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# GROWTH, DEVELOPMENT AND PRODUCTIVITY OF *Bromus inermis* DEPENDING ON THE ELEMENTS OF GROWING TECHNOLOGY IN NON-IRRADIATED CONDITIONS

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***Abstract***

*The article presents the results of many years of field research of the Bromus inermis productivity with different feed systems. The studies were conducted during 2011-2014 on gray forest soils. The following factors and their variants were included in the research scheme: the rate of mineral fertilizers and the time of foliar feeding with water-soluble fertilizer Master 18.18.18+3 at a dose of 5 kg/ha. Mars and Vseslav varieties were grown during the experiments. The experimental data from Bromus inermis were processed by the standard ANOVA procedure within MS Excel software. The most effective system of Bromus inermis fertilizer is the combination of mineral fertilizers $N_{60}P_{45}K_{45}$ with the application of water-soluble fertilizer Master in the tillering stage (1-2 ten-days periods of April) and in the heading stage (1-2 ten-days periods of May) at a dose of 5 kg/ha, which, during the years of experiments in average, provided 355 kg/ha of the seeds yield of the Mars variety and 370 kg/ha of the Vseslav variety, that is 55 and 60 kg/ha more than with the use of mineral fertilizers and 225 and 245 kg/ha more than in variant without fertilizers.*

***Key words**: Bromus inermis, fertilizers, generative shoot, height, vegetative shoot, yield.*

## INTRODUCTION

Perennial grasses are a major factor in environmental stability and soil restoration. Their unsatisfactory condition is associated with poor agrotechnical cultivation, which leads to a significant decrease in plant productivity, decrease in microbial mass, etc. (Perkins & Hatfield, 2016; Bach et al., 2012; Bartelt-Ryser et al., 2005; Corbin & D'Antonio, 2012).

*Bromopsis inermis* (Leyss.) Holub is a perennial rhizome cereal species of the winter-spring type of development with high fodder value. It is indispensable on slopes that are influenced by water and wind erosion. In addition, it is a crop that can withstand floods by spring waters for 45-50 days, so it is a valuable species for flood-meadows (Otfinowski et al., 2007; Ulrich & Perkins, 2014).

It is used in the feed diet of farm (Heroy et al., 2017; Rautio et al., 2012). The feeding value of the grass is high; it is well eaten by all kinds of animals due to the high leafiness of vegetative shoots. Protein content in the tillering stage is 23.0-24.4%, and in the heading stage, it is 11.7-12.0%. This plan reaches its maximum development in the second or third year. In the composition of grass mixtures, it provides highly productive grass stands for a long time - up to 6-8 years or more.

It grows well after mowing and grazing. Harvest of *Bromus inermis* hay for two mowing is 6-9 t/ha, with the content of 56-58 fodder units and 5.5-5.8 kg of digestible protein per 100 kg of hay.

Perennial grasses are of great importance in the cultural haylands and pastures development. They compound the bulk in herbage mixtures on the 4-6 years of life, in comparison with legumes. However, the development of such highly productive artificial seeding is prevented by seed shortages, especially in perennial grasslands (Antoniv, 2005; Foster et al., 2009). Seed sowings are only used for 2-3 years, which is not always effective, while the development of appropriate measures allow significantly increase the production of high-quality seeds and eliminate its current shortage for the needs of field and meadow forage production (Brunotte, 2008).

Studies in northern China have shown that the amount of moisture and sowing density has a great influence on the emergence and growth of plants, as well as on the accumulation of biomass of *Leymus chinensis* (Trin.) Tzvel. and *Bromus inermis* Leyss (Liu et al., 2016). Similar results were obtained by other scientists in other parts of the planet (Ruprecht et al., 2008; Bissels et al., 2006; Eckstein & Donath, 2005; Hovstad & Ohlson, 2008; Jensen & Gutekunst, 2003; Liu et al., 2008; Liu et al., 2015; Quested & Eriksson, 2006; Fink & Wilson, 2011).

Other experiments in the aspen parkland ecoregion of Alberta, Canada, which is a savanna-type habitat consisting of multiple plant community types and invaded by nonnative smooth brome, characterized by four community types by a suite of biotic and abiotic variables (brome seed density, plant richness, plant cover, soil pH, soil moisture, and organic and inorganic N) and performed a brome seed addition experiment. Brome seedling growth and survival were greater with increased levels of soil moisture, while growth decreased with increases in dissolved organic N, but did not vary with other environmental conditions. Both survival and growth of brome seedlings were lowest in brome-dominated areas. These results show support for the passenger model of invasion, as variation in local environmental conditions were associated with variation in brome performance. Further, brome appears to have a negative effect on its growth, a pattern uncommon among plant invaders (Carrigy et al., 2016).

