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HEIGHT DYNAMICS OF PERENNIAL LEGUMINOUS HERBS IN THE CONTEXT OF SOIL CONTAMINATION WITH HEAVY METALS

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ABSTRACT

The researches were envisaged the effect of increased concentration of mowing heavy metals in soil on the growth and development of leguminous perennial herbs 6 species of leguminous perennial herbs were grown: Medicago sativa I., Trifolium pratense L., Onobrychis arenaria Kit., Melilotus albus L., Littus corniculatus L. and Galega orientalis Lam. The field research where leguminous herbs were grown was characterized by moderate soil pollution with heavy metals. In particular, the content of mobile lead forms in the soil according to the maximum concentration was 1 MPC, cadmium – 0.9 MPC, copper – 2.3 MPC, zinc – 0.4 MPC. In conditions of moderate soil contamination with heavy metals (lead, cadmium, copper and zinc), all the studied herbs grow and develop without inhibition, which will contribute to the good accumulation of heavy metals in their tissues and removal from the soil. In the first year, Melilotus albus L. – 130 cm and Onobrychis arenaria Kit reach the highest heights – 95 cm. In the second and subsequent years, the highest herbs in the first generation were Melilotus albus L. – 174 cm, Galega orientalis Lam. – 105 cm. In the second and following mowings – Onobrychis arenaria Kit. – 82 cm, Galega orientalis Lam. – 79 cm.

Keywords: Leguminous perennials, height, dynamics, heavy metals, soil, pollution.

Formulation of the problem. Over recent decades, degradation of agricultural land has worsened and become critical. Primarily it concerns the soil cover, which has lost its ability for self-regulation. Prolonged use of land without sufficient nutrient supplementation has caused various types of deterioration: dehumidification, reduction of nutrient, erosion, soil re-compaction, water permeability reduction, soil acidification, toxicity etc. It is known, there is a certain degree of dehumidification on 39 million hectares of the crop lands in Ukraine, in particular in Vinnitsia region because of the high level of plowing this type of degradation was spread over 90 per cent of arable lands [1].

The major task today is searching for ways to restore and maintain the optimal level of soil fertility. Cultivation of leguminous perennial herbs could be one of the major resources and perspective directions for solution of this problem [2].

Food production is one of the determining factors, which helps to stabilize the processes taking place in the systems "soil–plant-animal-human being". Significant phytomeliorative role of perennials on the cropland, optimal matching of the cultivated land, hayfields, pasture land will provide an opportunity to eliminate the destructive process on the agricultural land, lower the erosion and improve the soil fertility and crop productivity [3]. There might also be some deviations from normal development and growing within cultivation of leguminous perennial herbs on degraded soils. One of these harmful effects is soil pollution with heavy metals. Therefore, there is a need to study the intensity of leguminous perennial herbs growing on such soils, it determines the relevance of this research.

Analysis of recent research and publications. Leguminous perennial herbs are able to form a powerful vegetative mass from the second and following years of vegetation. But in the year of sowing leguminous perennial grasses develop extremely slowly, they often have stunted growth, are highly susceptible to the effects of drought, weeds, pests, diseases or soil toxicants. Therefore, the characteristics of growth processes in the year of sowing of leguminous perennial herbs depend on the capacity of their development in the following years of vegetation [4].

Leguminous perennial herbs are very whimsical plants to soil nutrition and other characteristics. So they need fertile soils that are neutral by the reaction of the soil solution, with no toxic substances in the soil (heavy metals, pesticides, radionuclides, petroleum products) [5].

At the same time, due to the regeneration abilities of perennial herbs to improve soil condition, they are often planted on contaminated soil. Such soils can inhibit the herb growing and development [6].

It is often recommended to cultivate leguminous perennial on soils contaminated with heavy metals. These toxicants can affect the living organisms as they have a powerful toxic effect. To limit the accumulation of heavy metals in the soil, a system of maximum permissible concentrations was introduced. But considering the capacity of the heavy metals to input into the soil with mineral fertilizers, pesticides, emissions from motor vehicles and industrial enterprises, which have a negative impact each year, there is a tendency of accumulation of heavy metals in the soil [7].

