. (2012) reported for the first time data about the species of *Bracon* (subfamily Braconinae) in the territory of Serbia. Thirty-eight of the reported species occur in Bulgaria, including the species *Bracon* (Lucobracon) *nigriventris* Wesmael 1838 with hosts *Plagionotus floralis* (Cerambycidae), *Hylobius piceus* and *Pissodes pini* (Curculionidae). Zhekova et al., 2012; Nikolova et al., 2012; Nikolova et al., 2015). Наличие на сапонини при люцерната се свързва с резистентност към някои неприятел и патогени (Pedersen et al., 1976; Sutherland et al., 1982; Gorski et al., 1991; Tava et al., 1992; Tava and Odoardi, 1996; Sylwia et al., 2006; Chaib, 2010).

В Турция по ларвите на *Pl. floralis* е идентифициран друг вид ектопаразитоид от род *Bracon* - *Bracon nigriventris* Wesmael 1838, който се среща в Палеарктическа зона – Кавказ, Централна Азия, Казахстан, Монголия, Русия, Западна Европа, а гостоприемници са люцерновия сечко и др. видове насекоми.

Žikić et al. (2012) за първи път съобщиха за присъщите в техния вид ектопаразитоид *Bracon* (subfamily Braconinae) в територията на *Plagionotus floralis* (Cerambycidae), *Hylobius piceus* и *Pissodes pini* (Curculionidae). Zhekova et al., 2012; Nikolova et al., 2012; Nikolova et al., 2015). Наличие на сапонини при люцерната се свързва с резистентност към някои неприятел и патогени (Pedersen et al., 1976; Sutherland et al., 1982; Gorski et al., 1991; Tava et al., 1992; Tava and Odoardi, 1996; Sylwia et al., 2006; Chaib, 2010).

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Zhekova (2015) reported that the relative amount of infected larvae of *Pl. floralis* from *Bracon* (*Lucobracon*) *nigriventris* Wesmael 1838 ranges from 0 to 12.5% depending on the age of alfalfa plants.

In entomological literature, there is a little information about pest control of alfalfa longhorn beetle.

According to Makarov (1968) the use of chemicals against larvae is ineffective because of their hidden lifestyle. Based on the results of a laboratory test on the efficacy of eight plant protection products (already out of use) against the imago, the author suggests that the chemical treatment should be carried out against the beetles when they eat the floral parts of the weed plants in or around the alfalfa crops, before the oviposition. To reduce the number of the enemy contributes also the cutting of the weeds around the alfalfa fields.

Đukić and Erić (1995) offer plowing and burning roots to prevent the imagination of adult insects and intensive irrigation, which helps to reduce damage. The authors consider that the chemical treatment gives poor results.

Fu and Xie (1986) tested the efficacy of chemicals products against *Pl. floralis* and found that Dimethoate (40%) provides effective control of the pest. To control of the alfalfa longhorn beetle in Greece, Diazinon 60 EC (60% diazinon) is registered (Chimac Agriphar SA, 2005).

In Bulgaria there is no insecticide product registered for control of alfalfa longhorn beetle (BFSA, 2018). Zhekova and Nikolova (2015) tested eight insecticides against the adults of the alfalfa lohghorn beetle from IRAC groups 1B, 3A and 4A in the laboratory. Synthetic pyrethroids (3A) Karate Zeon (lambda-
Синтетичните пиретроиди (3А) Карате Зеон (ламбда цихалотрин) и Децис 2.5 EC (дeltаметрин) и неоникотиноид (4А) Калипсо 480 SC (тиаклоприд) показват бързо инициално действие и висока ефикасност. Неоникотиноидите (4А) Моспилан 20 SP (acetamiprid) и Актара 25 WG (thiamethoxam) показват незадоволителен ефект.

Изследванията на Toshova et al. (2010, 2017) и Imrei et al. (2014, 2018) показват, че жълтите флуоресцентни капани (CSALOMON®ARb3z и TERN lure) могат да се използват успешно за откриване и контролиране на огнища на вредителя.