The results of previous studies have shown that under the conditions of the central forest-steppe of Ukraine, nitrogen fertilizers should be applied in the first ten-day period of September, which contributes to the initiation of larger amount of generative shoots. $N_{90-110}$ in combination with phosphorus-potassium fertilizers must be applied in the sowings of *Bromus inermis* to obtain high seed productivity on gray forest soils. However, this amount of nitrogen fertilizers applied at one time, as a rule, is not fully absorbed by the *Bromus inermis* plants. In addition, fertilizers that are applied on the surface of vegetative sowings, without mixing it with a soil, are largely weathered. The single application of a high rate of nitrogen fertilizers contributes to the increase of vegetative shoots, the excessive growth of *Bromus inermis* plants, which leads to the crops lodging, and hence their poor pollination and seeds formation. Such crops are characterized by the irregular seed maturity, which complicates harvesting and leads to significant seed losses. In addition, *Bromus inermis* plants form the best yield in quantitative and qualitative terms, if mineral fertilizers, especially nitrogen, in addition to the main fertilizer in the autumn, are applied in the year of a crop formation in multiple steps, starting with early spring growth and ending with seed formation. Consequently, there is a need to develop a fertilizer system for *Bromus inermis*, which on the one hand will help to reduce the cost of fertilizers, and on the other hand will allow to obtain seed yields at the potential level of the crop (Antoniv, 2005; Petrichenko et al., 2005; Senyk, 2010; Senyk, 2010; Koziar, 2003; Kurgak & Lukianets, 2004; Petrichenko, 2003).

This study aims to develop the most optimal mode of fertilization for new varieties of *Bromus inermis* - Mars and Vseslav, components of which are the application of mineral fertilizers containing only macronutrients in the basic fertilizers and the use of water-soluble microfertilizers in critical periods of growth and development of *Bromus inermis* plants.

## MATERIALS AND METHODS

The experiments were conducted at the experimental plots of the Institute of Feed Research & Agriculture of Podillya of NAAS. The experimental plots are located at the 49°18'03.27"N latitude, 28°35'78.04"E longitude at an altitude of +5.79 286 m above mean sea level.

The following factors and their variants were included in the research scheme:

- A - rate of mineral fertilizers: A1 - $N_0P_0K_0$; A2 - $N_{60}$; A3 - $N_{60}P_{45}K_{45}$;
- B - time of foliar application of water-soluble fertilizer Master 18.18.18+3 (manufactured by Valagro); pH (1% solution) - 4.3; solubility at 20 C - 58 g/l; electrical conductivity (EC), µS/cm (0.1% solution) - 0.744; composition, %: N - 18.0 including: $NO_3$ - 1.5, $NH_4$ - 1.5, $NH_2$ - 15.0; $P_2O_5$ - 20.0; $K_2O$ - 20.0; MgO - 3.0; B - 0.02; Mn - 0.03, chelate in EDTA form; Zn - 0.01, chelate

in EDTA form; Cu - 0.005, chelate in EDTA form; Fe - 0.07, chelate in EDTA form) at a dose of 5 kg/ha: B1 - fertilizer wasn't applied; B2 - applied in autumn at the tillering stage (2-3 ten-days periods of October); B3 - in spring at the tillering stage (1-2 ten-days periods of April); B4 - in spring at the heading stage (1-2 ten-days periods of May); B5 - in spring at the tillering stage (1-2 ten-days periods of April) and at the heading stage (1-2 ten-days periods of May).

The study was conducted on gray forest soils. The topsoil tilth is characterized by the following agrochemical parameters: humus content is 1.75-1.91, pH of salt extract is 5.2-5.6, hydrolytic acidity is 1.73-3.6 mg-eq. per 100 g of soil, easy hydrolysable nitrogen is 75-100 mg/kg, the content of mobile forms of phosphorus is 84-120 mg/kg and potassium 64-85 mg/kg in the air-dry soil, the amount of absorbed bases is 12-13 mg-eq. per 100 g of soil. The vegetation periods of 2011-2014 had different weather conditions but they were favorable for *Bromus inermis* growing (Table 1).