Previous researches have examined the effectiveness of cultivation of Trifolium pratense L. on soils polluted with heavy metals without inhibiting its growth processes. Given the ability of Trifolium pratense L. to absorb, cleave and accumulate heavy metals in its tissues, thus improving the agro-ecological state of the soil, its crops are planted on such lands [8].

Separation of previously unresolved parts of a common problem. As there are more than 6 species of leguminous perennial herbs that differ in intensity of growing and development, their influence on the change of agro-ecological indicators of soil can be changed, according to the reducing of its pollution by

heavy metals. However, with the exception of Trifolium pratense L., the cultivation possibility of other leguminous perennial herbs on soils polluted with heavy metals has not been studied.

Purpose of the article. Field researches was conducted during 2013–2019 at Research farm "Ahronomichne" of Vinnytsia National Agrarian University (Ukraine), where intensive technologies of agricultural chemistry are used for cultivation of crops. Laboratory researches were carried out in the laboratories of the department of radioecology in the agro sphere of the Institute of Agroecology and Environmental Management of the National Academy of Agrarian Sciences of Ukraine and the Department of Ecology and Environmental Protection of Vinnitsa National Agricultural University.

Field of research of the Ahronomichne Research farm, where field researches were conducted, is located in the central part of Vinnitsa region in the Central Forest-Steppe of Ukraine. The territory of the farm is flat with a slight elevation and a weak division of its aria. The absolute altitudes reach 298 m above sea level. The height difference between the highest part of the watersheds and the decrease of the beams is 25–30 m.

Field experimental area has a wide undulating terrain, flat land dominated by slopes. The surface of the watershed plateau is leveled, its slope does not exceed 2–3 °, so the surface runoff of atmospheric and melt water is slow and soil washout is almost absent. Soil moisture is due to precipitation, the groundwater level is at a depth of 10–15 m.

Soil on the experimental site is grey podzolic medium-loam. The agrochemical composition of the soil of the study area is characterized by the following indicators: content of humus – 2.0%, nitrogen of hydrolyzed (according to Cornfild) – 133 mg/kg of soil-low, mobile forms of phosphorus (according to Chirikov) – 390 mg/kg of soil-very high, mobile forms of potassium (according to Chirikov) – 64 mg/kg of soil-medium, calcium – 130 mg/kg of soil-sufficient, acidity hydrolytic – 2.53 mg-eq/100 g of soil-increased, reaction of soil solution of $pH_{Nol.}$ 5.0 – medium acid.

The researches were envisaged the effect of increased concentration of mowing heavy metals in soil on the growth and development of leguminous perennial herbs 6 species of leguminous perennial herbs were grown: Medicago sativa I., Trifolium pratense L., Onobrychis arenaria Kit., Melilotus albus L., Littus corniculatus L. and Galega orientalis Lam. There were studied the influence on the features of growth and development of such heavy metals: lead (Pb), cadmium (Cd), zinc (Zn), copper (Cu).

The researches were repeated four times. The accounting area of field experience is 50 m^2, the total area of the site is 70 m^2. The variants in the research are systematically arranged in 6 blocks.

There were conducted the following observations, records and measurements:

- determination of soil pollution by moving forms of heavy metals was carried out in certified and accredited laboratories: the Test Center of Vinnytsia Branch of the State Institution of the State Soil Protection Department of the Ministry of Agrarian Policy and Food of Ukraine and the Scientific and Measuring Agrochemical Laboratory of the Department of Ecology and Environmental Protection of Vinnitsa National Agrarian University;

- soil samples were taken from the 0–20 cm layer according to DSTU ISO 10381-1: 2004;

- determination of the content of the gross metals (after extraction of 1.0 n HCl) and moving forms (after removal of acetate-ammonium by buffer solution pH 4.8) of heavy metals in soil: lead, cadmium, copper and zinc - by atomic absorption spectrophotometry according to DSTU 4362: 2004, DSTU 4770 (2, 3, 9): 2007;

- determination of plant height dynamics - in three replications by phases of plant development.

Statement of the main material. The experimental field where leguminous perennial herbs were grown was characterized by moderate soil pollution with heavy metals. In particular, the content of mobile lead forms in the soil relative to the maximum permissible concentration was 1 MPC, cadmium – 0.9 MPC, copper – 2.3 MPC, zinc – 0.4 MPC (Table.1).

