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GROWTH AND DEVELOPMENT OF LEGUMINOUS PERENNIAL HERBS IN SOIL POLLUTION WITH HEAVY METALS

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ABSTRACT

In the conditions of soil pollution by the moving forms of heavy metals Pb – 1 MPC, Cd – 1 MPC, Cu – 2.3 MPC, there were researched the features of growth and development in sowing of six species of legume perennial grasses: Medicinal sativa I., Trifolium pratense L., Onobrychis arenaria Kit., Melilotus albus L., Lotus corniculatus L. and Galega orientalis Lam. It is founded that leguminous perennial herbs have differences in morphological features and processes of growth and development; Lotus corniculatus L., Onobrychis arenaria Kit.), Medicago sativa I., Trifolium pratense L. develop in the spring type; Galega orientalis Lam. and Melilotus albus L. develop in the winter type; the earliest Lotus corniculatus L. reaches flowering phase – on the 60 th day after sowing and till the end of the growing season forms 2 more mowing in the beginning of flowering phase; later Trifolium pratense L. begins to bloom meadow – in 23 days after Lotus corniculatus L.; the most competitive with weeds are Melunotus albus L. and Onobrychis arenaria Kit. and, to say the least are Galega orientalis Lam. and Trifolium pratense L.

Keywords: Leguminous perennial herbs , growth, development, heavy metals, pollution, soil.

Formulation of the problem. In recent decades in Ukraine, as a result of the increasing the use of mineral fertilizers and pesticides the potential threat to soils may be their pollution with heavy metals. Heavy metals include chemical elements with an atomic mass greater than 40 and a density exceeding 5 g/cm^3, which have the properties of metals [1]. The notion of «heavy metals» is conditional, because this group includes copper, zinc and other elements that have a positive biological value, they are called microelements, but when they accumulate above the limit they can be toxic and to activate or vice versa to block biochemical processes in living organisms. Particular attention is drawn to heavy metals such as Zn, Cu, Pb and Cd [2, 3].

Researches of many scientists have found that phytotoxicity of heavy metals depends on such factors as: chemical properties, soil and climatic conditions and species features of plants and their resistance to pollution [4].

Analysis of recent research and publications. Grass-fed fodder is one of the factors that can stabilize the degradation processes occurring in the soil. Large phytomeliorative role of leguminous perennial herbs on plowland , optimal ratio of plowed land, hayfields and pastures would be able to eliminate destructive processes occurring in agricultural landscapes, to reduce erosion and to increase soil fertility and crop yields [5].

Leguminous perennial herbs improve soil fertility, protect it from wind and water erosion, leave in the soil dry roots and crop residues. Their root system contains from 2.5-3% to 4% nitrogen. After it dies and decomposes, nitrogen reserves in the soil increase by 150-200, sometimes 300 kg / ha. Nitrogen which is accumulated in the root system and the crop residues of leguminous perennial herbs after their decomposition in the soil is well absorbed by other crop rotation cultures [6].

Separation of previously unresolved parts of a common problem. In recent years, the positive impact of the cultivation of leguminous perennial herbs on reducing soil pollution by heavy metals has been confirmed. Therefore, under such conditions, there will be an increase in their acreage on lands polluted with heavy metals. In turn, heavy metals, such as toxic substances, can inhibit leguminous perennial herbs and affect their growth and development. It is the study of these parameters that is the task of our research.

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 agrosphere 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 Research farm "Ahronomichne", 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 has a flat terrain which is characterized by a slight elevation and a weak division of the territory. 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 - veryhigh, 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 [7];

- 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 [8].

- phenological observations - approximately based on visual observations of the onset of phases of plant development [9].

Statement of the main material. In the conditions of intensive agriculture of the Central Forest-Steppe of Ukraine, the content of mobile forms of lead and cadmium is responsible for the high level of chemicalisation in crop production when growing the main field crops on grey podzolic medium-loam soils MPC and midi – 2.3 MPC (Table.1).

Table 1.