Table 1. Meteorological indexes during the period of *Bromus inermis* vegetation in the field experiments

| 2011 | | | 2012 | | | 2013 | | | 2014 | | | Months |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT, ºC | PA, mm | RH, % | PA, mm | RH, % | RH, % | AT, ºC | PA, mm | RH, % | AT, ºC | PA, mm | RH, % | |
| - 7.2 | 19.0 | 91 | - 6.8 | 19.0 | 86 | - 2.4 | 27.0 | 85 | - 11.5 | 28.0 | 82 | January |
| - 3.5 | 20.0 | 85 | - 2.8 | 20.0 | 84 | - 1.7 | 30.0 | 81 | 0.2 | 20.0 | 76 | February |
| 4.0 | 16.0 | 83 | 4.0 | 16.0 | 80 | - 1.5 | 64.0 | 78 | 5.8 | 17.2 | 74 | March |
| 9.4 | 30.0 | 80 | 8.7 | 37.0 | 77 | 10.2 | 16.0 | 74 | 9.2 | 47.0 | 65 | April |
| 15.7 | 32.0 | 75 | 15.3 | 34.0 | 61 | 17.5 | 62.0 | 65 | 17.0 | 127.0 | 69 | May |
| 19.9 | 30.0 | 62 | 19.4 | 35.0 | 75 | 19.3 | 127.0 | 80 | 16.6 | 53.0 | 62 | June |
| 21.1 | 85.0 | 65 | 21.1 | 15.0 | 60 | 18.8 | 22.2 | 74 | 20.2 | 65.0 | 73 | July |
| 20.1 | 4.0 | 68 | 21.3 | 4.0 | 67 | 18.9 | 61.0 | 71 | 20.2 | 12.8 | 74 | August |
| 8.5 | 35.0 | 74 | 17.0 | 35.0 | 75 | 11.9 | 121.0 | 88 | 14.8 | 32.0 | 62 | September |
| 6.3 | 46.0 | 81 | 7.1 | 46.0 | 84 | 9.3 | 12.0 | 85 | 8.3 | 30.0 | 73 | October |
| 4.2 | 32.0 | 87 | 4.2 | 12.0 | 88 | 6.7 | 45.0 | 89 | 2.3 | 43.0 | 79 | November |
| - 3.1 | 36.0 | 93 | - 1.7 | 36.0 | 91 | - 1.1 | 10.9 | 93 | - 3.2 | 21.0 | 93 | December |

**Note:** AT - air temperature; PA - precipitation amounts; RH - relative humidity.

The growing technology of *Bromus inermis* was generally accepted for the conditions of Ukraine. Mars and Vseslav varieties were grown during the experiments.

Mars variety is early-ripening, resistant to trampling and intensive grazing. Type of use is pasture and hay. It has high forage production. It is resistant to lodging and diseases. The growing season before the first hay cutting is 68-70 days, before the seed harvesting - 88-90 days. The dry matter yield for three cuttings is 12.5-12.6 t/ha, the seeds harvest is 0.69-0.71 t/ha. The content of crude protein in the dry matter is 13.8-14.0% and the content of fiber is 19.8-20.0

Vseslav variety is resistant to lodging and drought. Type of use is haymaking. It has high potential of vegetative mass and seeds productivity. It grows intensively in spring and after cutting. The growing season before the first hay cutting is 65-66 days, before the seeds harvesting - 87-89 days. The dry matter yield for three cuttings is 12.7-13.0 t/ha, the seeds harvest is 0.79-0.81 t/ha. The content of crude protein in the dry matter is 13.4-14.9%, and the content of fiber is 19.4-20.1%.

Winter wheat was a forecrop in the experiment. After harvesting the forecrop, stubble disking was carried out to a depth of 8-10 cm. Two weeks later tillage to a depth of 18-20 cm was performed. 14 days after tillage, cultivation to a depth of 10-12 cm was carried out for the additional soil smoothing. Harrowing was conducted in the early spring to destroy weeds and for the further soil smoothing. Sowing cultivation was performed to a depth of 1.5-2.0 cm. Pre-sowing cultivation was performed to a depth of 1.5-2.0 cm. Fertilizers (ammonium nitrate, standard superphosphate, potassium salt) were introduced before the cultivation according to the scheme of the experiment. *Bromus inermis* varieties were sowed with a row spacing of 30 cm with a seeding rate of 5.0 million / ha of similar seeds. After sowing the field was tilth rolled. During the growing season of *Bromus inermis*, 2-3 inter tillage's were carried out to a depth of 8-10 cm. Spring harrowing of sowings was performed next year and further. The herbicide Dianate (active ingredient is Dicamba, 480 g/l) or Agritox (active ingredient is 2-methyl-4-chlorophenoxyacetic acid in the form of salts of dimethylamine, sodium and potassium, 500 g/l) were used to control weeds in a phase of 2-4 pairs of leaves. The fertilization of sowings with mineral fertilizers was carried out according to the scheme of experiments.