**CONCLUSIONS**

The presented literature shows that alfalfa longhorn beetle is among the economically dangerous alfalfa pests in many countries in Europe and the world and one of the main factors for reducing the durability and premature dying of alfalfa crops. For the development of effective control systems, the efforts of scientists in these countries are aimed at studying the phenological and biological characteristics of the pest, the harmful activity of the larvae, as well as ways of limiting it; looking for alfalfa resistance genes to *Pl. floralis* and new methods and means of pest control.

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Performance of Productive Potential of Winter Rape (Brassica napus) at Different Sowing Times

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**SUMMARY**

The study was carried out from 2014 to 2017 in the experimental field of IASS "Obraztsov Chiflik" - Rousse. The field experiment was a randomized block design with four replications and harvesting plot size 10 m\(^2\). The object of the study was Jackson winter oilseed rape hybrid. It's the same sowing times, over an equal time intervals at with the same sowing rate (6 kg ha\(^{-1}\)) and at the same soil pre-sowing agrotechnics activities.

The economic seeds productivity by the following indicators was reported: grain yield, kg da\(^{-1}\); structural elements - plant height, beans number and beans mass per plant, seeds number and seeds mass per plant; content of plastid pigments.

The aim of present study was the impact of sowing time on the productivity of Jackson winter oilseed rape hybrid to be investigated.
It was found that sowing period had the strongest effect on seeds yield of winter rape, followed by the conditions of the year.

Key words: winter rape, productivity, structural elements of yield, sowing dates, plastid pigments

**INTRODUCTION**

Rapeseed (*Brassica napus*) comes from the Mediterranean, but is grown massively in cool and temperate climates around the world. It is not a very pretentious plant and grows well at low temperatures. In our country, it is mainly grown in Central and Northern Bulgaria and flower from April 15 to May 10, because of which the rape is a main source of pollen for the bees.

The winter rape sowing time plays an important role in the development stages pass, but it has the most significant effect on the seeds yield. In the most cases the late sowing leads to the formation of fewer flowers (Ivanova et al., 1999).

Numerous studies in Ukraine were showed that maximum yield of 3200 kg ha\(^{-1}\) and oil content of 47.27% were obtained at sowing from 28 August to 01 September. The sowing delaying by 5 to 10 days results in decrease in yield by 15 kg ha\(^{-1}\) and in oil content by 1.93% (Shelestov and Vdovichenko, 1985, 1991).

Of the 4 varieties tested at sowing times 07 - 27.09; 16 - 20.10; 13.11; 3.12, in England, the highest yield of 6700 kg ha\(^{-1}\), oil content of 43.3% and 26.4 seeds number per pod were obtained from the Jet Neof variety and sowing date 13.11 (Jenkin and Leitch, 1986).

In some regions of Poland and Russia, the field experiments were carried out to find the most suitable sowing period. Based on the results obtained, it is concluded that the optimal sowing time for...
оптималния срок за сеитба на зимна маслодайна рапица е първата половина на август (Moore and Cuy, 1997; Anderson and Bengtsson, 1992; Vos and Putten, 1997).

Опитите изведени в Институт по фуражите в Плевен, потвърждават данните на други автори, че срокът на сеитба на зимна рапица влияе върху продължителността на юния период и зимоустойчивостта. При сеитба на 20.08. периодът поникване – пълна зрялост на семената обхваща 306 дни, а при сеитба на 10.10. – 255 дни. Най-висок добив семена в Северна България е получен при дата на сеитба на 10.09. – 4300 kg ha⁻¹ (Stefanova, 1990).

За района на Русе, такива изследвания липсват, което определи целта на настоящото проучване – да се проучи влиянието на срока на сеитба върху продуктивността на зимната рапица хибрид Jackson.

**MATERIAL AND METHODS**

The study was carried out in the experimental field of the Institute of Agriculture and Seed Science "Obraztsov chiflik" - Rousse in the period 2014-2017, on an area of 5 da on leached chernozem. The subject of the study is the winter oilseed rape hybrid Jackson. The soil is characterized by good potassium (33.17 mg 100g⁻¹ soil), insufficient nitrogen (16.84 mg 100g⁻¹ soil) and poor phosphorus (6.15 mg 100 g⁻¹ soil) nutritive rate. The soil reaction (pH) is slightly acidic (in KCL 5.6 - 6.7, degree of saturation with bases 89 - 92%).