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

Heavy metals	Actual content, mg /kg	MPC, hg/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

Such a level of content of moving forms of lead and cadmium in the soil defines as a moderately dangerous degree of soil contamination. The area of such lands in Ukraine according to Grabak N.H. (2014) is 789,000 ha [10]. The level of content of moving copper forms in the soil is a highly dangerous degree of soil contamination. The area of such soils in Ukraine is 285000 ha (Table 2).

Table 2

Distribution and areas of soils of Ukraine by degree of contamination with heavy metals (according to Hrabak N. A, 2014)

The degree of contamination	Degree criterion	Distribution Area in Ukraine, ha
Extremely dangerous	More than 2.5 MPC	57000
Highly dangerous	1.5–2.5 MPC	285000
Moderately dangerous	0.5–1.5 MPC	789000

Leguminous perennial herbs which are grown on soils polluted with lead, cadmium and copper in the year of sowing develop very slowly, often lagging behind in growth, losing rivalry to weeds. This significantly reduces their positive agri-environment role both in the crop as a whole and in the improvement of the soil condition in particular. Therefore, our researches will be able to to form herbaceous leguminous perennial herbs in a non-covering method. Under these conditions, plants can develop much faster, but they need more intensive protection against adverse abiotic and biotic factors.

Germination of leguminous perennial herbs began almost simultaneously – on the 7-8 th day after sowing at an average daily temperature of 16ºC and the accumulation of the sum of active temperatures of 112-128 ºC. Complete seedlings of all leguminous perennial

herbs appeared on the 11th day with the accumulation of sows sum of active temperatures of 179 ºC and average daily temperature of 17.3 ºC (Tables 3, 4).

Table 3

The passage of the growth and development phases in the sowing year

Leguminous perennial herbs	Depending on the phase of growth and development									
	Start ladder	Full ladder	Thefirstthriceleaf	Thethird thric eleaf	Branches	Budding	Startflowering	Startregrowth	Startf lowering 2 mowing	Startf lowering 3 mowing
Medicago sativa I.	7	11	16	24	35	64	70	6	51	-
Trifolium pratense L.	7	11	18	26	36	80	83	4	49	-
Onobrychis arenaria Kit.	8	11	16	24	35	60	62	8	46	-
Melilotus albus L.	7	11	21	24	35	-	-	8	-	-
Lotus corniculatus L.	8	11	16	22	35	49	60	8	21	57
Galega orientalis Lam.	8	11	21	32	43	-	-	-	-	-

The first simple leaf is formed by Onobrychis arenaria Kit., Trifolium pratense L., Melilotus albus L. and Galéga orientalis Lam. While Lotus corniculatus L. and Medicago sativa I. form the first complex leaf at once. At this time, the crops of leguminous perennial herbs develop pests such as Sitona lineatus Germ., and the weed is clogged with Setaria glauca L. The most Sitona lineatus Germ. occur on Medicago sativa I., slightly less – on Trifolium pratense L. and Melilotus albus L. The rest of the herbs are not observed.

The first trigeminal leaf appeared on the 16th day after sowing in Medicago sativa I., Onobrychis arenaria Kit. and Lotus corniculatus L. with an accumulation of active temperatures by sowing 272 ºC on 2 days later – in Trifolium pratense L. and for 5 days – in Melilotus albus L. and Galega orientalis Lam.

The third trigeminal leaf was formed on the 22nd day after sowing in Lotus corniculatus L. with accumulation of the sum of active temperatures by sowing 384 ºC and on the 24th day – in Medicago sativa I., Onobrychis arenaria Kit. Melilotus albus L. with the accumulation of active temperatures by their crops of 421 ºC. Trifolium pratense L. the third trigeminal leaf was formed on 2 days later than in Medicago sativa I., and Galega orientalis Lam. – on 8 days later. Lotus corniculatus L. was developing the fastest at this time.