Plant height plays an important role in the total agro-ecological stability of agroecosystem. The faster the plant height grows, the more competitive they are in such an ecosystem, the more they absorb from the soil of heavy metals, they needless anthropogenic energy and, accordingly, more enrich the soil with aboveground abscission.

Table 1.

Content of moving forms of heavy metals in soil during intensive agriculture

Heavy metals	Actual content, mg/kg	MPC, mg/kg	Pollution assessment
Pb	5.9	6.0	1.0 MPC
Cd	0.6	0.7	0.9 MPC
Cu	6.8	3.0	2.3 MPC
Zn	9.1	23.0	0.4 MPC

All leguminous perennial herbs in the year of sowing with no cover cultivation have a very slow growth during the first 30 days. By this time they grow from 4 cm – Galega orientalis Lam. up to 10 cm – Onobrychis arenaria Kit. Such slow growth of leguminous occurs before the formation of the 3rd compound leaf of the herbs (Table 2).

Table 2

Dynamics of the height of legumes perennial grasses in the year of sowing, depending on the duration of growth

Legumes perennial herbs	Height, cm, per day after sowing												
	20	30	40	50	60	70	80	90	100	110	120	130	140
Medicago sativa I.	4	8	28	46	78	83/*	12	33	43	55	73/	8	11
Trifolium pratense L.	3	6	16	24	56	63	68/	11	20	30	34/	5	7
Onobrychis arenaria Kit.	7	10	30	43	95/	12	23	31	44	62/	9	9	12
Melilotus albus L.	3	5	26	42	95	118	130/	20	20	27	62	69	69/
Lotus corniculatus L.	2	6	16	26	49/	6	21	32/	6	7	22	26/	5
Galega orientalis Lam.	3	4	16	19	23	51	61	64	64	64	64	62/	20

* Note: / - mowing grass.

Starting from the 30th to the 60th day of the growing season the growth of Onobrychis arenaria Kit, Medicago sativa I., Melilotus albus L. significantly increases. On the 60th day of vegetation, the highest are Onobrychis arenaria Kit and Melilotus albus L. – 95 cm, and Medicago sativa I. – 78 cm. The average daily growth during the specified period ranged from 3.0 cm in Melilotus albus L. to 2.3 cm in Medicago sativa I.

Trifolium pratense L., Lotus corniculatus L. and Galega orientalis Lam. have growing smaller during this time-from 1.7 cm/day in Trifolium pratense L. to 1.0 cm/day in Galega orientalis Lam. During this time, the herbs undergo a branching phase, budding, and some – the beginning of flowering. In particular, Onobrychis arenaria Kit. and Lotus corniculatus L. reached the beginning of flowering phase with a height of 95 cm and 49 cm, respectively.

Over the next 60 to 80 days of the vegetation day, the intensity of linear growing of Medicago sativa I. and Trifolium pratense L. decreases to 0.5–0.6 cm/day. This coincides with the stages of the beginning of budding – beginning of flowering Medicago sativa I. and branching – beginning of budding – beginning of flowering – Trifolium pratense L. Medicago sativa I. reached a height of 83 cm, and Trifolium pratense L. – 68 cm.

Melilotus albus L. continued to grow intensively in the next time period, from the 60s to the 90th, with daily growths of 1.2 cm, due to the absence of budding and flowering phases at this time.

Galega orientalis Lam. plants grew intensively from the 30th to the 70th day with an average daily growth of 1.2 cm, and from the 70th day the growth rate decreased to 0.65 cm/day.

The largest daily average annual growth of leguminous in the first mowing, with the exception of Galega orientalis Lam., was observed during the 50-60th vegetation period, and in Galega orientalis Lam. – during the 60-70th day of vegetation.

During the formation of the second mowing, the average daily growth of Lotus corniculatus L. was 1.52 cm/day, Medicago sativa I. – 1.43 cm/day, Onobrychis arenaria Kit. – 1.35 cm/day. The growths of Trifolium pratense L. were in 2 times smaller and amounted to 0.70 cm/day. The vegetative growth of these herbs was approximately equal throughout the period of formation of the second mowing.

In the second mowing of leguminous perennial herbs, there is no single trend in the predominance of any time interval in growth rate. This is due to the mowing of herbs in different calendar times and different weather conditions. Medicago sativa I. and Onobrychis arenaria Kit. grew most intensively between 10 and 20 and 40 to 50 days after mowing the first slop, Melilotus albus L. – since 30 till 40 days, and Lotus corniculatus L. – from 20th through 30th day.