Rapeseed was sown after the pre-crop field peas Ruse 1 variety, with nitrogen application rates of 140 kg ha⁻¹ a.s., phosphorus - 80 kg ha⁻¹ a.s. and potassium - 40 kg ha⁻¹ a.s. The phosphorus and potassium as well as 30% of nitrogen were applied once at basic tillage before sowing, and the rest of the nitrogen was imported in the spring, after the beginning of the winter rape growing season. The sowing of the crop was performed in four
The winter rape was harvested in a full maturity stage and productivity (kg ha\(^{-1}\)) was determined by the biometric indicators: plant height (cm); number and weight of pods per plant (g); number and weight of seeds per plant (g). To account the biometric indicators, 20 plants were taken from each plot of the variants tested and then manipulated and equalized to average for 1 plant.

For content of plastid pigments (chlorophyll \(a\), chlorophyll \(b\) and carotenoids) determination samples of fresh mass (200 g) were taken (Zelenskii and Mogileva, 1980). For this purpose, plant samples of each variant are taken, which are extracted with 80% acetone and filtered with a G-3 filter. They were determined with Specol 11 spectrophotometer. The measurement was performed at three light wavelengths corresponding to the absorption maxima of each individual pigment: chlorophyll \(a\) = 663 nm; chlorophyll \(b\) = 644 nm; carotenoids
\[ b = 644\ \text{nm}; \quad \text{к ротеноиди (в) = 440 nm.} \]

Тъй като експериментът бил с нестабилен, поради промените в основни негови характеристики, периода на изследване, от 2014 до 2017 г., е резултатите от изследване установени чрез многорангов тест на Дънкан, с помощта на програмния продукт SPSS 19.0 (Ganeva, 2016).

РЕЗУЛТАТИ И ОБСЪЖДАНЕ

Климатът на нашата планета, в частност и климата на България, в началото на ХХІ век може да се определи като нестабилен, поради промените в основни негови характеристики. Периодът на изследване, от 2014 до 2017 г., е различен в климатично отношение.

През годините на изследването валежите през месец август са недостатъчни и доведоха до задържане на основните обработки на почвата, което след себе доведе до задържане на сеитбата на рапицата. Падналите валежи през месец октомври успяха да подобрят влагосъдържанието на почвата в повърхностните слоеве и осигуриха влага за нормално протичане на начинните фази от вегетацията на зимната рапица (Фигура 1).

През есенно-зимния период не се съблюдаваха екстремно ниски температури. Валежите в същото време са малко над нормата за региона. 2016 г. характеризира със същото отношение.

Падналото снеговалежи успяха да направят снежно ложе, което предпази културата от зимно замръзване. Метеорологичните условия през есента благоприятстваха развитието на рапицата, която успя да достигне фаза розетка.

Пролетта, средно за периода, беше с равенство в температурите. Валежите през април и май са високи над нормата за региона, а температурната сума беше около нормата.
Fig. 1. Climate characteristic for the period 2014-2017
In 2017, the rainfall in May and April were higher than the long-term norm. The lack of rainfall in the second half of June and July allowed the harvest on time to be done.

Observation data showed that the sowing period had a strong influence on the plant development and the incoming of specific stages.

From all stages of development the most important is the rosette phase, since from that depends in what degree of tempering the plants will be in the beginning of the winter, and hence the percentage of frost and the yield increase.

Data regarding the impact of sowing time on the seeds quantities obtained depending on weather conditions are presented in Table 1.