Table 4

Accumulation of active temperatures by crops of leguminous perennial herbs depending on the phases of growth and development

Leguminous perennial herbs	The sum of active temperatures, C depending on the phase of growth and development									
	Start ladder	Full ladder	Thefirstthriceleaf	Thethird thric eleaf	Branches	Budding	Startflowering	Startregrowth	Startf lowering 2 mowing	Startf lowering 3 mowing
Medicago sativa I.	112	179	272	421	612	1142	1267	118	989	-
Trifolium pratense L.	112	179	309	459	627	1464	1519	73	918	-
Onobrychis arenaria Kit.	128	179	272	421	612	1059	1101	166	901	-
Melilotus albus L.	112	179	365	421	612	-	-	-	-	-
Lotus corniculatus L.	128	179	272	384	612	843	1059	166	423	1030
Galega orientalis Lam.	128	179	365	565	740	-	-	-	-	-

Branching of leguminous perennial herbs began simultaneously on the 35th - 36th day after sowing with the accumulation of the sum of active temperatures by crops of 612ºC, with the exception of Galega orientalis Lam., where this process began on 8 days later at accumulation of the sum of active temperatures by its sowing 740 ºC.

At this time morphological changes are observed in the studied herbs. In particular, Onobrychis arenaria Kit. is formed after the formation of the 5th leaf from the head on the root neck, which includes 6-12 leaves. Trifolium pratense L. develops similarly, but the number of leaves which are growing out of the head are 5 pieces. Gradually, the number of stems in the bushes of these herbs increases to 20. On 46 days after sowing, Onobrychis arenaria Kit. is separated from the sand asparagus which is created flower.

Branching in Lotus corniculatus L. begins with the formation of 5 leaves. At formation of 8 leaves it is observed growth of stems from underground kidneys on a stalk.

Branching of white Melilotus albus L begins with the formation of 6 leaves. The branches in it are placed perpendicular to the main stem.

When it is forming a 7th leaf of Medicago sativa I. a branch of buds which is located on the underground stem grows. After 15 days the branches grow from the lower nodes of the aboveground part of the stem.

The sprouting of branches from the buds of the underground stem of Galega orientalis Lam. also begins when the 5th leaf is formed. From the budding phase of leguminous perennial herbs it is observed differences in the timing of its occurrence. in particular, in plants of Trifolium pratense L., the budding phase occurs 42 days after the branching phase, and in Lotus corniculatus L. after 12 days.

Phases of budding and flowering in the year of sowing of leguminous perennial herbs are not typical for all species. In particular, the start of flowering phase in Lotus corniculatus L. began 60 days after sowing with the accumulation of the active temperatures by sowing 1059 ºC, and in Onobrychis arenaria Kit. on 2 days later. Medicago sativa I. began to bloom on 10 days after Lotus corniculatus L., and Trifolium pratense L. – after 23 days with the accumulation of the sum of active temperatures by crops of 1519 ºC. Galega orientalis Lam. and Melilotus albus L. did not bloom in the year of sowing. The absence of flowering of Melilotus albus L. is compensated for by large above-ground vegetative growth, and in Galega orientalis Lam., aboveground growth per year is minimal.

During the flowering phase, the plants of Lotus corniculatus L. form a bush of 20–25 stems. 7 complex leaves are formed on each stem. Complex trigeminal leaves have 2 stipules. Simple leaves are oblong-rounded, and stipules – pointed. Branches are formed at the basis of the 2nd and subsequent complex leaves. Each branch bears 1–3 complex leaflets with stipules. A flower develops at the base of the 4-7th complex leaves from the branches.

Bush of Onobrychis arenaria Kit. includes up to 17 stems. Eight complex leaves are formed on each stem. Each complex leaf contains 13–17 simple leaflets. Leaves are odd-feathery lanceolate. At the base of the complex leaves is a small branch with 10–12 simple leaves that are unpaired. A flower develops at the base of the 5th and subsequent complex leaves.

Bush of Medicago sativa I. consists of 4 stems. Each stem includes 8 branches. Each branch bears 5-8 complex leaves. Almost every bush stem forms a flower.

Thus, in the year of sowing, Lotus corniculatus L., Onobrychis arenaria Kit., Medicago sativa I. and Trifolium pratense L. develop in early summer sowing without covertype of development, and the white-rumped Melilotus albus L. and Galega orientalis Lam. – in winter. Under unfavorable conditions of coverless sowing (pollution of soil with heavy metals above standard content, clogging of weeds, suppression of herbicide, acidic soil, insufficient supply of moisture and nutrients) development of leguminous perennial herbs are delayed and can pass by winter type.