Seeds of *Bromus inermis* were harvested by direct combining in the phase of its full maturity. The optimum moisture content of *Bromus inermis* seeds for direct combining is about 30%. After harvest, the seed yield was converted to basic humidity (15%).

The experimental data of *Bromus inermis* were processed by the standard procedure of ANOVA within MS Excel software. The significance of the differences was proved for the reliability level of 95% ($LSD_{05}$).

## RESULTS AND DISCUSSIONS

The results of the study showed that the fertilizers significantly influenced the individual growth of the plant of *Bromus inermis* (Tables 2-5). The average height of vegetative shoots (average over 2011-2014) for the Mars variety ranged from 50.1-76.7 cm, for generative shoots it was 76.6-107.7 cm. For the Vseslav variety, the height of the vegetative shoots (average for 2012-2014) was 49.2-75.6 cm, for generative shoots – 73.0-101.2 cm. Fertilizers introduced into the main fertilizer contributed to the height growth. Thus, at the introduction of $N_{60}$, the height of generative shoots, compared to the variant without fertilizers, increased by 9.0-11.1 cm depending on the variety, the height of vegetative shoots - by 6.2-10.6 cm. At the introduction of complete mineral fertilizers ($N_{60}P_{45}K_{45}$), further increase in height of generative shoots by 8.1-12.7 cm and of vegetative shoots by 6.8-7.1 cm was observed, which in the total amount was 17.1-23.8 cm for generative and 13.0-17.7 cm for vegetative shoots.

Study has shown that the number of generative and vegetative shoots depended on the dosage of mineral nutrition. The largest impact on the shoots number had mineral fertilizers introduced in the main fertilizer. Thus, on the variant without fertilizers, the number of generative shoots for the Mars variety was 100 pieces/m$^2$ during the period of 2011-2014, and at the introduction of $N_{60}$, it was 151 pieces/m$^2$, at the introduction of $N_{60}P_{45}K_{45}$ - 183 pieces/m$^2$. For the Vseslav variety, on average for the 2012-2014, these figures were 122; 180, and 208 pieces/m$^2$, respectively. The increase in the number of productive shoots, at the introduction of $N_{60}$ and $N_{60}P_{45}K_{45}$ in the main fertilizer, was 51 and 83 pieces/m$^2$ for the Mars variety and 58 and 86 pieces/m$^2$ for the Vseslav variety.

The foliar application of water-soluble fertilizers also helped to increase the number of generative shoots. For the variants without fertilizers, the increase was 11-31 pieces/m$^2$ depending on the application time, with the basic fertilizers $N_{60}$ and $N_{60}P_{45}K_{45}$ it was 12-34 and 14-32 pieces/m$^2$ for the Mars variety, and 13-31, 11-33 and 12-30 pieces/m$^2$ for Vseslav variety, respectively. The highest number of generative shoots was observed in variants where water-soluble fertilizers were applied twice: in the stages of tillering and heading. According to the variety and dosage of the main fertilizer, the numbers of generative shoots on these variants were 131, 184, 215 and 153, 213, 238 pieces/m$^2$. The increase in the number of generative shoots in comparison with the corresponding variants without foliar fertilizing, depending on the dosage of the main fertilizer was 31, 34 and 32 for the Mars variety, and 31, 33 and 30 shoots per m$^2$ for the variety Vseslav.

Study has shown that applied mineral fertilizers also contributed to increasing the number of vegetative shoots. The most significant increase in the number of such shoots was influenced by mineral fertilizers introduced into the main fertilizer. For example, at the introduction of $N_{60}$, depending on the variety, the number of vegetative shoots increased by 56-66, at the introduction of $N_{60}P_{45}K_{45}$ - by 86-111 pieces/m$^2$, respectively.