Table 1. Comparative analysis of yield index, kg ha\(^{-1}\) of winter rape hybrid Jackson, average for 2014-2017

<table>
<thead>
<tr>
<th>№</th>
<th>Sowing date</th>
<th>Seeds yield, kg ha(^{-1})</th>
<th>Method of Duncan</th>
<th>Differences ± kg ha(^{-1})</th>
<th>% vs. control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I date (Control)</td>
<td>2094 n.s.</td>
<td>a</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>II date</td>
<td>2050  n.s.</td>
<td>a</td>
<td>-44</td>
<td>97,9</td>
</tr>
<tr>
<td>3</td>
<td>III date</td>
<td>2386  n.s.</td>
<td>a</td>
<td>+292</td>
<td>113,9</td>
</tr>
<tr>
<td>4</td>
<td>IV date</td>
<td>2440  n.s.</td>
<td>a</td>
<td>+346</td>
<td>116,5</td>
</tr>
</tbody>
</table>

Legend: *Sufficient evidence for the reliability \( \alpha = 0.05 \); **Sufficient evidence for the reliability \( \alpha = 0.01 \); ***Sufficient evidence for the reliability \( \alpha = 0.001 \); n.s. - no significant differences among variants at \( P < 0.05 \).

The results showed that due to the favorable temperature and moisture in the initial stages of winter rape development, seed yield was significantly higher (2440 kg ha\(^{-1}\)) in the last fourth (IV) sowing date. The excess compared to the control was 346 kg ha\(^{-1}\) or 16.5%. Fewer amount of precipitation and the
higher temperatures, in the initial stages of rape development at the first three sowing dates contributed to lower yields than this one at the fourth (IV) date. Average for the period in the first three sowing dates, the average yield ranged from 2050 kg ha\(^{-1}\) to 2386 kg ha\(^{-1}\). There were not found significant differences in the yields obtained, over the years and average for the period regarding sowing times.

The two-factor analysis of variance of the yield structural elements showed that both the year with their specific meteorological conditions and the term sowing had a strong statistical impact on the plants height (\(\eta 90.7; \eta 66.4\)), the pods number per plant (\(\eta 99, \eta 99\)), the mass of pods per plant (\(\eta 85.7; \eta 87.5\)), the seeds number per plant (\(\eta 100; \eta 99\)) and the mass of seeds per plant (\(\eta 100; \eta 100\)) (Table 2).

The combined effect of the both factors year and sowing time was especially strong on the indicators pods number per plant (\(\eta 98\)), mass of pods per plant (\(\eta 100\), seeds number per plant (\(\eta 100\)), mass of seeds per plant (\(\eta 99\)) and lower but statistically significant on plants height (\(\eta 50.8\)).
Table 2. Analysis of variance for yield components of winter rape, average for 2014-2017

<table>
<thead>
<tr>
<th>Source of variation / Източник на вариране</th>
<th>Sum of Square / Сума на квадратните отклонения</th>
<th>Mean Square / Средни квадрати</th>
<th>Sig of F / Ση²</th>
<th>Degree effect, % / степен на влияние, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>35.39</td>
<td>27.34</td>
<td>3.00</td>
<td>12.25</td>
</tr>
<tr>
<td>Sowing time - В / срок на сеитба - B</td>
<td>7.16</td>
<td>19.05</td>
<td>3.50</td>
<td>12.58</td>
</tr>
<tr>
<td>A x B / A x V</td>
<td>3.75</td>
<td>4.92</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Residual</td>
<td>3.63</td>
<td>0.00</td>
<td>0.50</td>
<td>0.00</td>
</tr>
</tbody>
</table>
The average values of the yield structural elements for the study period are presented in Table 3.

Table 3. Effect of biometrics indicators on the productivity of the JACKSON rape hybrid, averaged for 2014-2017

<table>
<thead>
<tr>
<th>Sowing time</th>
<th>pods height, cm</th>
<th>pods number per plant</th>
<th>pods weight per plant, g</th>
<th>seeds number per plant</th>
<th>seeds weight per plant, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date (control)</td>
<td>127.4 n.s.</td>
<td>135.2 n.s.</td>
<td>11.31 n.s.</td>
<td>1093.2 n.s.</td>
<td>5.02 n.s.</td>
</tr>
<tr>
<td>Date</td>
<td>128.8 n.s.</td>
<td>148.2*</td>
<td>12.26 n.s.</td>
<td>1257.6 n.s.</td>
<td>8.50 n.s.</td>
</tr>
<tr>
<td>Date</td>
<td>128.2 n.s.</td>
<td>130.6 n.s.</td>
<td>11.27 n.s.</td>
<td>1262.6 n.s.</td>
<td>5.68 n.s.</td>
</tr>
<tr>
<td>Date</td>
<td>134.8*</td>
<td>139.2*</td>
<td>11.69 n.s.</td>
<td>1200.4 n.s.</td>
<td>5.67 n.s.</td>
</tr>
</tbody>
</table>

Legend: *Sufficient evidence for the reliability α = 0.05; **Sufficient evidence for the reliability α = 0.01; ***Sufficient evidence for the reliability α = 0.001; n.s. - had no significant differences with the control.