Regrowth of leguminous perennial grasses after mowing occurs in 4-8 days, which depends on the presence of moisture in the soil and the accumulation of active temperatures by crops of 73-166 ºC. Lotus corniculatus L. grows from the uncut part of the stem from the above-ground buds and buds located on the underground part of the stem. Medicago sativa I. grows from buds located at the ground level, as well as from buds on the not cut part of the stem. Onobrychis arenaria Kit. and Trifolium pratense L. grow out of the buds located at ground level. Melilotus albus L. grows from the buds located on the unmixed part of the stem, but the initial growth is very slow. The buds develop small leaves, but their linear growth is almost absent.

When the leguminous perennial herbs are sown and because of their very slow growth and development, they are often overgrown with weeds. This requires the use of herbicides. However, often in humid weather, single crop spraying is not enough. This is influenced by the linear growth of the herbs and the formation of a leaf surface. Due to the intense growth and high abundance of Onobrychis arenaria Kit. and Melilotus albus L., they protect themselves from the second wave of weeds and have a small grass weed percentage. Lotus corniculatus L. and Medicago sativa I. are more weedy but competitive with weeds.

On the coverless crops of the listed herbs, only one herbicide treatment is sufficient, and in some wet years additional cultivation of the herbs requires Medicago sativa I. and Lotus corniculatus L. The least competitive with weeds is the Trifolium pratense L., and especially Galéga orientalis Lam. These grasses, when covered with sowing, require two times the application of herbicides, and Galega orientalis Lam., under certain conditions, and three times.

In competition with weeds, leguminous perennial herbs are arranged in the following order (from larger to smaller): Melilotus albus L., Onobrychis arenaria Kit., Medicago sativa I., Lotus corniculatus L., Trifolium pratense L., Galega orientalis Lam.

In the second mowing among leguminous perennial herbs grow best in the sowing year of Lotus corniculatus L., which already 21 days after mowing, with the accumulation of the sum of active temperatures of 423 ºC, reaches the beginning of flowering phase. Onobrychis arenaria Kit., Trifolium pratense L. and Medicago sativa I. formed a second mowing in the early flowering phase, 46–51 days after mowing, with the accumulation of the sum of active temperature scrops 901–989ºC.

The bush of Onobrychis arenaria Kit. in the second mowing consists of 13 stems, each of which averages 8 complex leaves. The flower is at the base of the 6th and following leaves. 3 flowers are formed on the central stem. Compared with the plants of Onobrychis arenaria Kit. In the first mowing , the second decreases the number of stems in the bush by 4, and the flower develops 1 leaf higher.

Medicago sativa I. has 4–7 stems with 18 complex leaves on a single stem and 26 flowers. The flowers are placed on the first branch at the base of the 5th and subsequent leaves. Compared to the first mowing, the second one shows an increase in the number of stems in Medicago sativa I. by 3 stems.

The bush of Trifolium pratense L. forms 22 stems, of which only 3 form a flower. As a rule, in the second mowing, flowering reaches those stems that did not flowering in the first mowing, so flowering is thinner, so a liquid bush of Trifolium pratense L. with many root leaves is formed.

Melilotus albus L. in the second mowing forms only vegetative shoots. Initially, the regrowth begins very slowly with the buds on the not cut part of the stem. At a cutting height of 20 cm, 4 buds remain undamaged. the lower height – 1 cm from the soil surface, the next – 3 cm from the previous, the third – 5 cm and the fourth – 8 cm from the previous one. At the edges of the area around the perimeter, it grows more intensively (up to 1 m from the edge of the site), which is due to more light coming into the plants growing at the edges of the site. This pattern is confirmed by researches. However, 20 to 25 days after mowing, the plants of Melilotus albus L. also begin to grow out of the buds located at ground level. Melilotus albus L. plants that were not cut in the first mowing, in the first half of August, that is, 110 days after sowing, begin to dry out and do not reach the budding and flowering phases.