Foliar fertilization, depending on the period of application, contributed to the increase in the number of vegetative shoots in the sowings of Mars variety by 6-12 in variants without basic fertilizer, by 5-22 at applying $N_{60}$ and 14-26 pieces/m$^2$ at applying $N_{60}P_{45}K_{45}$. In the sowing of Vseslav variety, the increase of vegetative shoots amounted to 12-19, 15-18 and 4-8 pieces/m$^2$, respectively. The smallest increase in the number of vegetative shoots was observed during the autumn term of foliar fertilization.

The two-time application of water-soluble fertilizers contributed to the increase in the number of vegetative shoots, depending on the variety, by 2-23 pieces/m$^2$, compared to the same terms with a single application. In the study, mineral fertilizers applied to the main fertilizer in conditions of sufficient moisture supply contribute more to the growth of vegetative shoots than generative, so their application in high rates can cause excessive sowing densification, their lodging, and hence significantly reduction of their seed production.

Table 2. The height of the generative and vegetative shoots of *Bromus inermis* of Mars variety depending on the fertilizer

| Rate of mineral fertilizers | Time of the foliar fertilizing | The height of the generative shoots, cm | | | | | The height of the vegetative shoots, cm | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Years of the study | | | | average | Years of the study | | | | average |
| | | 2011 | 2012 | 2013 | 2014 | | 2011 | 2012 | 2013 | 2014 | |
| A1 | B1 | 68.2 | 84.7 | 69.0 | 84.6 | 76.6 | 47.6 | 49.2 | 46.1 | 57.5 | 50.1 |
| | B2 | 75.0 | 86.0 | 72.1 | 87.4 | 80.1 | 48.3 | 50.5 | 47.7 | 58.3 | 51.2 |
| | B3 | 78.9 | 87.5 | 79.4 | 91.9 | 84.4 | 54.0 | 53.0 | 48.3 | 60.6 | 54.0 |
| | B4 | 80.9 | 88.2 | 78.4 | 90.7 | 84.6 | 52.6 | 52.8 | 47.9 | 61.2 | 53.6 |
| | B5 | 81.0 | 87.9 | 80.5 | 93.0 | 85.6 | 58.4 | 55.4 | 49.1 | 62.2 | 56.3 |
| A2 | B1 | 88.5 | 93.2 | 89.2 | 100.9 | 93.0 | 62.4 | 65.7 | 55.4 | 67.1 | 62.6 |
| | B2 | 93.8 | 97.2 | 92.3 | 101.3 | 96.2 | 63.1 | 68.3 | 57.0 | 68.2 | 64.2 |
| | B3 | 93.8 | 96.4 | 95.0 | 105.7 | 97.7 | 65.9 | 68.8 | 58.6 | 70.9 | 66.0 |
| | B4 | 96.1 | 97.0 | 94.1 | 105.3 | 98.1 | 64.8 | 69.5 | 58.0 | 72.1 | 66.1 |
| | B5 | 106.3 | 98.0 | 95.5 | 108.2 | 102.0 | 70.6 | 70.2 | 60.0 | 72.0 | 68.2 |
| A3 | B1 | 99.3 | 101.3 | 96.1 | 107.7 | 101.1 | 64.2 | 70.8 | 65.0 | 77.7 | 69.4 |
| | B2 | 100.0 | 102.0 | 97.0 | 109.2 | 102.1 | 68.5 | 72.2 | 66.8 | 80.2 | 71.9 |
| | B3 | 104.1 | 103.4 | 99.3 | 113.5 | 105.1 | 70.1 | 76.0 | 68.0 | 82.0 | 74.0 |
| | B4 | 106.8 | 104.5 | 98.7 | 111.2 | 105.3 | 69.6 | 75.2 | 67.8 | 81.4 | 73.5 |
| | B5 | 108.8 | 105.2 | 102.2 | 114.7 | 107.7 | 75.5 | 78.0 | 69.0 | 84.3 | 76.7 |