Herbs that form a single mowing during the growing season (Galega orientalis Lam. and partly Melilotus albus L.) have intense vegetative growth for the first 90–100 days. Then the growth slows down and almost stops. Mowing Melilotus albus L. on the 80th day after the sowing, with its height of 130 cm, leads to the restoration of vegetative growth after 30 days in the form of blooming leaves from the buds on the not cut part of the stem but their linear growth is practically absent. Only 35–40 days after mowing, the growth of Melilotus albus L. significantly increases and reaches 69 cm after 60 days after mowing. More intense growth of white bourbon was observed around the perimeter areas associated with uneven lighting of plants in the first mowing.

The highest in the second mowing are Medicago sativa I. plants – 73 cm, Melilotus albus L. – 69 cm and Onobrychis arenaria Kit. – 62 cm. However, the average daily growth of Melilotus albus L. plants was 1.15 cm. It was 0.2–0.3 cm/day less than Medicago sativa I. and Onobrychis arenaria Kit.

The third mowing among leguminous perennial herbs was formed only by Lotus corniculatus L. with an average daily growth at 0.46 cm with a final height of plants 26 cm.

Summarizing the results of research on the study of features increase in the height of leguminous in the year of sowing, it should be noted:

- during the first 30 days of vegetation, before the phase of the 3rd compound leaf, all leguminous perennial herbs have a very slow growth and development and most of the time they need protection from weeds;

- the next 30 days when the herbs are in the stalking phases – branching, growth rate significantly increases 5–6 times in plants Melilotus albus L., Onobrychis arenaria Kit. and Medicago sativa I. Gains of 3–4 times greater than in the first 30 days of vegetation are observed in Galega orientalis Lam., Trifolium pratense L. and Lotus corniculatus L.;

- in the budding phase, the intensity of linear growth decreases in Medicago sativa I. and Trifolium pratense L. Most ripe grasses – Onobrychis arenaria

Kit. and Lotus corniculatus L., continue to grow intensively even when the budding phase is reached;

- from the 70th vegetation period of herbs that have not reached budding (Melilotus albus L. and Galega orientalis Lam.), the growth rate decreases by 2.0– 2.5 times;

- Melilotus albus L. reaches the highest height in the year of sowing, as a biennial crop, and the lowest – Galega orientalis Lam. and Lotus corniculatus L. as the most long-term herbs.

In the second and following years of vegetation of leguminous perennial herbs also showed differences in the dynamics of their height in conditions of soil pollution with heavy metals. As the average daily temperature was 4.0–6.0 ºC at the time of the regeneration of leguminous perennial vegetation and did not rise above 8.0 ºC over the next 30–40 days, the intensity of grass growth at this time was low. In particular, Trifolium pratense L. and Onobrychis arenaria Kit. plants, which started vegetation earlier among all legumes, and Lotus corniculatus L. – grew slowly during the first 40 days of vegetation, with an average daily growth of 0.1–0.2 cm (Table 3).

Medicago sativa I. and Melilotus albus L. herbs, starting vegetation 7 days later, grew slowly during the first 30 days of vegetation, with average daily growth of 0.20–0.25 cm, as the average daily temperature was slightly higher due to later in time growth.

Galega orientalis Lam. begins growing at the end of March at average daily temperature of 9.0 ºC, which contributed to its intensive growth from the beginning of the reviving of vegetation.

Table 3

Height dynamics of the of leguminous perennials herbs depending on the duration of growing, the average for the second or fourth years of vegetation

Legumes perennial herbs	Height, cm, per day after the beginning of spring regrowth															
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
Medicago sativa I.	6	7	11	20	33	45	63	82	94/*	11	26	60	69/	6	26	35
Trifolium pratense L.	4	5	6	7	16	33	46	64	79/	15	20	36	60/	7	12	17
Onobrychis arenaria Kit.	8	9	10	12	42	53	71	94/	7	12	18	26	36	82/	7	13
Melilotus albus L.	4	5	8	14	40	50	76	112	174/	-	-	-	-	-	-	-
Lotus corniculatus L.	3	4	6	9	14	26	48/	5	10	22	27	33/	7	20	35/	-
Galega orientalis Lam.	4	10	28	64	77	105/	10	18	25	48	58	79/	7	12	22	-

* Note: / - mowing grass.