Data in respect plants height showed that higher amounts of rainfall at the end of September and in the beginning of October contributed to normal plant development, and higher stems formation (134.8 cm) at the last fourth (IV) sowing date.

As a result of less amounts of rainfall at the first three sowing dates from 6.0 cm to 7.4 cm shorter plants were developed. In the first (I) date of sowing (control) the plants were with a height of 127.4 cm and in the second (II) and third (III) date the values reported for the indicator were 128.8 cm and 128.2 cm, respectively. The statistical analysis results indicated that in the fourth (IV) last date of sowing, the rape formed significantly (α = 0.05) higher plants.

For the indicator pods number per plant, a statistically significant difference was reported in the second (II) and fourth (IV) sowing date (α = 0.05). At the third (III) date, the rape plants had fewer pods per plant (4.6). The average pods number per
броят на бобовете в 1 растение варира
от 130.6 до 148.2 бр. ок з тела м с
брояте в 1 р стение, кореспон-
дир с пок з тела брой бобове от 1
р стение. ост н лите пок з тели
р злики в отчетените стойности з
четирите д ти н сеитб не с
ст тистическо док з ни.

зменения в метеорологични-
те условия през годините на проуч-
нето с причин з формир не се-
мен с р зличен брой и тегло. й-
ниски стойности н пок з телите брой
и м с н семен т от 1 р стение с
отчетени в първ т ( ) д т н сеитб
(1093.2 бр. семен с м с 5.02 г),
н й-високи във втор т ( ) (1257.6 бр.
с м с 8.5 г) и трет т ( ) д т (1262.6
бр. с м с 5.68 г). тънки е отчетените по-високи стойности, спрямо контрол-
ния в ри нт ( д т ), нам ст тистичес-
к док з ност н р злики между
в ри нтите и контрол т.

истните пигменти - хлорофил ,
хлорофил b и к ротениди (c) с един
от основните критерии з оценк н
функцион ли т ктивност н фото-
синтетичния пр т н р стеният ,
чрез който се осъществяв поглъщ-
нето н светлинните кв нт и тр нс-
формир нето н тяхн т енергия в
химическ .

във фотосинтетичния пр т н
изслед ните р стения, при д товото
отглеждане н зимн т р пиц , се
измена от 0.092 мг g⁻¹ до 0.114 мг g⁻¹.
във фотосинтетичния пр т н
във вир в гр ниците от 0.033 мг g⁻¹ до 0.041 мг g⁻¹.
й-високи средни стойности н фото-
синтетичните пигменти с уст новени
във втор т ( ) и трет ( ) д т н
сеитб , н й-високи нив с регист-
трир ни в последн т четвърт (v)
д т н сеитб ( блиц 4).

plant for the study period varied from
130.6 to 148.2. Data showed the pods
weight per plant corresponded to the
pods number per plant. In respect the
other indicators there were not
statistically significant differences for the
values reported between the four sowing
dates.

The weather conditions changes
over the years of study were the reason
for the formation of seeds with different
numbers and weighs. The lowest values
about the number and weight of seeds
per plant were reported in the first (I)
sowing date (1093.2 seeds number with
weight of 5.02 g) and the highest in the
second (II) (1257.6 seeds number with
weight of 8.5 g) and a third (III) date
(1262.6 seeds number with weight 5.68 g).
Regardless of the higher values
reported compared to the control variant
(first date), there were no statistically
significant differences between the
variants and the control.