Table 3. The height of the generative and vegetative shoots of *Bromus inermis* of Vseslav variety depending on the fertilizer

| Rate of mineral fertilizers | Time of the foliar fertilizing | The height of the generative shoots, cm | | | | The height of the vegetative shoots, cm | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Years of the study | | | average | Years of the study | | | average |
| | | 2012 | 2013 | 2014 | | 2012 | 2013 | 2014 | |
| A1 | B1 | 71.4 | 67.3 | 80.4 | 73.0 | 46.0 | 48.4 | 53.2 | 49.2 |
| | B2 | 76.6 | 69.5 | 82.2 | 76.1 | 48.2 | 49.7 | 54.4 | 50.8 |
| | B3 | 76.4 | 74.1 | 83.6 | 78.0 | 52.4 | 50.7 | 56.0 | 53.0 |
| | B4 | 77.0 | 74.5 | 84.0 | 78.5 | 52.6 | 50.4 | 56.5 | 53.2 |
| | B5 | 77.2 | 77.9 | 85.6 | 80.2 | 54.4 | 51.0 | 58.2 | 54.5 |
| A2 | B1 | 79.5 | 85.2 | 87.6 | 84.1 | 60.0 | 56.1 | 63.4 | 59.8 |
| | B2 | 80.4 | 85.0 | 90.2 | 85.2 | 62.2 | 56.9 | 64.0 | 61.0 |
| | B3 | 82.5 | 88.3 | 96.4 | 89.1 | 63.6 | 63.0 | 67.0 | 64.5 |
| | B4 | 82.9 | 88.0 | 97.2 | 89.4 | 64.6 | 64.2 | 66.8 | 65.2 |
| | B5 | 83.5 | 89.5 | 100.6 | 91.2 | 68.6 | 65.0 | 69.2 | 67.6 |
| A3 | B1 | 91.9 | 93.1 | 105.5 | 96.8 | 64.2 | 66.0 | 70.4 | 66.9 |
| | B2 | 93.4 | 95.5 | 106.8 | 98.6 | 66.5 | 67.1 | 70.8 | 68.1 |
| | B3 | 93.9 | 95.0 | 109.0 | 99.3 | 68.5 | 70.1 | 74.4 | 71.0 |
| | B4 | 92.5 | 96.1 | 108.4 | 99.0 | 68.6 | 72.0 | 75.7 | 72.1 |
| | B5 | 94.0 | 99.0 | 110.6 | 101.2 | 73.5 | 74.4 | 78.8 | 75.6 |

Table 4. The seeds yield of *Bromus inermis* of Mars variety depending on the fertilizer

| Rate of mineral fertilizers | Time of the foliar fertilizing | Seed yield, kg/ha | | | | |
|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2013 | 2014 | Average |
| A1 | B1 | 95 | 125 | 151 | 130 | 125 |
| | B2 | 108 | 148 | 167 | 152 | 144 |
| | B3 | 113 | 165 | 170 | 166 | 154 |
| | B4 | 118 | 168 | 181 | 170 | 159 |
| | B5 | 133 | 190 | 195 | 188 | 176 |
| A2 | B1 | 223 | 235 | 287 | 220 | 241 |
| | B2 | 239 | 260 | 293 | 235 | 257 |
| | B3 | 240 | 282 | 322 | 255 | 275 |
| | B4 | 250 | 285 | 318 | 250 | 276 |
| | B5 | 268 | 300 | 350 | 270 | 297 |
| A3 | B1 | 270 | 330 | 388 | 300 | 322 |
| | B2 | 285 | 358 | 400 | 320 | 341 |
| | B3 | 288 | 370 | 429 | 333 | 355 |
| | B4 | 300 | 380 | 427 | 340 | 362 |
| | B5 | 318 | 420 | 450 | 355 | 386 |
| $LSD_{05}$ | A | 9.8 | 10.4 | 12.0 | 10.5 | 10.7 |
| | B | 10.6 | 9.7 | 10.2 | 11.3 | 10.5 |
| | AB | 12.1 | 11.4 | 11.7 | 10.7 | 11.5 |

Table 5. The seeds yield of *Bromus inermis* of Vseslav variety depending on the fertilizer