In the following periods, starting with the till ring phase, the intensity growing processes of leguminous perennial herbs increases significantly. Medicago sativa I. and Trifolium pratense L. plants grew more evenly from the tillering phase to the beginning of flowering (with average daily increments of 0.9 –1.9 cm). This is due to the long growing season in the first mowing – 88–90 days before flowering. Medicago sativa I. plants had the largest growth on the 60–80th day from the beginning of the growing season – in the end of branching – budding, and the crops of Trifolium pratense L. – two periods of intensive growth – 50–60 days vegetation – in the branching phase and 70–80 days – in the same phase.

Daily average plant growth of Onobrychis arenaria Kit. and Galega orientalis Lam was 1.1–3.6 cm tall. The highest plants were Onobrychis arenaria Kit. on the 40–50th day of vegetation in the till ring phase – branching and on the 70–80th day – in the budding phase. The largest growth of Onobrychis arenaria Kit. plants was on the 30–40th day of the growing season – in the branching phase and on the 50–60th day – in the budding phase. Similarity to growth processes of Onobrychis arenaria Kit. and Galega orientalis Lam. is determined by the early maturity of both herbs. The growth processes of Lotus corniculatus L. were more equal and much smaller than Onobrychis arenaria Kit. and Galega orientalis Lam. – 0.5–2.2 cm/day, with a maximum of 60–70th day of vegetation in the budding phase.

The average daily growth of Melilotus albus L. plants ranged from 0.6 to 6.2 cm. They were highest during the 80–90th day of vegetation in the budding phase, but they were also significant – 2.6–3.6 cm/day during 40–50s and 60–80s in the till ring phase – branching.

According to the calendar, most legumes of perennial herbs had the highest growth during May at an average daily temperature of 15.0 °C, with only Onobrychis arenaria Kit. plants – in the third decade of April – May at an average daily temperature of 13.5 ºC, and Medicago sativa I. – in May – the first decade of June at an average daily temperature of 18.0 ºC.

Among all perennial herbs, the tallest in the first mowing were Melilotus albus L. plants – 174 cm, then Galega orientalis Lam. – 69 cm smaller – 105 cm, Onobrychis arenaria Kit. and Medicago sativa I. – 94 cm, Trifolium pratense L. – 79 cm and the lowest – Lotus corniculatus L. – 48 cm. – 1.87–1.81 cm, then Onobrychis arenaria Kit. – 1.25 cm, Medicago sativa I. – 1.04 cm, smallest in Trifolium pratense L. and Lotus corniculatus L. were 0.90 and 0.68 cm/day, respectively.

The intensity of growth of leguminous perennials in the second mowing is similar to the first. The height of Lotus corniculatus L. plants increased most evenly, with daily increment of 0.5–1.2 cm and a maximum of 20–30 days after mowing the first mowing before the budding phase began.

Plant height levels of Onobrychis arenaria Kit. plants were 0.5–1.0 cm/day, and they increased to 4.6

cm/day by 50–60 days after harvesting the first mowing, in the budding phase.

Growths of plant height of Trifolium pratense L. increased equally from 0.5 cm/day on the 10th to 20th day after mowing the first crop – up to 2.4 cm/day on the 30–40th day in the budding phase.

The growth rate of Medicago sativa I. plants was 0.9–3.4 cm/day with a maximum of 20–30 days after mowing the first crop in the end of branching phase – budding.

Average daily growth of plants Galega orientalis Lam. was 0.7–2.3 cm with two maxima – on 30–40 and 50–60 days after mowing in the branching and budding phase, respectively.

The plants of Onobrychis arenaria Kit. – 82 cm and Galega orientalis Lam. – 79 cm were the highest at the time of mowing of the second crop with average daily growth of 1.37 and 1.32 cm, respectively, slightly lower – Medicago sativa I. – 69 cm and Trifolium pratense L. – 60 cm with average daily growth of 1.73 and 1.4 cm, respectively. The lowest in the second mowing were the crops of Lotus corniculatus L., with a height of 33 cm and an average daily gain of 0.66 cm.