The foliar pigments - chlorophyll a,
chlorophyll b and carotenoids (c) are one
of the main criteria to evaluate the
functional activity of plant photosynthetic
apparatus through which the absorption
of the light quantums and the
transformation of their energy into a
chemical one was carried out.

The content of chlorophyll a in the
photosynthetic apparatus of the plants
tested at rape cultivation at different
sowing times varied from 0.092 mg g⁻¹
to 0.114 mg g⁻¹. It was established the
chlorophyll b content ranges from 0.033
mg g⁻¹ to 0.041 mg g⁻¹. The highest
average values of photosynthetic
pigments were found in the second (II)
and third (III) sowing dates, and the
lowest levels in the last fourth (IV) sowing
date were recorded (Table 4).
The degree of photosynthetic apparatus formation is determined by the chlorophyll $a$ to chlorophyll $b$ ratio. This ratio is related to the activity of the basic chlorophyll $a$, which is an indicator of the response to light intensity, and is also an early indicator of aging. It is relatively constant and is considered to be genetically determined (Petkova and Poryazov, 2007; Titova, 2010).

The values obtained for the chlorophyll $a$ to chlorophyll $b$ ratio varied in narrow range from 2.56 for plants grown in the third (III) sowing date to 2.85 for those in the first (I) sowing date. The carotenoids content in the leaves of the rape plants varied from 0.138 mg g$^{-1}$ to 0.156 mg g$^{-1}$ at different sowing dates. The results found for the green/yellow pigments ratio (chlorophyll $a$+c/carotenoids) showed that the plants grown in the first (I) sowing date with the highest value (1.10 mg g$^{-1}$) were distinguished and with the lowest (0.91 mg g$^{-1}$) the plants grown in the fourth (IV), last sowing date. The lower value of the green/yellow pigments ratio is associated with protection increase against chlorophyll photooxidation (Koyama, 1991; Demming-Adams and Adams, 1996). According to the authors, one of the most important functions of the carotenoids in the xanthophyll cycle is to prevent the destroying of chlorophyll molecules by the action of active oxygen forms, the

<table>
<thead>
<tr>
<th>Variants / дати / date</th>
<th>Варианти / Variants</th>
<th>0.114</th>
<th>0.040</th>
<th>0.140</th>
<th>2.85</th>
<th>1.10</th>
<th>0.294</th>
</tr>
</thead>
<tbody>
<tr>
<td>I date (Контрол) / І date (Сонтрол)</td>
<td>0.113</td>
<td>0.041</td>
<td>0.156</td>
<td>2.76</td>
<td>0.99</td>
<td>0.310</td>
<td></td>
</tr>
<tr>
<td>II date / ІІ date</td>
<td>0.105</td>
<td>0.041</td>
<td>0.155</td>
<td>2.56</td>
<td>0.94</td>
<td>0.301</td>
<td></td>
</tr>
<tr>
<td>III date / ІІІ date</td>
<td>0.092</td>
<td>0.033</td>
<td>0.138</td>
<td>2.79</td>
<td>0.91</td>
<td>0.263</td>
<td></td>
</tr>
</tbody>
</table>
приятни въздействия, е един от най-важните функции на каротеноидите в ксантофиловия цикъл.

ИЗВОДИ
Изследвания агротехнически фактор - срок на сеитба в съчетание със специфичните метеорологични условия през годините на проучване има значително влияние върху структурните елементи и добив семена от зимна рапица сорт Jackson.

Най-високи стойности на добивните компоненти (височина на растението, брой и маса на бобовете от 1 растение и брой и маса на семената от 1 растение) са полученi при втората (II) дата на сеитба (05.09-09.09).

През периода на проучване (2014-2017) най-висок добив (2440 kg ha⁻¹) бе реализиран при четвъртата (IV) дата на сеитба (03.10-07.10), а най-нисък (2050 kg ha⁻¹) при втората (II) сеитба (05.09-09.09), който е с 2,1% по-малко от контролния вариант (2094 kg ha⁻¹).

Съдържанието на пластидни пигменти е близко и няма данни за преждевременно стареене, дължащо се на стресови фактори на околната среда.

За района на Русе, най-подходящото време за сеитба на зимна рапица е през периода 05.09-19.09.

REFERENCES