| Rate of mineral fertilizers | Time of the foliar fertilizing | Seed yield, kg/ha | | | |
|---|---|---|---|---|---|
| | | 2012 | 2013 | 2014 | Average |
| A1 | B1 | 258 | 167 | 125 | 183 |
| | B2 | 285 | 180 | 140 | 202 |
| | B3 | 288 | 195 | 175 | 213 |
| | B4 | 300 | 191 | 177 | 223 |
| | B5 | 320 | 210 | 195 | 242 |
| A2 | B1 | 360 | 279 | 230 | 290 |
| | B2 | 388 | 325 | 247 | 320 |
| | B3 | 408 | 347 | 270 | 342 |
| | B4 | 442 | 346 | 266 | 351 |
| | B5 | 460 | 355 | 290 | 368 |
| A3 | B1 | 488 | 397 | 310 | 378 |
| | B2 | 506 | 422 | 327 | 418 |
| | B3 | 518 | 450 | 345 | 438 |
| | B4 | 525 | 442 | 350 | 439 |
| | B5 | 555 | 476 | 370 | 467 |
| $LSD_{05}$ | A | 10.0 | 10.7 | 9.7 | 10.1 |
| | B | 9.8 | 11.2 | 10.2 | 10.4 |
| | AB | 11.6 | 10.5 | 10.3 | 10.8 |

The analysis of the research results on seed productivity showed that due to the natural fertility (variants without fertilizers), on average, in 2011-2014, the harvest of *Bromus inermis* seeds of Mars varieties was obtained at the level of 125 kg/ha, whereas the seed productivity of the Vseslav variety (average for 2012-2014) amounted to 167 kg/ha.

Like all types of grasses, *Bromus inermis* respond positively to nitrogen fertilizers. With the optimal nitrogen nutrition, the intensity of the synthesis of organic matter increases, the growth processes are stimulated, and with its high dosages, the growing season is prolonged, the process of seeds ripening is slowed down and its yield is reduced.

In our study, nitrogen fertilizers, introduced into the basic fertilizer in the $N_{60}$ rate in variants without fertilization allowed to increase the seed yield, compared to the variant without nutrition, by 116 kg/ha for Mars variety and by 107 kg/ha for Vseslav variety, and to reach the yield level 241 and 290 kg/ha, respectively.

In the case of full fertilizer application ($N_{60}P_{45}K_{45}$), the seed yield of Mars variety was 322 kg/ha. The Vseslav variety provided a yield at a level of 378 kg/ha. The yield increase from the introduced phosphorus-potassium fertilizers, compared to the $N_{60}$ variant, was 81 and 88 kg/ha, respectively.

Study has shown the increase in yield, due to foliar fertilization. The introduction of water-soluble fertilizer at different times in variants without basic fertilizer contributed to the increase of seed yield in Mars and Vseslav varieties by almost the same values - 19-34 and 19-40 kg/ha, respectively, with a significant difference in yield in favor of the Vseslav variety (Mars variety - 144-159 kg/ha, Vseslav variety - 202-223 kg/ha).

Foliar fertilizer with the $N_{60}$ dosage contributed to the yield increase depending on the terms of application by 16-35 kg/ha for the Mars variety and 20-61 kg/ha for the Vseslav variety, with yields of 241-276 and 320-351 kg/ha, respectively.

With the main fertilizer $N_{60}P_{45}K_{45}$, yield growth with the foliar fertilization was 19-40 and 20-41 kg/ha, respectively. Seeds harvest were 341-362 and 418-439 kg /ha.

In terms of application time, the smallest effect on seed productivity growth was achie-ved when water-soluble fertilizers were introduced in the autumn (1 ten-day period of September). However, the effectiveness of water-soluble fertilizers almost did not depend on the dosage of the main fertilizer. The yield increase for the Mars variety according to the dosage of the main fertilizer was 19, 16 and 19 kg/ha, for the Vseslav variety it was 19, 20 and 20 kg/ha.

The dosage of the main fertilizer did not significantly affect the yield increase during the application of water-soluble fertilizers in the tillering stage - 29, 34, 33 and 30, 32, 43 kg/ha. Increases in seed productivity during the fertilization of sowings in the heading stage were slightly larger - 34, 35, 40 and 40, 61, 41 kg/ha.

The greatest effect of water-soluble fertilizers in our study was achieved by double nutrition of the sowings: in the stages of tillering and heading. Accordingly, the dosage of water-soluble fertilizers was double - 5 kg/ha + 5 kg/ha. Depending on the variety, the yield of the sowings increased in the variants without the main fertilizer by 51, 59 kg/ha, at the application of $N_{60}$ - by 56, 78 kg/ha and at $N_{60}P_{45}K_{45}$ - 64, 69 kg/ha.

Research on the development of new and improvement of existing technologies for the cereals growing is currently conducted mainly on their most common species, but all of them relate only to individual agrotechnical techniques, without a comprehensive study of their relationship.