The height of all legumes of perennial herbs in the second mowing was lower than in the first 1,15–1,45 times. Onobrychis arenaria Kit. plants more closely correspond to the height of the first mowing, and the least – Lotus corniculatus L.

During the formation of the third mowing, subsequent plant height growths of Trifolium pratense L. were similar to the second mowing and were 0.3–2.6 cm/day, Medicago sativa I. – decreased to 0.9–2.0 cm/day. Growth intensity of Onobrychis arenaria Kit. and Lotus corniculatus L. on the contrary, increased to 0.5–1.5 and 1.4–1.5 cm/day, respectively.

Medicago sativa I. herbs had the highest height in the third mowing – 62 cm with average daily increments of 1.24 cm, slightly lower than the ones of Onobrychis arenaria Kit. and Trifolium pratense L. – 48–46 cm with increments of 0.96–0.92 cm/day. The height of the plants of Lotus corniculatus L. was 35 cm with an average daily growth of 1.17 cm. Galega orientalis Lam. had a height of 22 cm with increments of 0.73 cm/day, but the complete mowing of the economically valuable crop they were not formed.

Comparing the dynamics of legumes perennial grasses hight, it was studied:

- in the initial phase of vegetation, during the first 30–40 days, all leguminous of perennial grasses grow very slowly, due to the influence of low temperatures;

- the lower the temperature of the beginning of spring vegetation is – the longer the period of slow growth in them;

- from the phase of tillering of leguminous, the intensity of their growth significantly increases and reaches maximum in the branching and budding phase;

- early ripe herbs – Onobrychis arenaria Kit. and Galega orientalis Lam. – have two periods of intensive growth – on the 30–40–50th day after the beginning of regrowth, and on the 50–70th day, it coincided with other leguminous perennials in the second term;

- medium ripe herbs – Medicago sativa I., Melilotus albus L., and Lotus corniculatus L., have mainly one period of intensive growth – for 60–80 days from the beginning of the restoration of vegetation;

- during the formation of the second mowing of leguminous perennial herbs, their maximum growth was in the branching-budding phase;

- the plant height of most leguminous perennial herbs in the second mowing decreased by 24–27 % compared to the first one in Onobrychis arenaria Kit. – by 12.8 %, Lotus corniculatus L. – by 31.1 %, but the average daily growth rate of Medicago sativa I. and Trifolium pratense L. plants increased by 40.0–35.7 %, Onobrychis arenaria Kit. – by 8.8 %;

- the height of leguminous perennial herbs in the third mowing was 10.1 % lower than in the second mowing of Medicago sativa I., by 41.5 % – Onobrychis arenaria Kit., by 72.2 % – by Galega orientalis Lam. and only the height of Lotus corniculatus L. plants increased by 5.7 % compared to the second mowing.

Comparing the growing processes of leguminous perennial herbs in the year of sowing and in subsequent years of vegetation, it was studied:

- similarity of growth processes in the initial phases of vegetation, within 30 –40 days with an increase rate of 0.1–0.5 cm/day, both in the sowing year and in subsequent years of vegetation;

- acceleration of growth processes in the second growing season, which fell in the first and subsequent years of vegetation of Onobrychis arenaria Kit., Medicago sativa I., Trifolium pratense L., but increased significantly in the second and subsequent years of vegetation of Galega orientalis Lam.;

- the height of plants in the first mowing in the year of leguminous perennial grasses sowing was lower than in subsequent years of vegetation in Medicago sativa I. and Trifolium pratense L. – by 11.7–13.9 %, Melilotus albus L. – by 25.2 %, Galega orientalis Lam. – at 41.0 %, at the same time the height of Onobrychis arenaria Kit. and Lotus corniculatus L. was the same both in the sowing year and in the following years of vegetation;

- average daily growth of Melilotus albus L., Trifolium pratense L. in the first mowing of the sowing year and subsequent vegetation years was similar; average daily growth of Medicago sativa I. decreased in the second and subsequent vegetation years by 0.36 cm/day, Onobrychis arenaria Kit. – by 0.55 cm/day, Lotus corniculatus L. – by 0.32 cm/day, but Galega orientalis Lam. grew by 1.31 cm/day;

- deceleration in average daily growth of leguminous perennial grasses of the second and subsequent vegetation years in the first mowing is associated with early restoration of vegetation at low temperatures (4–6 °C), which were unfavorable to intensive growth of herbs during the first 30–40 days of vegetation, at that time the average daily temperature was much higher during the sowing of leguminous;