Plants of Galega orientalis Lam. were growing until late autumn. Like Melilotus albus L., their drying was observed 110 days after sowing. 130 days after sowing, the plants of Galega orientalis Lam. grazing plant are observed – in late August – early September.

After the 2nd mowing of the grasses, Onobrychis arenaria Kit. grows out of the buds located on the not cut part of the stem, and also partly from the buds at the soil level. Medicago sativa I. grows from the buds at the soil level.

The third sowing among leguminous perennial herbs in the year of sowing reaches only Lotus corniculatus L. in 57 days after mowing the 2nd sowing with the accumulation of the sum of active temperatures by its crops 1030ºC.

Conclusions and offers. Summarizing the results of researches on the growth and development of leguminous perennial herbs in the year of sowing with high content in the soil of the moving forms of heavy metals of lead, cadmium and copper, it should be noted: leguminous perennial herbs have differences in both morphological features and processes of growth and development; According to the spring type, Lotus corniculatus L., Onobrychis arenaria Kit., Medicago sativa I., Trifolium pratense L.in winter – Galega orientalis Lam and Melilotus albus L.; the earliest reaches the flowering onset of Lotus corniculatus L. in the 60th day after sowing and until the end of the growing season forms 2 more mowing in the flowering start phase. Later Trifolium pratense L. begins to bloom on 23 days after Lotus corniculatus L. glacier the third thrice. leaf. Most competitive with weeds are Melunotus albus L. and Onobrychis arenaria Kit. and, to say the least, Galega orientalis Lam. and Trifolium pratense L.

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ВПЛИВ ЕФЕКТИВНОСТІ РЕГУЛЯТОРІВ РОСТУ, ХІМІЧНИХ І БІОЛОГІЧНИХ ПРЕПАРАТІВ ПРОТИ ХВОРОБ КАРТОПЛІ ALTERNARIA SOLANI ТА PHYTOPHTHORA INFESTANS

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EFFICIENCY OF GROWTH-REGULATING CHEMICALS, AGROCHEMICALS AND BIOLOGICAL PREPARATIONS AGAINST ALTERNARIA SOLANI AND PHYTOPHTHORA INFESTANS OF POTATO

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АНОТАЦІЯ

У статті наведені дослідження, щодо ефективності стимуляторів росту, хімічних і біологічних фунгіцидів проти альтернаріозу та фітофторозу картоплі. Було встановлено, що застосування на сортах картоплі різних за стійкістю до хвороб регуляторів росту знижує розвиток патогенів альтернаріозу на 8,3–47,0%, фітофторозу – 3,0–55,7%; хімічних препаратів – на 6,5-23,0% альтернаріозу та 1,5-25,3% фітофторозу; біопрепаратів – на 7,7-35,1% альтернаріозу та 3,5-33,5% фітофторозу. Виявлено, що найбільш ефективними були такі хімічні препарати, як Акробат МЦ та Антракол 70 WP, а з біологічних препаратів – Фітоспорин-М., та з регуляторів росту – Гумісол.

ABSTRACT

The article is devoted to studying efficiency of growth-regulating chemicals, chemical and biological fungicidal agents against early blight and late blight of potato. It was established that usage of growth-regulating chemicals decreases evolution of pathogenic agents on breeds with different tolerance to early blight by 8,3 – 47,0%, to late blight by 3,0 – 55,7%; using agrochemicals – by 6,5 – 23,0% for early blight and 1,5 - 25,3% for late blight; biological preparations – by 7,7 – 35,1% for early blight and 3,5 – 33,5% for late blight. On the basis of the conducted study it was revealed that the most efficient agrochemicals were Akrobat MTs, Antrakol 70 WP, among biological preparations these were Fitosporyn-M, and among growth-regulating chemicals it was Gumisol.

Ключові слова: картопля, сорт, Alternaria Solani, Phytophthora infestans, регулятори росту, фунгіциди, біологічні препарати.

Keywords: potato, breed, Alternaria Solani, Phytophthora infestans, early blight, late blight, evolution, growth-regulating chemicals, fungicidal agents, biological preparations.

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