A field trial was sown at Melfort, SK, Canada, in May 2013 to evaluate forage accumulation, nutritive value, and botanical composition of different mixtures of grasses and CMV under two-cut and three-cut harvest management from 2014 to 2017. Thirteen forage mixtures consisted of (i) monocultures of *Bromus riparius* Rehm. (MB), *Bromus riparius* Rehm. × *B. inermis* Leyss. (HB), *Agropyron cristatum* (L.) (CWG), *Agropyron intermedium* Beauv. (IWG), and CMV; (ii) binary mixtures of each of the grass + CMV; (iii) a four-grass mixture (MB, HB, CWG, and IWG) (Mix 4); (iv) Mix 4 + CMV (Mix 5); (v) a six-grass mixture (Mix 4) + *Dactylis glomerata* L. and *Phleum pratense* L. (Mix 6); and (vi) Mix 6 + CMV (Mix 7). The two-cut system resulted in greater total forage accumulation (10.3 ± 2.8 Mg $ha^{-1}$) compared with the three-cut system (8.6 ± 2.3 Mg $ha^{-1}$) with the exception of 2017. On average, grass mixtures containing CMV and CMV monoculture (11.1 ± 1.7 Mg $ha^{-1}$) had greater forage accumulation than grass monocultures and grass only mixtures (7.5 ± 2.4 Mg $ha^{-1}$). Cicer milkvetch dominated in all mixtures (44.0–68.8% of forage mass) in 2016 compared with its initial proportion of 2.1 to 31.2%. The concentration of crude protein was significantly increased with the inclusion of CMV compared with the grass-only treatments. Acid detergent fiber and neutral detergent fiber (NDF) concentrations were similar, but mixtures without CMV tended to have a greater NDF concentration. In conclusion, the inclusion of CMV in forage mixtures increased forage accumulation and protein concentration. Binary CMV-grass mixtures produced similar or greater forage accumulation than more complex CMV-grass mixtures (Foster et al., 2019).

The effectiveness of nitrogen depends largely on the presence of other nutrient elements in the soil. One researches (Fischer, 1987) showed that it depended on the content of phosphorus in the soil, and others (Holmes, 1980) - on the content of potassium, as well as phosphorus and potassium together. Regular application of high doses of nitrogen fertilizers did not increase yields unless phosphorus and potassium were applied at the same time. The introduction of phosphorus fertilizers into the soil causes a lack of zinc for plants and the use of potassium fertilizers - lack of magnesium (Horodnii, 2008; Kutuzova et al., 1998; Petrichenko et al., 2005). The availability of plant nutrients is also affected by the soil solution reaction. It is found that the efficiency of molybdenum increases with increasing acidity, and the efficiency of copper - with decreasing acidity.

The use of trace elements and bacterial fertilizers, along with other agrotechnical techniques is an additional reserve of increase in yield and quality of agricultural products, especially of perennial grasses (Videnko et al., 2008; Beliaeva et al., 2009; Vinton & Goergen, 2006; Piper et al., 2015; Bardgett et al., 2003).

Mowing the aboveground part of plants affects its underground part, that is, the death of the part of old and the formation of new roots, stops their growth, reduces the ability to absorb nutrients.

According to Kurkyn & Yakushev (1983), this is due to the relatively rapid loss and slow accumulation of nutrients in the plant, primarily carbohydrates, the low content of which is observed in the period of the maximum weight gain (stages of the stem elongation and the beginning of heading).

After the early mowing, new shoots grow better, appears the opportunity to make more mowing and to obtain higher quality fodder (Babych et al., 1991).

Thus, it is evident that the study of the dosages and timing of mineral fertilizers are necessary, and a comprehensive approach to the issue of technology development, which, taking into account both agro-environmental and agrotechnical factors, will make the process of *Bromus inermis* growing more controlled.

## CONCLUSIONS

The most effective fertilizer system for *Bromus inermis* is the combination of mineral fertilizers $N_{60}P_{45}K_{45}$ with the application of water-soluble fertilizer Master in the tillering stage (1-2 ten-day periods of April) and heading stage (1-2 ten-day periods of May) at a dose of 5 kg/ha, which, during the years of experiments in average provided 355 kg/ha of the seeds yield of the Mars variety and 370 kg/ha of the Vseslav variety, that is 55 and 60 kg/ha more than with the use of mineral fertilizers and 225 and 245 kg/ha more than in variant without fertilizers.

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