- average daily growth of Onobrychis arenaria Kit. of the second mowing in the sowing year and in the following years of vegetation was similar, greater than in the second and subsequent years of vegetation by 0.3 cm/day – Medicago sativa I., by 0.7 cm/day – Trifolium pratense L., but Lotus corniculatus L. – smaller than the second and subsequent years – by 0.86 cm/day;

- the height of the plants of the second mowing in the year of sowing of leguminous perennial herbs and in the second and subsequent years of vegetation was similar in the crops of Medicago sativa I. and Lotus corniculatus L. the Trifolium pratense L. herbage was two times higher in the second and subsequent years, but lower by 24,4% – Onobrychis arenaria Kit.

Conclusions and offers. In conditions of moderate soil pollution with heavy metals of lead, cadmium, copper and zinc, all the studied herbs grow and develop without inhibition. It will contribute to the good accumulation of their tissues of heavy metals and their removal from the soil. In the first year of life, Melilotus albus L. – 130 cm and Onobrychis arenaria Kit. reach the highest height. – 95 cm. Second and subsequent years of life – Melilotus albus L. – 174 cm, Galega orientalis Lam. – 105 cm were the highest in mowing. In the second and following mowings – Onobrychis arenaria Kit. – 82 cm and Galega orientalis Lam. – 79 cm.

References

1. Гоменюк В.О. Практичний посібник з використання комплексних добрив: наукове видання. Вінниця: ФОП Данилюк В.Г., 2008. 104 с. [Homeniuk V.O. Praktychnyi posibnyk z vykorystannia kompleksnykh dobryv: naukove vydannia. Vinnytsia: FOP Danyliuk V.H., 2008. 104. (in Ukraine).].

2. Балаєв А.Д., Ковальчук О.П., Дорошкевич Н.Ф. Зміна вмісту та запасів гумусу в сірому лісовому грунті за застосування різних сидеральних культур як зеленого добрива // Корми і кормовиробництво. Вінниця, 2011. Вип. 70. С. 106 – 110. [Balaiev A.D., Kovalchuk O.P., Doroshkevych N.F. Zmina vmistu ta zapasiv humusu v siromu lisovomu grunti za zastosuvannia riznykh syderalnykh kultur yak zelenoho dobryva. Kormy i kormovyrobnytstvo. Vinnytsia, 2011. 70. 106 – 110. (in Ukraine).].

3. Петриченко В.Ф. Теоретичні основи інтенсифікації кормовиробництва в Україні // Вісник аграрної науки. Київ, 2007. № 10. С. 19–22. [Petrychenko V.F. Teoretychni osnovy intensyfikatsii kormovyrobnytstva v Ukraini. Visnyk ahrarnoi nauky. Kyiv, 2007. 10. 19–22. (in Ukraine).].

4. Schnidtke K., Rauber R. Gefardet der Leduminosenanbau im okologischen Landbau die Grundwassergualitat? Bio-Land, 1990. № 5. s. 15 – 18.

5. Sauve S., Hendershot W., Allen H.E. Solid-solution partitioning of metals in contaminated soils: Dependence of pH, totalmetal burden, and organic matter. Crit. Rev. Environ. Sci. Technol., 2000. № 34. P. 1125–1131.

6. Sedum alfredii H – a new zinc hyperaccumulating plant species native to China / Yang X.E. et all. Chinese Sci. Bulletin, 2002. № 47. P. 1003 – 1006.

7. Cadmium tolerance and hyperaccumulation in a new Znhyperaccumulating plant species (Sedum Alfredii Hance) / Yang X.E. et all. Plant Soil, 2004. № 259. P. 181–189.

8. Довгопола К.А. Екологічна оцінка вмісту важких металів у грунті та TRIFOLIUM PRATENSE L. URL: www.irbis-nbuv.gov.ua/cgi-bin/irbis_nbuv/cgiirbis_64.exe?... (13.02.2014). [Dovhopola K.A. Ekolohichna otsinka vmistu vazhkykh metaliv u hrunti ta TRIFOLIUM PRATENSE L. URL: www.irbis-nbuv.gov.ua/cgi-bin/irbis_nbuv/cgiirbis_64.exe?... (in Ukraine).].

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